North-west Australia 4D Marine Seismic Survey Environment Plan

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TABLE OF CONTENTS

1 INTRODUCTION....12
1.1 Overview....12
1.2 Defining the Petroleum Activity....12
1.3 Purpose of the Environment Plan....12
1.4 Scope of the Environment Plan....13
1.5 Environment Plan Summary....13
1.6 Environment Plan Structure....14
1.7 Description of the Titleholder....15
1.8 Details of Titleholder, Liaison Person and Public Affairs Contact....16
1.8.1 Titleholder....16
1.8.2 Activity Contact....17
1.8.3 Nominated Liaison Person....17
1.8.4 Arrangements for Notifying of Change....17
1.9 Woodside Management System....17
1.9.1 Environment Policy....19
1.10 Description of Relevant Requirements....19
1.10.1 Applicable Environmental Legislation....19
2. ENVIRONMENT PLAN PROCESS....23
2.1 Overview....23
2.2 Environmental Risk Management Methodology....23
2.2.1 Woodside Risk Management Processes....23
2.2.2 Health, Safety and Environment Management Procedure....24
2.2.3 Impact Assessment Procedure....24
2.3 Environment Plan Process....25
2.4 Establish the Context....27
2.4.1 Define the Activity....27
2.4.2 Define the Existing Environment....27
2.4.3 Relevant Requirements....28
2.5 Impact and Risk Identification....28
2.6 Impact and Risk Analysis....29
2.6.1 Decision Support Framework....29
2.6.2 Control Measures (Hierarchy of Controls)....31
2.6.3 Impact and Risk Classification....32
2.7 Impact and Risk Evaluation....34
2.7.1 Demonstration of ALARP....35
2.7.2 Demonstration of Acceptability....35
2.8 Environmental Performance Objectives/Outcomes, Standards and Measurement Criteria 36
2.9 Implementation, Monitoring, Review and Reporting....36
2.10 Stakeholder Consultation....37
3. DESCRIPTION OF THE ACTIVITY....38

3.1 Overview ... 38
3.2 Project Overview ... 38
3.3 Purpose of the Activity ... 38
3.4 Location ... 40
3.4.1 Area A ... 43
3.4.2 Area B ... 43
3.4.3 Area C ... 43
3.4.4 Operational Areas ... 43
3.5 Timing ... 46
3.6 Activity Components ... 47
3.6.1 Survey Method ... 47
3.6.2 Seismic Source ... 47
3.6.3 Receiver Technology ... 50
3.6.4 Project Vessels ... 50
3.6.5 Helicopters ... 51
3.6.6 Refuelling ... 51

4. DESCRIPTION OF THE EXISTING ENVIRONMENT ... 52

4.1 Overview ... 52
4.2 Summary of Key Existing Environment Characteristics ... 52
4.3 Regional Context ... 57
4.4 Physical Environment ... 61
4.4.1 Climate and Meteorology ... 61
4.4.2 Oceanography ... 64
4.4.3 Marine Sediment ... 70
4.4.4 Air Quality ... 70
4.5 Biological Environment ... 70
4.5.1 Habitats ... 70
4.5.2 Species ... 79
4.6 Socio-economic and Cultural ... 111
4.6.1 Cultural Heritage ... 111
4.6.2 Ramsar Wetlands ... 111
4.6.3 Fisheries – Commercial ... 112
4.6.4 Fisheries – Traditional ... 120
4.6.5 Tourism and Recreation ... 120
4.6.6 Shipping ... 121
4.6.7 Oil and Gas Activities ... 122
4.6.8 Defence ... 127
4.7 Values and Sensitivities ... 127
4.7.1 Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area ... 130
4.7.2 Ningaloo Coast and Gascoyne ... 132
4.7.3 Pilbara ... 137
4.7.4 Key Ecological Features ... 138

4.7.5 Other Sensitive Areas ... 142

5. STAKEHOLDER CONSULTATION ... 143

5.1 Summary ... 143
5.2 Stakeholder Consultation Guidance ... 143
5.3 Stakeholder Consultation Objectives ... 143
5.4 Stakeholder Expectations for Consultation ... 144
5.5 Consultation Engagement Plan ... 148
5.6 Consultation Feedback ... 153
5.7 Ongoing Stakeholder Consultation ... 168

6. ENVIRONMENTAL RISK ASSESSMENT, PERFORMANCE OUTCOMES, STANDARDS AND MEASUREMENT CRITERIA ... 169

6.1 Overview ... 169
6.2 Risk Analysis and Evaluation ... 169
6.2.1 Cumulative Impacts ... 169
6.3 Environmental Performance Outcomes, Standards and Measurement Criteria ... 171
6.4 Presentation ... 171
6.5 Potential Environment Risks Not Included Within the Scope of the Environment Plan .. 173
6.6 Planned Activities (Routine and Non-routine) ... 174
6.6.1 Physical Presence: Disturbance to Other Users ... 174
6.6.2 Routine Acoustic Emissions: Vessel, Helicopters and Mechanical Equipment Operation ... 181
6.6.3 Routine Acoustic Emissions: Seismic Survey Equipment ... 186
6.6.4 Routine Atmospheric Emissions: Fuel Combustion ... 259
6.6.5 Routine Light Emissions: External Lighting on Project Vessels ... 262
6.6.6 Routine Discharge: Bilge Water, Grey Water, Sewage, Putrescible Wastes and Deck Drainage Water ... 265
6.7 Unplanned Activities (Accidents, Incidents, Emergency Solutions) ... 270
6.7.1 Quantitative Spill Risk Assessment Methodology ... 270
6.7.2 Accidental Hydrocarbon Release: Vessel Collision ... 274
6.7.3 Accidental Hydrocarbon Release: Bunkering ... 292
6.7.4 Unplanned Discharge: Deck Spills ... 297
6.7.5 Unplanned Discharge: Loss of Solid Hazardous and Non-hazardous Wastes/Equipment ... 300
6.7.6 Physical Presence: Vessel Collision with Marine Fauna ... 303
6.7.7 Physical Presence: Loss or Grounding of Equipment ... 309
6.7.8 Physical Presence: Accidental Introduction and Establishment of Invasive Marine Species ... 313

7. IMPLEMENTATION STRATEGY ... 318

7.1 Overview ... 318
7.2 Systems, Practice and Procedures ... 318
7.3 Roles and Responsibilities ... 318
7.4 Training and Competency ... 322
7.4.1 Overview ... 322

7.4.2 Inductions 322
7.4.3 Petroleum Activities Specific Environmental Awareness 322
7.4.4 Management of Training Requirements 323
7.5 Monitoring, Auditing, Management of Non-conformance and Review 323
7.5.1 Monitoring 323
7.5.2 Auditing/Inspections 323
7.5.3 Marine Assurance 324
7.5.4 Management of Non-conformance 325
7.5.5 Management Review 326
7.5.6 Learning and Knowledge Sharing 326
7.6 Environment Plan Management of Change and Revision 326
7.7 Record Keeping 326
7.8 Reporting 327
7.8.1 Routine Reporting (Internal) 327
7.8.2 Routine Reporting (External) 327
7.8.3 Incident Reporting (Internal) 328
7.8.4 Incident Reporting (External) – NOPSEMA Reportable and Recordable 328
7.9 Emergency Preparedness and Response 332
7.9.1 Overview 332
7.9.2 Emergency Response Preparation 332
7.9.3 Oil and Other Hazardous Materials Spill 333
7.9.4 Emergency and Spill Response Drills and Exercises 333
7.9.5 Cyclone and Dangerous Weather Preparation 334
7.10 Implementation Strategy and Reporting of Performance Outcomes, Standards and Measurement Criteria 335

8. REFERENCES 339

9. GLOSSARY AND ABBREVIATIONS 359

APPENDIX A: WOODSIDE ENVIRONMENT AND RISK MANAGEMENT POLICIES 367

APPENDIX B: RELEVANT REQUIREMENTS 370

APPENDIX C: EPBC ACT PROTECTED MATTERS SEARCH 371

APPENDIX D: OIL SPILL PREPAREDNESS AND RESPONSE STRATEGY SELECTION AND EVALUATION 372

APPENDIX E: NOPSEMA REPORTING FORMS 373

APPENDIX F: STAKEHOLDER CONSULTATION 374

APPENDIX G: DEPARTMENT OF DEFENCE HERITAGE ENQUIRY SYSTEM 375

APPENDIX H: JASCO NOISE MODELLING REPORTS 376

APPENDIX I: PASSIVE ACOUSTIC MONITORING 377

List of Tables

Table 1-1: EP summary table 13

Table 1-2: EP Process phases, applicable regulations and relevant section of EP........................ 14
Table 1-3: Operator and joint ventures for the Petroleum Activities Program 16
Table 1-4: The Australian IUCN Reserve Management Principles for Multiple Use Zone (IUCN category VI) 20
Table 1-5:Conditions of Class Approval relevant to the Petroleum Activities Program 21
Table 1-6: Relevant Management Principles under Schedule 5—Australian World Heritage management principles of the EPBC Act 22
Table 2-1: Environmental values potentially impacted by the Petroleum Activities Program which are assessed within the EP 28
Table 2-2: Example of layout of identification of risks and impacts in relation to risk sources 29
Table 2-3: Woodside risk matrix (environment and social and cultural) consequence descriptions 33
Table 2-4: Woodside risk matrix likelihood levels 34
Table 2-5: Summary of Woodside's criteria for demonstrating ALARP 35
Table 2-6: Summary of Woodside's criteria for Acceptability 35
Table 3-1: Petroleum Activities Program overview 39
Table 3-2: Boundary coordinates for Areas A, B and C 40
Table 3-3: Indicative boundary coordinates for the Petroleum Activities Program Acquisition and Operational Areas 44
Table 3-4: Survey acquisition parameters 48
Table 3-5: Typical vessel specifications 50
Table 4-1: Summary of key existing environment characteristics for Areas A, B and C 53
Table 4-2: Fish spawning timing in the North Coast bioregion 72
Table 4-3: EPBC Act listed threatened and migratory marine species potentially occurring within Area A, B or C 80
Table 4-4: Conservation advice for EPBC Act listed species considered during environmental risk assessment and their relevance to Areas A, B and C 83
Table 4-5: Key environmental sensitivities and timings for fauna potentially occurring in Areas A, B or C as identified in the EPBC Protected Matters Search (indicative) 90
Table 4-6: Key information about marine turtles in the NWMR 100
Table 4-7: Recorded historical shipwrecks in the vicinity of the Areas (DoEE n.d.) 111
Table 4-8: Commonwealth and State fisheries of relevance to the Petroleum Activities Program 113
Table 4-9: Other oil and gas facilities in the vicinity of Areas A, B and C 123
Table 4-10: Potential concurrent and past marine seismic surveys within 100 km of Areas A, B and C 123
Table 4-11: Summary of established and proposed MPAs and other sensitive locations within and nearby Areas A, B and C 128
Table 5-1: Assessment of relevant stakeholders for the proposed activity 145
Table 5-2: Stakeholder consultation plan activities 148
Table 5-3: Stakeholder consultation feedback 153
Table 6-1: Environmental risk analysis and summary 170
Table 6-2: Description of potential impacts of seismic noise on marine fauna 187
Table 6-3: Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on cetaceans 189
Table 6-4: Criteria for seismic noise exposure for fish, adapted from Popper et al. (2014) 190
Table 6-5: Maximum predicted MOD R_{max} distances to thresholds assigned to PTS (injury), TTS and behavioural response in low frequency whales (pygmy blue whales) for Areas A, B and C (McPherson et al., 2019a) 194
Table 6-6: Maximum predicted R_{max} distances to thresholds associated with PTS onset, TTS onset and behavioural response in medium frequency (MF) and high frequency (HF) cetaceans for Areas A, B and C (McPherson et al., 2019a) 194
Table 6-7: Maximum predicted MOD distances and areas to SEL_{24h} based cetacean PTS thresholds (McPherson et al., 2019a) 195
Table 6-8: Maximum predicted MOD distances and areas to SEL_{24h} based cetacean PTS threshold for pygmy blue whales (McPherson et al., 2019a) 195

Table 6-9: Area A: Summary of ANIMAT simulation results for migratory pygmy blue whales (Weirathmueller et al., 2019; Appendix H). The 95th percentile exposure ranges (km), and the number of real-world individuals exposed above threshold (using the estimated densities) are provided. Estimates related to injury criteria (NMFS, 2018) and behaviour (NMFS, 2014) are normalised to 24-hours from the 7 days of operation simulated to aid comparison to acoustic modelling results. For comparison, maximum distances to threshold from previously completed acoustic modelling are provided. 196
Table 6-10: Area C: Summary of animal movement and sound exposure results for migratory and foraging pygmy blue whales (Weirathmueller et al., 2019; Appendix H). The 95th percentile exposure ranges (km), and the number of real-world individuals exposed above threshold (using the estimated densities) are provided. Estimates related to injury criteria (NMFS, 2018) and behaviour (NMFS, 2014) are normalised to 24-hours from the 7 days of operation simulated to aid comparison to acoustic modelling results. For comparison, maximum distances to threshold from previously completed acoustic modelling are provided. 196
Table 6-9: Maximum predicted R_{max} distances (in km) to PTS, TTS and behavioural response thresholds in turtles for Areas A, B and C (McPherson et al., 2019a) 201
Table 6-10: Maximum predicted R_{max} distances (I km) to injury and TTS thresholds for fish, fish eggs, and larvae for single-pulse and SEL_{24h} modelled scenarios, for both water column and at the seafloor, for Areas A, B and C (McPherson et al., 2019) 207
Table 6-11: Maximum predicted R_{max} distances to effect thresholds for crustaceans at the seafloor for Areas A and C 210
Table 6-12: Maximum predicted R_{max} distances (in km) to mortality/PMI thresholds in the water column for fish eggs and larvae and zooplankton, for Areas A and C (McPherson et al., 2019) .. 212
Table 6-13: Spatial overlap between key indicator commercial fish species and the 2.5 km behavioural response zone for surveys in Area A 214
Table 6-14: Summary of potential impacts of seismic noise emissions to AMP conservation values 220
Table 6-15: Summary of environmental impact thresholds applied to the quantitative hydrocarbon spill risk modelling results 271
Table 6-16: The Bonn Agreement oil appearance code 271
Table 6-17: Summary of dissolved hydrocarbon acute and chronic effects concentrations for key life histories of different biota based on toxicity tests for water-accommodated fractions of unweathered marine diesel type 2 (based on desktop review performed by Woodside, 2013) 272
Table 6-18: Operational Area credible scenarios for hydrocarbon spill as a result of loss of vessel structural integrity 275
Table 6-19: Characteristics of the marine diesel used in the modelling 276
Table 6-20: Summary of annualised exposure predictions for floating oil at sensitive receptors for an instantaneous 190 m³ spill of marine diesel onto the sea surface within Area C 277
Table 6-21: Summary of annualised exposure predictions for entrained oil at sensitive receptors for an instantaneous 190 m³ spill of marine diesel onto the sea surface within Area C 278
Table 6-22: EMBA – Key receptor locations and sensitivities with the summary hydrocarbon spill contact for an instantaneous release of marine diesel 279
Table 6-23: Evaluation of risks and impacts from marine pest translocation 314
Table 7-1: Roles and responsibilities 319
Table 7-2: Routine external reporting requirements 328
Table 7-3: AMSA and DoEE External incident reporting requirements 331
Table 7-4: Oil pollution and preparedness and response overview 332
Table 7-5: Testing of response capability to incidents 334
Table 7-6: Implementation strategy and reporting of environmental performance outcomes, performance standards and measurement criteria 335

List of Figures

Figure 1-1: The four major elements of the WMS System 18

Figure 1-2: The WMS business process hierarchy 18
Figure 2-1: Woodside’s risk management process 24
Figure 2-2: Woodside’s impact assessment process 25
Figure 2-3: Environment plan development process 26
Figure 2-4: Risk-related decision-making framework (Oil and Gas UK, 2014) 30
Figure 2-5: Environmental impact analysis 32
Figure 2-6: Woodside risk matrix: risk level 34
Figure 3-1: Location of Areas A, B and C 41
Figure 3-2: Laverda and Cimatti Operational Areas and Acquisition Areas in Area C. Note that NCWHA refers to the Ningaloo Coast WHA in the figure 42
Figure 3-2: Seismic array Safe Navigation Area (Note that streamer lengths for each survey will be based on Table 3-4) 51
Figure 4-1: Provincial scale marine regions within Area A, B and C, and the location of the Areas (IMCRA Version 4.0, DEH, 2006) 60
Figure 4-2: Mean monthly average maximum and minimum temperature and mean rainfall from 1999 to 2019 at Barrow Island (BoM, 2019) 61
Figure 4-3: Mean monthly average maximum and minimum temperature and mean rainfall from 1999 to 2019 at Exmouth (Learmonth Airport) (BoM, 2019) 62
Figure 4-4: Cyclone tracks within the NWMR 63
Figure 4-5: Generalised schematic of ocean circulation for wider marine region (DEWHA, 2008) 65
Figure 4-6: Bathymetry and seabed features of Area A (includes data from Pluto Deep Bathymetry Model AUV 3D) 67
Figure 4-7: Bathymetry and seabed features of Area B (includes data from Scarborough Deep Bathymetry Model AUV 3D) 68
Figure 4-8: Bathymetry and seabed features of Area C (includes data from Exmouth Deep Bathymetry Model AUV 3D) 69
Figure 4-9: Species distribution (depth range) of blue spotted emperor, red emperor and ruby snapper in the Pilbara bioregion 74
Figure 4-10: Species distribution (depth range) of goldband snapper, Rankin cod and Spanish mackerel in the Pilbara bioregion 75
Figure 4-11: Pygmy blue whale satellite tracks and BIAs (after Double et al., 2012b, 2014) 93
Figure 4-12: Humpback whale satellite tracks and BIA (Double et al., 2010, after 2012a) 95
Figure 4-13: Marine turtle BIAs 104
Figure 4-15: Satellite tracks of whale sharks tagged between 2005 and 2008 (after Meekan and Radford, 2010) 109
Figure 4-16: Location of Commonwealth fisheries in relation to the Areas (Geoscience Australia, 2018) 117
Figure 4-17: Location of State fisheries in relation to the Areas (Geoscience Australia, 2018) 118
Figure 4-18: Pilbara Demersal Scalefish Managed Fishery zoning (Geoscience Australia, 2018) 119
Figure 4-19: Vessel density map for Areas A, B and C from 2019, derived from AMSA satellite tracking system data 122
Figure 4-20: Location of potential concurrent seismic surveys in proximity to Areas A, B and C . 125
Figure 4-21: Petroleum titles and type within and adjacent to the Areas 126
Figure 4-22: Established Australian and State Marine parks in relation to Areas A, B and C 129
Figure 4-23: Key ecological features in relation to Areas A, B and C 139
Figure 6-1: Overview of the features for the pygmy blue whale exposure modelling for the 4-D seismic campaign 192
Figure 6-5: Proportional mass balance plot representing weathering of a surface spill of marine diesel 276

1 INTRODUCTION

1.1 Overview

Woodside Energy Ltd (Woodside), under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth) (referred to as the Environment Regulations), proposes to conduct a series of monitoring seismic surveys as part of a reservoir management and surveillance program. This project is known as the North-west Australia Four-Dimensional Marine Seismic Survey Campaign (4D MSS); hereafter referred to as the Petroleum Activities Program.

The proposed Petroleum Activities Program comprises six 4D seismic surveys that will be acquired in different areas of the Northern Carnarvon Basin, ranging from:

- a pre-development high definition 4D Baseline survey – Scarborough 4D B1
- First Monitor (M1) surveys – Harmony 4D M1, Cimatti 4D M1 and Laverda 4D M1
- Second Monitor (M2) surveys – Pluto 4D M2 and Vincent 4D M2.

All surveys except for Pluto 4D M2 have not yet been confirmed and are potential future acquisitions that require joint venture approval to commence. However, as it is considered within the scope of this Environment Plan (EP), all risks and impacts have been considered. This EP has been prepared as part of the requirements under the Environment Regulations, as administered by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

1.2 Defining the Petroleum Activity

The Petroleum Activity Program to be undertaken comprises seismic surveys using a source array and set of towed streamers, with supporting vessel(s) as required to execute the seismic campaign. These activities are defined as petroleum activities within Regulation 4 of the Environment Regulations, so an EP is required.

1.3 Purpose of the Environment Plan

In accordance with the objectives of the Environment Regulations, the purpose of this EP is to demonstrate that:

- the potential environmental impacts and risks (planned (routine and non-routine) and unplanned) that may result from the Petroleum Activities Program are identified
- appropriate management controls are implemented to reduce impacts and risks to a level that is 'as low as reasonably practicable' (ALARP) and acceptable
- the Petroleum Activities Program is executed consistent with the principles of ecologically sustainable development (as defined in Section 3A of the *Environment Protection and Biodiversity Conservation Act 1999 (Cth)* (EPBC Act)).

This EP describes the process and resulting outputs of the risk assessment, whereby impacts and risks are managed accordingly.

The EP defines activity-specific environmental performance outcomes (EPOs), environmental performance standards (EPSs) and measurement criteria (MCs). These form the basis for monitoring, auditing and managing the Petroleum Activities Program to be executed by Woodside and its contractors. The implementation strategy (derived from the decision support framework tools) specified within this EP provides Woodside and NOPSEMA with the required level of assurance that impacts and risks associated with the activity are reduced to ALARP and are acceptable.

1.4 Scope of the Environment Plan

The scope of this EP covers six seismic surveys, to be acquired within three separate geographical locations: Area A: Pluto/Brunello (Harmony 4D M1); Area B: Scarborough; and Area C: Vincent/Laverda/Cimatti. The Petroleum Activities Program is described further in **Section 3**.

This EP addresses potential environmental impacts from planned and potential unplanned activities within the Operational Area that could originate from the Petroleum Activities Program.

Transit to and from the Operational Area by survey and support vessels, as well as port activities associated with these vessels, are not within the scope of this EP. In addition, vessels supporting the Petroleum Activities Program operating outside the Operational Area (e.g. transiting to and from port) are subject to all applicable maritime regulations and other requirements and are not managed by this EP.

1.5 Environment Plan Summary

The North-west Australia 4D MSS EP summary shown in **Table 1-1** has been prepared from the material provided in this EP and as required by Regulation 11(4).

Table 1-1: EP summary table

EP Summary material requirement	Relevant section of EP containing EP Summary material
The location of the activity	**Section 3.3**, pages 38 to 40
A description of the receiving environment	**Section 4**, pages 52 to 143
A description of the activity	**Section 3**, pages 38 to 52
Details of the environmental impacts and risks	**Section 6**, pages 169 to 318
The control measures for the activity	**Section 6**, pages 169 to 318
The arrangements for ongoing monitoring of the titleholder's environmental performance	**Section 7.5**, pages 323 to 326
Response arrangements in the oil pollution emergency plan	**Section 7.9**, pages 332 to 335, **Appendix D**
Consultation already undertaken and plans for ongoing consultation	**Section 5**, pages 143 to 169
Details of the titleholder's nominated liaison person for the activity	**Section 1.8**, page 17

1.6 Environment Plan Structure

This EP has been structured to reflect the process and requirements of the Environment Regulations as outlined in **Table 1-2**.

Table 1-2: EP Process phases, applicable regulations and relevant section of EP

Criteria for acceptance	Content Requirements/Relevant Regulations	Applicable Elements of the EP	Section of EP
Regulation 10A(a): *is appropriate for the nature and scale of the activity*	Regulation 13: *Environmental assessment* Regulation 14: *Implementation strategy for the environment plan* Regulation 16: *Other information in the environment plan*	The principle of 'nature and scale' is applicable throughout the EP	**Section 3** **Section 4** **Section 5** **Section 6** **Section 7**
Regulation 10A(b): *demonstrates that the environmental impacts and risks of the activity will be reduced to as low as reasonably practicable* Regulation 10A(c): *demonstrates that the environmental impacts and risks of the activity will be of an acceptable level*	Regulation 13(1) to 13(7): *13(1) Description of the activity* *13(2)(3) Description of the environment* *13(4) Requirements* *13(5)(6) Evaluation of environmental impacts and risks* *13(7) Environmental performance outcomes and standards* Regulation 16(a) to 16(c): *A statement of the titleholder's corporate environmental policy* *A report on all consultations between the titleholder and any relevant person*	Set the context (activity and existing environment) Define 'acceptable' (the requirements, the corporate policy, relevant persons) Detail the impacts and risks Evaluate the nature and scale Detail the control measures – ALARP and acceptable	**Section 1** **Section 2** **Section 3** **Section 4** **Section 5** **Section 6**
Regulation 10A(d): *provides for appropriate environmental performance outcomes, environmental performance standards and measurement criteria*	Regulation 13(7): *Environmental performance outcomes and standards*	Environmental performance outcomes Environmental performance standards Measurement criteria	**Section 6**
Regulation 10A(e): *includes an appropriate implementation strategy and monitoring, recording and reporting arrangements*	Regulation 14: *Implementation strategy for the environment plan*	Implementation strategy, including: • Environmental Management System (EMS) • performance monitoring • Oil Pollution Emergency Plan (OPEP) and scientific monitoring • ongoing consultation.	**Section 7** **Appendix D**

Criteria for acceptance	Content Requirements/Relevant Regulations	Applicable Elements of the EP	Section of EP
Regulation 10A(f): *does not involve the activity or part of the activity, other than arrangements for environmental monitoring or for responding to an emergency, being undertaken in any part of a declared World Heritage property within the meaning of the EPBC Act*	Regulation 13(1) to 13(3): *13(1) Description of the activity* *13(2) Description of the environment* *13(3) Without limiting [Regulation 13(2)(b)], particular relevant values and sensitivities may include any of the following:* *(a) the world heritage values of a declared World Heritage property within the meaning of the EPBC Act;* *(b) the national heritage values of a National Heritage place within the meaning of that Act;* *(c) the ecological character of a declared Ramsar wetland within the meaning of that Act;* *(d) the presence of a listed threatened species or listed threatened ecological community within the meaning of that Act;* *(e) the presence of a listed migratory species within the meaning of that Act;* *(f) any values and sensitivities that exist in, or in relation to, part or all of:* *(i) a Commonwealth marine area within the meaning of that Act; or* *(ii) Commonwealth land within the meaning of that Act.*	No activity, or part of the activity, undertaken in any part of a declared World Heritage property	**Section 3** **Section 4**
Regulation 10A(g): *(i) the titleholder has carried out the consultations required by Division 2.2A* *(ii) the measures (if any) that the titleholder has adopted, or proposes to adopt, because of the consultations are appropriate*	Regulation 11A: *Consultation with relevant authorities, persons and organisations, etc.* Regulation 16(b): *A report on all consultations between the titleholder and any relevant person*	Consultation undertaken when preparing the EP	**Section 5**
Regulation 10A(h): *complies with the Act and the regulations*	Regulation 13(4)a: *Describe the requirements, including legislative requirements, that apply to activity and are relevant to the environmental management of the activity* Regulation 15: *Details of the Titleholder and liaison person* Regulation 16(a): *A statement of the titleholder's corporate environmental policy* Regulation 16(c): *Details of all reportable incidents in relation to the proposed activity*	All contents of the EP must comply with the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* and the Environment Regulations	**Section 1** **Section 6** **Appendix A** **Appendix B**

1.7 Description of the Titleholder

Woodside will be conducting the petroleum activities program on behalf of the Woodside titleholders and joint venture participants in respect to each joint venture outlined in **Table 1-3**. Petroleum titles relevant to this EP are listed in **Table 3-1.** In addition further titles where the petroleum activities program will take place will have Ingress Agreements or Access Authorities in place as required. Access Authorities are required from the National Offshore Petroleum Titles Administrator (NOPTA).

Table 1-3: Operator and joint ventures for the Petroleum Activities Program

Seismic survey	Operator/Woodside Titleholder	Joint Venture
Scarborough 4D B1	Woodside Energy Ltd	Woodside Energy Ltd, BHP Billiton Petroleum (North West Shelf) Pty Ltd
Pluto 4D M2	Woodside Burrup Pty Ltd	Woodside Burrup Pty Ltd, Tokyo Gas Pluto Pty Ltd, Kansai Electric Power Australia Pty Ltd
Harmony 4D M1	Woodside Energy Julimar Pty Ltd	Woodside Energy Julimar Pty Ltd, KUFPEC Australia (Julimar) Pty Ltd
Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2	Woodside Energy Ltd	Woodside Energy Ltd, Mitsui E&P Australia Pty Ltd

Woodside's mission is to deliver superior shareholder returns through realising its vision of becoming a global leader in upstream oil and gas. Wherever Woodside works, it is committed to living its values of integrity, respect, working sustainably, discipline, excellence and working together.

Woodside's operations are characterised by strong safety and environmental performance in remote and challenging locations.

Through collaboration, Woodside leverages its capabilities to progress its growth strategy. Since 1984, the company has been operating the landmark Australian project, the North West Shelf, and it remains one of the world's premier liquefied natural gas (LNG) facilities. In 2012, Woodside added the Pluto LNG Plant to its onshore operating facilities.

Woodside operates floating production, storage and offloading vessels (FPSOs), and has an excellent track record of efficient and safe production. Woodside strives for excellence in safety and environmental performance and continues to strengthen relationships with customers, partners co-venturers, governments and communities to ensure we are a partner of choice. Further information about Woodside can be found at http://www.woodside.com.au.

1.8 Details of Titleholder, Liaison Person and Public Affairs Contact

In accordance with Regulation 15 of the Environment Regulations, details of the titleholder, liaison person and arrangements for the notification of changes are described below.

1.8.1 Titleholder

Woodside Energy Ltd
11 Mount Street, Perth, Western Australia
Telephone: 08 9348 4000
Fax Number: 08 9214 2777
ABN: 63 005 482 986

1.8.2 Activity Contact

Mike Price
Vice President of Pluto, Floating Production Storage Offtake Vessels and Wheatstone
11 Mount Street, Perth, Western Australia
Phone: 08 9348 4000
Fax Number: 08 9214 2777
mike.price@woodside.com.au

1.8.3 Nominated Liaison Person

Daniel Clery
Corporate Affairs Manager
11 Mount Street, Perth, Western Australia
Phone: 08 9348 4000
Fax Number: 08 9214 2777
feedback@woodside.com.au

1.8.4 Arrangements for Notifying of Change

Should the titleholder, titleholder's nominated liaison person or the contact details for either the titleholder or the liaison person changes, NOPSEMA is to be notified of the change in writing within two weeks or as soon as practicable.

1.9 Woodside Management System

The Woodside Management System (WMS) provides a structured framework of documentation to set common expectations governing how all employees and contractors at Woodside will work. Many of the standards presented in **Section 2.2** are drawn from the WMS documentation, which comprises four elements: Compass & Policies; Expectations; Processes & Procedures; and Guidelines outlined below (and illustrated in **Figure 1-1**):

- **Compass & Policies:** Set the enterprise-wide direction for Woodside by governing our behaviours, actions and business decisions and ensuring we meet our legal and other external obligations.
- **Expectations:** Set essential activities or deliverables required to achieve the objectives of the Key Business Activities and provide the basis for developing processes and procedures.
- **Processes & Procedures:** Processes identify the set of interrelated or interacting activities which transforms inputs into outputs, to systematically achieve a purpose or specific objective. Procedures specify what steps, by whom and when required to perform an activity or a process.
- **Guidelines:** Provide recommended practice and advice on how to perform the steps defined in Procedures, together with supporting information and associated tools. Guidelines provide advice on: how activities or tasks may be performed; information that may be considered; or how to use tools and systems.

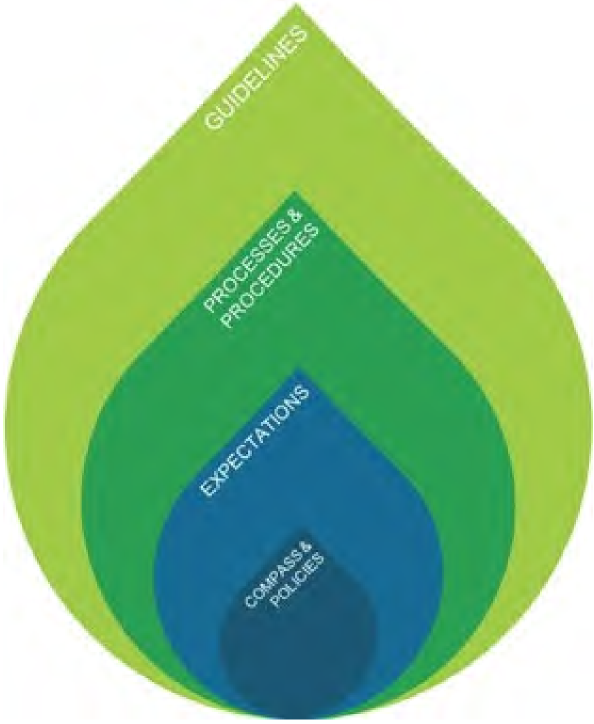

Figure 1-1: The four major elements of the WMS System

The WMS is organised within a business process hierarchy based upon key business activities to ensure the system remains independent of organisation structure, is globally applicable and scalable wherever required. These business activities are grouped into Management, Support and Value Stream activities as shown in **Figure 1-2**. The Value Stream activities capture, generate and deliver value through the exploration and production (E&P) lifecycle. The Management activities influence all areas of the business, while Support activities may influence one or more Value Stream activities.

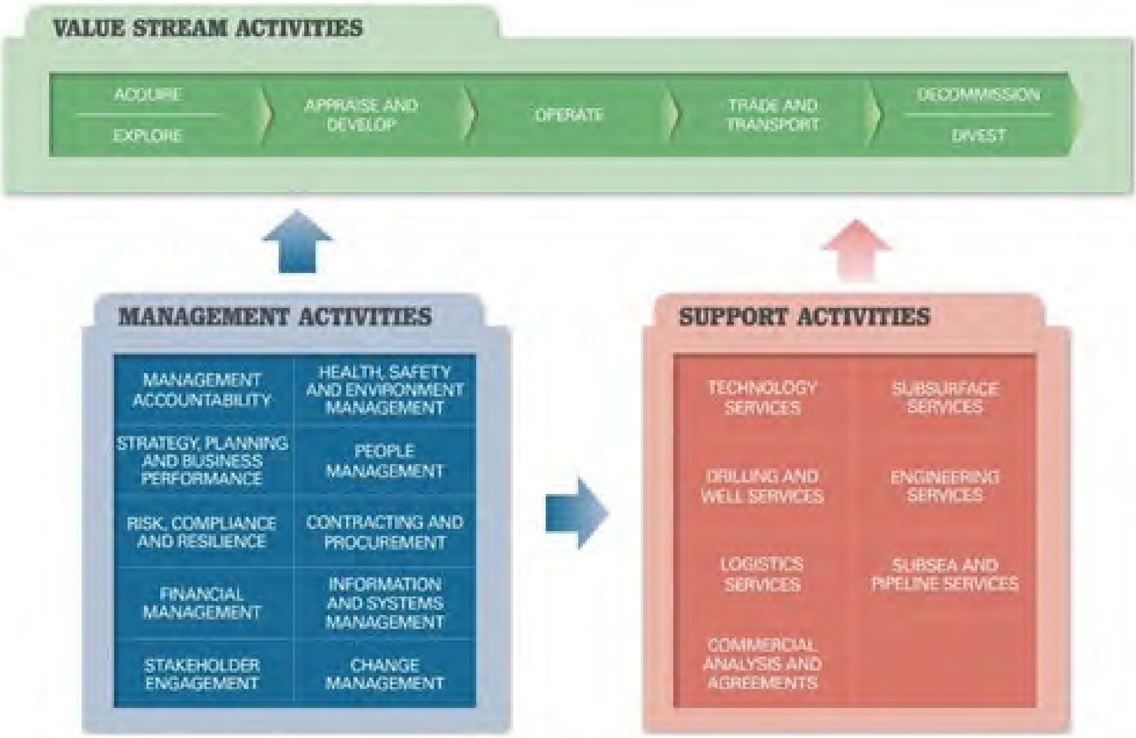

Figure 1-2: The WMS business process hierarchy

1.9.1 Environment Policy

In accordance with Regulation 16(a) of the Environment Regulations, Woodside's corporate Health Safety, Environment and Quality Policy is provided in **Appendix A** of this EP.

1.10 Description of Relevant Requirements

In accordance with Regulation 13(4) of the Environment Regulations, a description of requirements, including legislative requirements, that apply to the activity and are relevant to managing the risks and impacts of the Petroleum Activities Program is provided in **Appendix B**.

1.10.1 Applicable Environmental Legislation

The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) (Cth) controls exploration and production activities beyond three nautical miles to the outer extent of the Australian Exclusive Economic Zone at 200 nautical miles, also known as Commonwealth waters.

The Environment Regulations apply to petroleum activities in Commonwealth waters and are administered by NOPSEMA.

The objectives of the Environment Regulations include provisions to ensure petroleum activities are performed in a manner:

- consistent with the principles of ecologically sustainable development set out in section 3A of the EPBC Act
- by which the environmental impacts and risks of the activity will be reduced to ALARP
- by which the environmental impacts and risks of the activity will be of an acceptable level.

As part of NOPSEMA's assessment of an Environment Plan, it must be shown that the Petroleum Activity is not inconsistent with the values and objectives set out for any sensitive feature of the environment proclaimed under the EPBC Act, including for Australian Marine Parks (AMPs) and World Heritage Areas (WHAs[1]).

1.10.1.1 Australian Marine Parks

Under the EPBC Act, AMPs, formally known as Commonwealth Marine Reserves, are recognised for conserving marine habitats and the species that live and rely on these habitats. The Director of Marine Parks (DNP) is responsible for managing AMP's (supported by Parks Australia), and is required to publish management plans for them. Other parts of the Australian Government must not perform functions or exercise powers in relation to these parks that are inconsistent with management plans (s.362 of the EPBC Act). Relevant AMPs are described in **Section 4.7**, The North-west Marine Parks Network Management Plan describes the requirements for management.

Specific zones within AMPs have been allocated conservation objectives in the North West Marine Parks Management Plan (2018) which are based on the Australian (International Union for Conservation of Nature (IUCN) reserve management principles prescribed in Schedule 8 of the *EPBC Regulations 2000*. Management objectives for each zone include:

[1] Includes World Heritage Areas, Properties, Places.

- Special Purpose Zone (IUCN category VI)—managed to allow specific activities though special purpose management arrangements while conserving ecosystems, habitats and native species. The zone allows or prohibits specific activities.
- Sanctuary Zone (IUCN category Ia)—managed to conserve ecosystems, habitats and native species in as natural and undisturbed a state as possible. The zone allows only authorised scientific research and monitoring.
- National Park Zone (IUCN category II)—managed to protect and conserve ecosystems, habitats and native species in as natural a state as possible. The zone only allows non-extractive activities unless authorised for research and monitoring.
- Recreational Use Zone (IUCN category IV)—managed to allow recreational use, while conserving ecosystems, habitats and native species in as natural a state as possible. The zone allows for recreational fishing, but not commercial fishing.
- Habitat Protection Zone (IUCN category IV)—managed to allow activities that do not harm or cause destruction to seafloor habitats, while conserving ecosystems, habitats and native species in as natural a state as possible.
- Multiple Use Zone (IUCN category VI)—managed to allow ecologically sustainable use while conserving ecosystems, habitats and native species. The zone allows for a range of sustainable uses, including commercial fishing and mining where they are consistent with park values.

Acquisition and Operational Area A overlap a small portion of the Montebello Marine Park Multiple Use Zone (IUCN category VI). Operational Area C overlaps the Gascoyne Marine park Multiple Use Zone. There is potential for;

- seismic activities (**Section 3.6.1**) to be undertaken in very small portion of the Montebello Marine Park; and
- for run-ins, run-outs, source testing and soft starts to be undertaken in the Gascoyne Marine Park (**Section 3.4.4**).

The principles for each zone determine what activities are acceptable within a protected area under the EPBC Act . The Australian IUCN Reserve Management Principles for Multiple Use Zone (IUCN category VI) are considered relevant to the scope of this EP and are provided in **Table 1-4.** Further assessment of the impacts of the activity on the values of the marine park values is provided in **Section 6.6.3.**

Table 1-4: The Australian IUCN Reserve Management Principles for Multiple Use Zone (IUCN category VI)

Condition Number	Principle
7.01	The reserve or zone should be managed mainly for the sustainable use of natural ecosystems based on the following principles.
7.02	The biological diversity and other natural values of the reserve or zone should be protected and maintained in the long term.
7.03	Management practices should be applied to ensure ecologically sustainable use of the reserve or zone.
7.04	Management of the reserve or zone should contribute to regional and national development to the extent that this is consistent with these principles.

For the North West Marine Parks Network Management Plan (2018) Mining (petroleum activities including seismic), and oil spill response are permittable subject to approval in Multiple Use Zone

(IUCN category VI) and Special Purpose Zone Trawl (IUCN category VI). Proposed mining operations conducted under usage rights that existed immediately before the declaration of a marine park do not require approval.

Petroleum Activities occurring within these zones are approved by a class approval (Director of National Parks 2018a). Conditions of the Class Approval that are considered relevant to the scope of this EP are provided in **Table 1-5.**

Table 1-5:Conditions of Class Approval relevant to the Petroleum Activities Program

Condition Number	Condition	Relevant Section of the EP
1	The Approved Actions must be conducted in accordance with: (a) an Environment Plan accepted under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009; - (b) the EPBC Act; (c) the EPBC Regulations (d) the North-west Network Management Plan; (e) any prohibitions, restrictions or determinations made under the EPBC Regulations by the Director of National Parks; and (f) all other applicable Commonwealth and state laws (to the extent those laws are capable of operating concurrently with the laws and instruments described in paragraphs (a) to (e)).	Conditions 1a, b, c, f are met by the submitted EP (**Section 1.10.11)** 1d: The impacts on the marine park values have been considered in **Section 6.6.3.** 1e: Consultation has been undertaken with the Director of National Parks and no prohibitions, restrictions or determinations have been made **(Section 5)**
2	If requested by the Director of National Parks, an Approved Person must notify the Director prior to conducting Approved Actions within Approved Zones.	**Section 7** describes requirements to notify the DNP prior to activities within the Montebello or Gascoyne Multiple Use Zone.
3	If requested by the Director of National Parks, an Approved Person must provide the Director with information relating to undertaking the Approved Actions (or gathered while undertaking the Approved Actions), that is relevant to the Director's management of the Approved Zones.	If requested by the Director of National Parks, information relating to undertaking the Approved Actions (or gathered while undertaking the Approved Actions), that is relevant to the Director's management of the Approved Zones will be provided.

1.10.1.2 World Heritage Properties

Australian World Heritage management principles are prescribed in Schedule 5 of the *EPBC Regulations 2000*. Management principles that are considered relevant to the scope of this EP are provided in **Table 1-6.**

Table 1-6: Relevant Management Principles under Schedule 5—Australian World Heritage management principles of the EPBC Act

Number	Principle	Relevant Section of the EP
3	Environmental impact assessment and approval 3.01 This principle applies to the assessment of an action that is likely to have a significant impact on the World Heritage values of a property (whether the action is to occur inside the property or not). 3.02 Before the action is taken, the likely impact of the action on the World Heritage values of the property should be assessed under a statutory environmental impact assessment and approval process. 3.03 The assessment process should: (a) identify the World Heritage values of the property that are likely to be affected by the action; and (b) examine how the World Heritage values of the property might be affected; and (c) provide for adequate opportunity for public consultation. 3.04 An action should not be approved if it would be inconsistent with the protection, conservation, presentation or transmission to future generations of the World Heritage values of the property. 3.05 Approval of the action should be subject to conditions that are necessary to ensure protection, conservation, presentation or transmission to future generations of the World Heritage values of the property. 3.06 The action should be monitored by the authority responsible for giving the approval (or another appropriate authority) and, if necessary, enforcement action should be taken to ensure compliance with the conditions of the approval.	3.01 and 3.02: Assessment of whether Petroleum Activity will have a significant impact on the World Heritage values of the Ningaloo World Heritage Property, including controls to manage any predicted impact is included in **Section 6**. Principles are met by the submitted EP. 3.03 (a) and (b): World Heritage values are identified in **Section 4** and considered in the assessment of impacts and risks for the Petroleum Activity in **Section 6**. 3.03 (c): Relevant stakeholder consultation and feedback received in relation to impacts and risks to the Ningaloo World Heritage Property are outlined in **Section 5**. 3.04, 3.05 and 3.06: Principles are considered to be met by the acceptance of this EP.

Note that Section 1 – General Principles and 2 – Management Planning of Schedule 5 are not considered relevant to the scope of this EP and, therefore, have not been included.

2. ENVIRONMENT PLAN PROCESS

2.1 Overview

This section outlines the process that Woodside follows to prepare the EP once an activity has been defined as a petroleum activity (refer to **Section 1.2**). The process (**Section 2.3**) describes the environmental risk management methodology that is used to identify, analyse and evaluate risks to meet ALARP and acceptability requirements and develop environmental performance outcomes and standards. This section also describes Woodside's risk management methodologies applicable to implementation strategies applied during the activity.

Regulation 13(5) of the Environment Regulations requires environmental impacts and risks to be detailed and evaluated appropriate to the nature and scale of each impact and risk associated with the Petroleum Activities Program. The objective of the risk assessment process described in this section is to identify risks and associated impacts of an activity, so they can be assessed, and appropriate control measures applied to eliminate, control or mitigate the impact/risk to ALARP and to determine if the impact or risk level is acceptable.

Environmental impacts and risks include those directly and indirectly associated with the Petroleum Activities Program and includes potential emergency and accidental events.

- Planned activities have the potential for inherent environmental impacts.
- An environmental risk is an unplanned event with the potential for impact (termed risk 'consequence').

Herein, potential impact from planned activities are termed 'impacts', and 'risks' are associated with unplanned events with the potential for impact (should the risk be realised), with such impact termed potential 'consequence'.

2.2 Environmental Risk Management Methodology

2.2.1 Woodside Risk Management Processes

Woodside recognises that risk is inherent to its business and effectively managing those risk is vital to delivering on company objectives, success and continued growth. Woodside is committed to managing all risks proactively and effectively. The objective of Woodside's risk management system is to provide a consistent process for recognising and managing risks across Woodside's business. Achieving this objective includes ensuring risks consider impacts across the following key areas of exposure: health and safety, environment, finance, reputation and brand, legal and compliance, and social and cultural. A copy of Woodside's Risk Management Policy is provided in **Appendix A**.

The environmental risk management methodology used in this EP is based on Woodside's Risk Management Procedure. This procedure aligns to industry standards such as international standard ISO 31000:2009. The WMS risk management procedures, guidelines and tools provide guidance on specific techniques for managing risk applying the Risk Management Procedure, tailored for particular areas of risk within certain business processes. Three such procedures applied for managing environmental risk include Woodside's:

- Health Safety and Environment Management Procedure
- Impact Assessment Procedure
- Process Safety Management Procedure.

The risk management methodology provides a framework to demonstrate that the identified risks and impacts are continually identified, reduced to ALARP and assessed to be at an acceptable level, as required by the Environment Regulations. The key steps of Woodside's Risk Management

Process are shown in **Figure 2-1**. A description of each step and how it is applied to the scopes of this activity is provided in **Section 2.1** to **Section 2.10**.

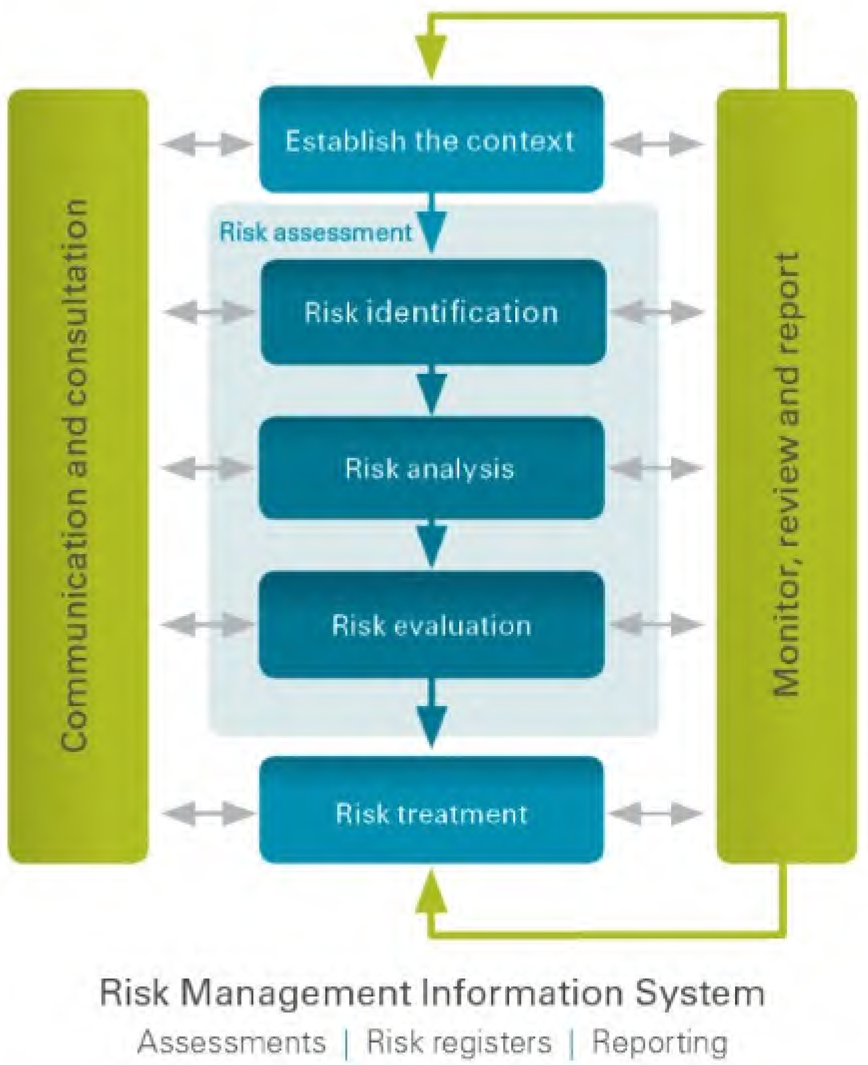

Figure 2-1: Woodside's risk management process

2.2.2 Health, Safety and Environment Management Procedure

Woodside's Health, Safety and Environment Management Procedure provides a structure for managing health, safety and environment (HSE) risks and impacts across Woodside and defines the decision authorities for company-wide HSE management activities and deliverables, and to support continuous improvement in HSE management.

2.2.3 Impact Assessment Procedure

To support effective environmental risk assessment, Woodside's Impact Assessment Procedure (**Figure 2-2**) provides the steps needed to meet required environment, health and social standards by ensuring impact assessments are performed appropriate to the nature and scale of the activity, the regulatory context, the receiving environment, interests, concerns and rights of stakeholders, and the applicable framework of standards and practices.

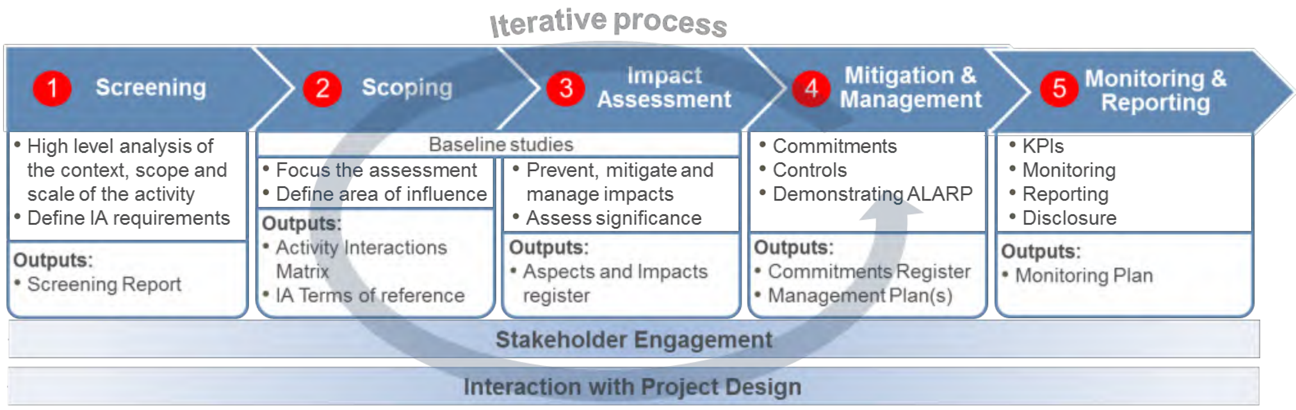

Figure 2-2: Woodside's impact assessment process

2.3 Environment Plan Process

Figure 2-3 illustrates the EP development process. Each element of this process is discussed in **Sections 2.4** to **2.10**.

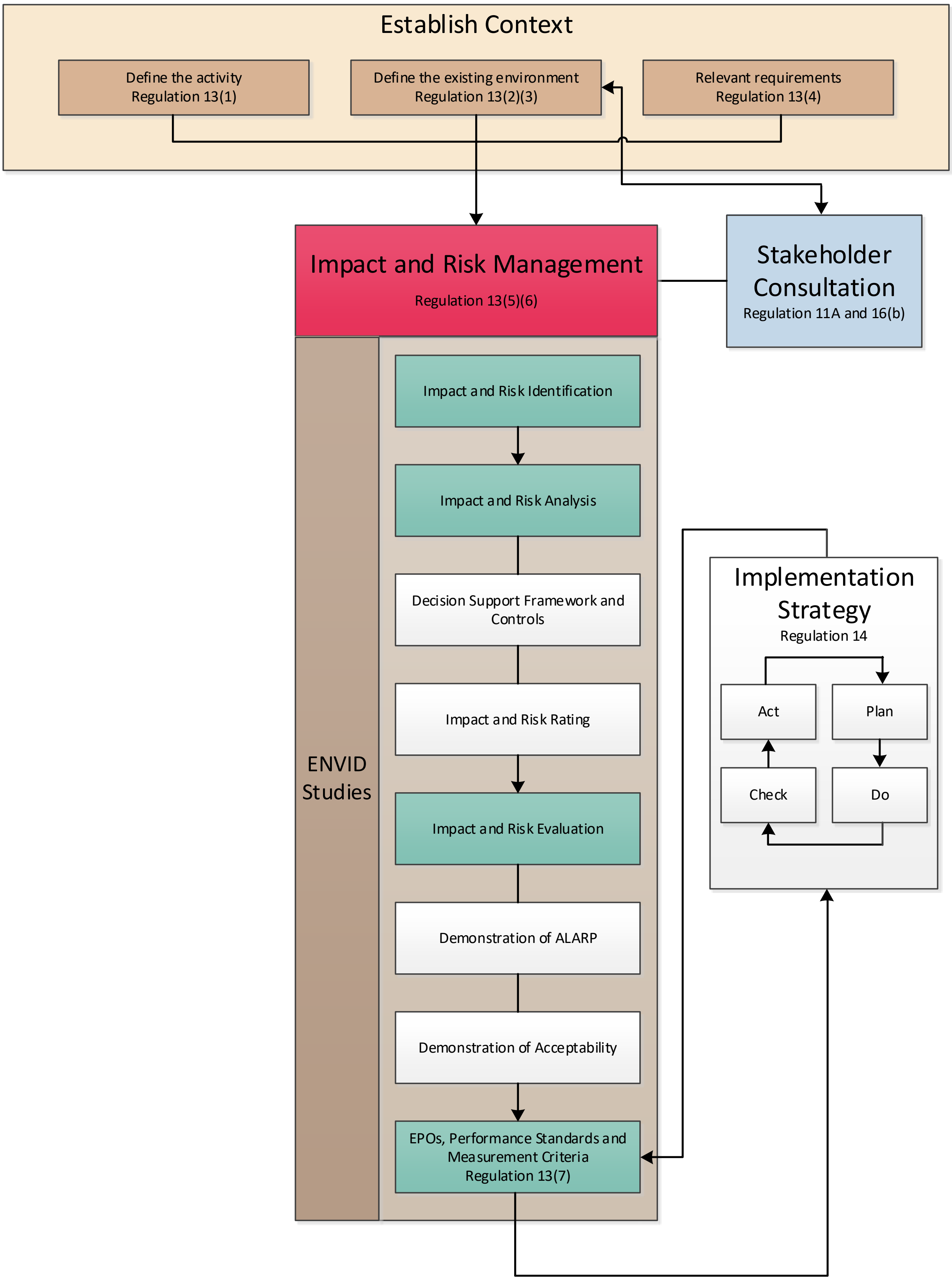

Figure 2-3: Environment plan development process

2.4 Establish the Context

2.4.1 Define the Activity

This first stage involves evaluating whether the activity meets the definition of a 'petroleum activity' as defined in the Environment Regulations.

The activity is then described in relation to:

- the location
- what is to be undertaken
- how it is planned to be undertaken, including outlining operational details of the activity, and proposed timeframes.

The 'what' and 'how' are described in the context of 'environmental aspects'[2] to inform the risk and impact assessment for planned (routine and non-routine) and unplanned (accidents/ incidents/ emergency conditions) activities.

The activity is described in **Section 3** and referred to as the Petroleum Activities Program.

2.4.2 Define the Existing Environment

The existing environment that may be impacted by the Petroleum Activities Program (as described in **Section 4**) is defined by considering the nature and scale of the activities (i.e. size, type, timing, duration, complexity and intensity). The existing environment may potentially be impacted directly or indirectly by planned and unplanned[3] events.

The existing environment section is structured into sub-sections defining the physical, biological, socio-economic and cultural attributes of the area of interest in accordance with the definition of 'environment' in Regulation 4(a) of the Environment Regulations. These sub-sections make particular reference to the following:

- The environmental values potentially impacted by the Petroleum Activities Program, which include key physical and biological attributes of the existing environment (as defined by Woodside in **Table 2-1** and **Section 4**).
- EPBC Act matters of national environmental significance (MNES) including listed Threatened species and ecological communities, and listed Migratory species. Defining the spatial extent of the existing environment is guided by the nature and scale of the Petroleum Activities Program within the Operational Area (planned activities) and the environment that may be affected (EMBA) by unplanned events. Potential impacts to MNES as defined within the EPBC Act are addressed through Woodside's impact and risk assessment process (**Section 2.2**).
- Relevant values and sensitivities, which may include world or national heritage listed areas, Ramsar wetlands, listed threatened species or ecological communities, listed migratory species, sensitive values that exist in, or in relation to commonwealth marine area or land.

[2] An environmental aspect is an element of the activity that can interact with the environment.

[3] The worst-case unplanned event is considered to be an unplanned hydrocarbon release, further defined for each activity through the risk assessment process. Interpretation of stochastic oil spill modelling determines the EMBA for the release, which defines the spatial scale of the environment that may be potentially impacted for the Petroleum Activities Program, which provides context to the 'nature and scale' of the existing environment.

In categorising the environmental values potentially impacted by the Petroleum Activities Program (as presented in **Table 2-1**), information is standardised relevant to the understanding of the receiving environment. Potential impacts to these environmental values are evaluated in the risk analysis (refer **Section 2.6**), and risk-rated for all planned and unplanned activities. This provides a robust approach to the overall environmental risk evaluation and its documentation in the EP.

Table 2-1: Environmental values potentially impacted by the Petroleum Activities Program which are assessed within the EP

Environmental Value Potentially Impacted *Regulations 13(2)(3)*						
Soil and Groundwater	***Marine Sediment***	***Water Quality***	***Air Quality (incl Odour)***	***Ecosystems/ Habitats***	***Species***	***Socio-Economic***

The existing environment is described in **Section 4**.

2.4.3 Relevant Requirements

The relevant requirements in the context of legislation, other environmental approval requirements, conditions and standards that apply to the Petroleum Activities Program are identified and reviewed.

Relevant requirements are presented in **Appendix B**.

Woodside's corporate Health, Safety, Environment and Quality Policy is presented in **Appendix A**.

2.5 Impact and Risk Identification

Relevant environmental aspects and hazards have been identified to support the process to define environmental impacts and risks associated with an activity.

The environmental impact and risk assessment presented in this EP has been informed by recent and historic hazard identification studies (e.g. HAZID/ENVID), process safety risk assessment processes, reviews and associated desktop studies associated with the Petroleum Activities Program. Risks are identified based on planned and potential interaction with the activity (based on the description in **Section 3** the existing environment (**Section 4**) and the outcomes of Woodside's stakeholder engagement process (**Section 5**). The environmental outputs of applicable risk and impact workshops and associated studies are referred to as ENVID hereafter in this EP.

The ENVID has been undertaken by multidisciplinary teams consisting of relevant engineering and environmental personnel with sufficient breadth of knowledge, training and experience to reasonably assure that risks were identified and their potential environmental impacts assessed. Impacts and risks were identified during the ENVID for both planned (routine and non-routine) activities and unplanned (accidents/incidents/emergency conditions) events. During this process risks that are identified as not applicable (not credible) are removed from the assessment. This is performed by defining the activity and identifying that an aspect is not applicable.

The impact and risk information is classified, evaluated and tabulated for each planned activity and unplanned event. Environmental impacts and risk are recorded in an environmental impacts and risk register. The output of the ENVID is used to present the risk assessment and forms the basis to develop performance outcomes, standards, and measurement criteria. This information is presented in **Section 5**), using the format presented in **Table 2-2**.

Table 2-2: Example of layout of identification of risks and impacts in relation to risk sources

Impacts and Risks Evaluation Summary													
Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***					
	Soil and Groundwater	***Marine Sediment***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitat***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence/Impact***	***Likelihood***	***Risk Rating***	***ALARP Tools***	***Acceptability***
Summary of source of impact/risk													

2.6 Impact and Risk Analysis

Risk analysis further develops the understanding of a risk by defining the impacts and assessing appropriate controls. Risk analysis considered previous risk assessments for similar activities, reviews of relevant studies, reviews of past performance, external stakeholder consultation feedback and review of the existing environment.

The key steps undertaken for each identified risk during the risk analysis were to:

- identify the decision type in accordance with the decision support framework
- identify appropriate control measures (preventative and mitigative) aligned with the decision type
- assess the risk rating.

2.6.1 Decision Support Framework

To support the risk assessment process, and Woodside's determination of acceptability (**Section 2.8**), Woodside's HSE risk management procedures include using a decision support framework based on principles set out in the Guidance on Risk Related Decision Making (Oil and Gas UK, 2014). This concept has been applied during the ENVID, or equivalent preceding processes during historical design decisions, to determine the level of supporting evidence that may be required to draw sound conclusions about risk level and whether the risk is acceptable and ALARP (**Table 2-4**). This is to confirm:

- activities do not pose an unacceptable environmental risk
- appropriate focus is placed on activities where the risk is anticipated to be acceptable and demonstrated to be ALARP
- appropriate effort is applied to manage risks based on the uncertainty of the risk, the complexity and risk rating (i.e. potential higher order environmental impacts are subject to further assessment).

The framework provides appropriate tools, commensurate to the level of uncertainty or novelty associated with the risk (referred to as Decision Type A, B or C). The decision type is selected based on an informed discussion around the uncertainty of the risk, and documented in ENVID worksheets.

This framework enables Woodside to appropriately understand a risk, determine if the risk is acceptable and can be demonstrated to be ALARP.

2.6.1.1 Decision Type A

Risks classified as a Decision Type A are well understood and established practice. They generally consider recognised good industry practice which is often embodied in legislation, codes and standards and use professional judgement.

2.6.1.2 Decision Type B

Risks classified as Decision Type B typically involve greater uncertainty and complexity (and can include potential higher order impacts/risks). These risks may deviate from established practice or have some lifecycle implications, and therefore require further engineering risk assessment to support the decision and ensure the risk is ALARP. Engineering risk assessment tools may include:

- risk-based tools such as cost based analysis or modelling
- consequence modelling
- reliability analysis
- company values.

2.6.1.3 Decision Type C

Risks classified as Decision Type C typically have significant risks related to environmental performance. Such risks typically involve greater complexity and uncertainty; therefore, requiring a precautionary approach. The risks may result in significant environmental impact, significant project risk/exposure or may elicit negative stakeholder concerns. For these risks, in addition to Decision Type A and B tools, company and societal values need to be considered by undertaking broader internal and external stakeholder consultation as part of the risk assessment process.

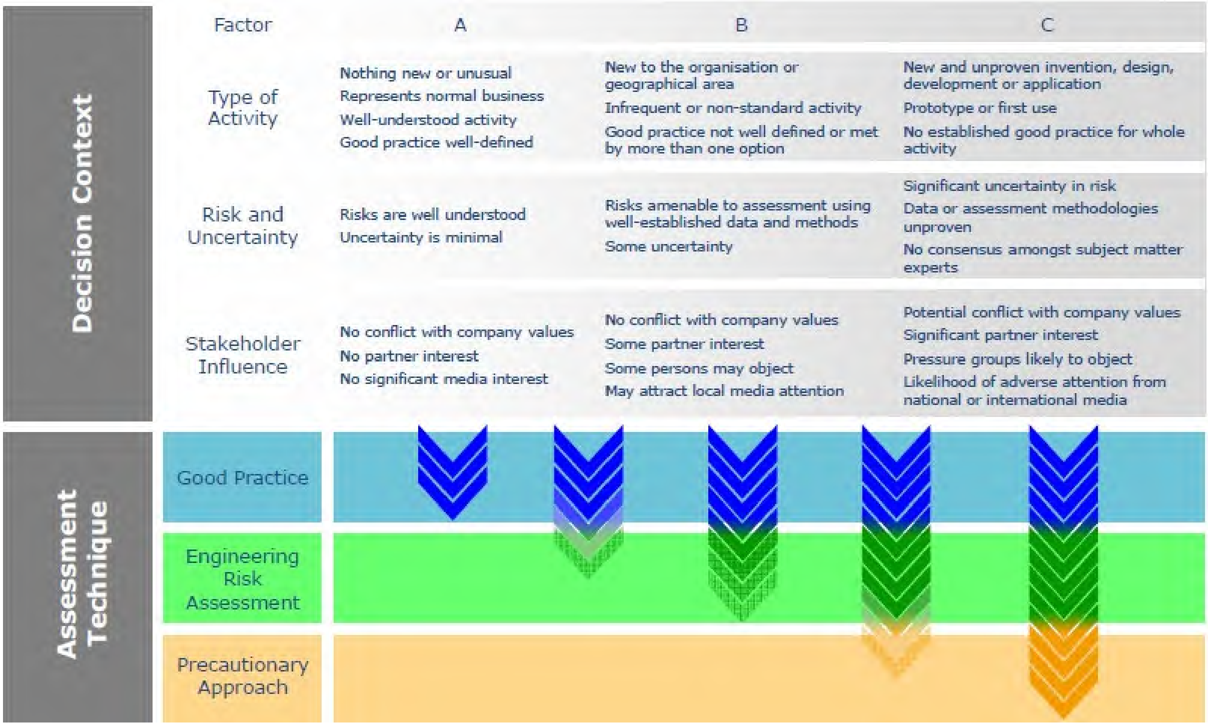

Figure 2-4: Risk-related decision-making framework (Oil and Gas UK, 2014)

2.6.1.4 Decision Support Framework Tools

The following framework tools are applied, as appropriate, to assist with identifying control measures based on the decision type described above:

- **Legislation, Codes and Standards (LCS)** identifies the requirements of legislation, codes and standards which are to be complied with for the activity.
- **Good Industry Practice (GP)** identifies further engineering control standards and guidelines which may be applied by Woodside above those required to meet the legislation, codes and standards.
- **Professional Judgement (PJ)** uses relevant personnel with the knowledge and experience to identify alternative controls. Woodside applies the hierarchy of control as part of the risk assessment to identify any alternative measures to control the risk.
- **Risk Based Analysis (RBA)** assesses the results of probabilistic analyses such as modelling, quantitative risk assessment and/or cost benefit analysis to support the selection of control measures identified during the risk assessment process.
- **Company Values (CV)** cites values detailed in Woodside's code of conduct and policies. Views, concerns and perceptions are to be considered from internal Woodside stakeholders directly affected by the planned impact or potential risk.
- **Societal Values (SV)** identifies the views, concerns and perceptions of relevant stakeholders and addresses relevant stakeholder views, concerns and perceptions.

2.6.1.5 Decision Calibration

To determine that the selected alternatives and control measures applied are suitable, the following tools may be used for calibration (i.e. checking) where required:

- **Legislation, Codes and Standards/Verification of Predictions** – verification of compliance with applicable legislation, codes and standards and/or good industry practice.
- **Peer Review** – independent peer review of professional judgements, supported by risk based analysis, where appropriate.
- **Benchmarking** – where appropriate, benchmarking against a similar facility or activity type or situation which has been accepted to represent acceptable risk.
- **Internal Stakeholder Consultation** – consultation undertaken within Woodside to inform the decision and verify company values are met.
- **External Stakeholder Consultation** – consultation undertaken to inform the decision and verify societal values are considered.

Where appropriate, additional calibration tools may be selected specific to the decision type and the activity.

2.6.2 Control Measures (Hierarchy of Controls)

Risk reduction measures should be prioritised and categorised in accordance with the hierarchy of controls, where risk reduction measures at the top of the hierarchy take precedence over risk reduction measures further down:

- **Elimination** of the risk by removing the hazard.
- **Substitution** of a hazard with a less hazardous one.

- **Engineering Controls** which include design measures to prevent or reduce the frequency of the risk event, detect or control the risk event (limiting the magnitude, intensity and duration) such as:

prevention: design measures that reduce the likelihood of a hazardous event occurring

detection: design measures that facilitate early detection of a hazardous event

control: design measures that limit the extent/escalation potential of a hazardous event

mitigation: design measures that protect the environment should a hazardous event occur

response equipment: design measures or safeguards that enable clean-up/response after a hazardous event occurs.

- **Procedures and Administration** which include management systems and work instructions used to prevent or mitigate environmental exposure to hazards.
- **Emergency Response and Contingency Planning** which includes methods to enable recovery from the impact of an event (e.g. protection barriers deployed near the sensitive receptor).

2.6.3 Impact and Risk Classification

Environmental impacts and risks are assessed to determine the potential impact significance/consequence. The impact significance/consequence considers the magnitude of the impact or risk and the sensitivity of the potentially impacted receptor (represented by **Figure 2-5**).

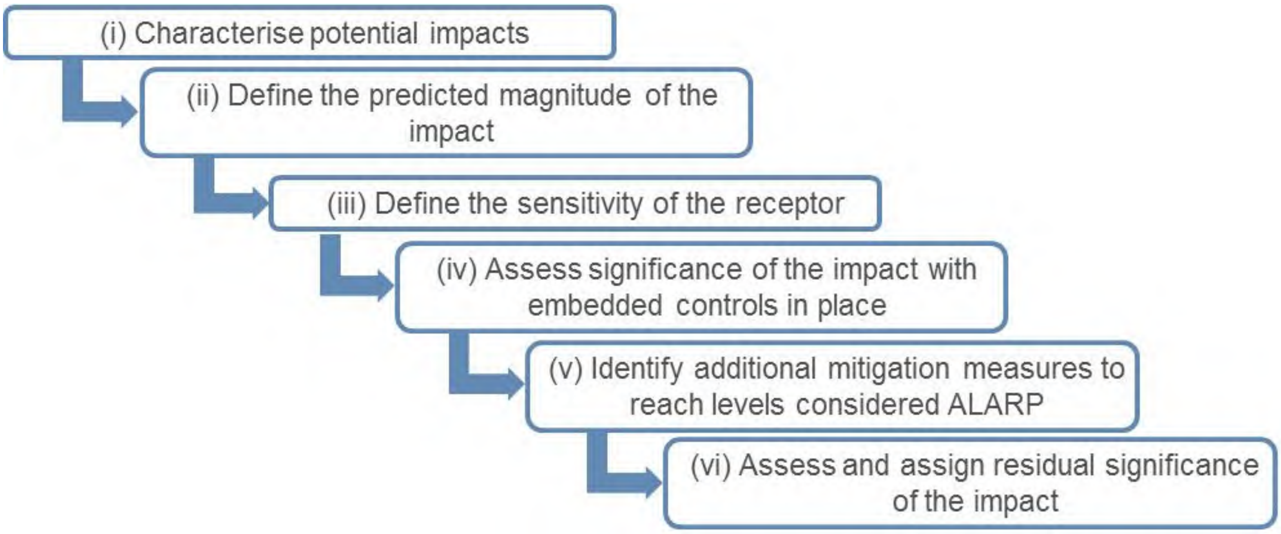

Figure 2-5: Environmental impact analysis

Impacts are classified in accordance with the consequence (**Section 2.3**) outlined in Woodside Risk Management Procedure and Risk Matrix.

Risks are assessed qualitatively and/or quantitatively in terms of both likelihood and consequence in accordance with the Woodside Risk Management Procedure and Risk Matrix.

The impact and risk information are summarised, including classification, and evaluation information as shown in the example (**Table 2-2**) for each planned activity and unplanned event evaluated.

Table 2-3: Woodside risk matrix (environment and social and cultural) consequence descriptions

Environment	Social & Cultural	Consequence Level
Catastrophic, long-term impact (>50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Catastrophic, long-term impact (>20 years) to a community, social infrastructure or highly valued areas/items of international cultural significance	***A***
Major, long term impact (10–50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	Major, long-term impact (5–20 years) to a community, social infrastructure or highly valued areas/items of national cultural significance	***B***
Moderate, medium-term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes	Moderate, medium term impact (2–5 years) to a community, social infrastructure or highly valued areas/items of national cultural significance	***C***
Minor, short-term impact (1–2 years) on species, habitat (but not affecting ecosystems function), physical or biological attributes	Minor, short-term impact (1–2 years) to a community or highly valued areas/items of cultural significance	***D***
Slight, short-term impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes	Slight, short-term impact (<1 year) to a community or areas/items of cultural significance	***E***
No lasting effect (<1 month). Localised impact not significant to environmental receptors	No lasting effect (<1 month). Localised impact not significant to areas/items of cultural significance	***F***

2.6.3.1 Risk Rating Process

The risk rating process is undertaken to assign a level of risk to each risk event, measured in terms of consequence and likelihood. The assigned risk level is therefore determined after identifying the decision type and appropriate control measures.

The risk rating process considers the potential environmental consequences and where applicable, the social and cultural consequences of the risk. The risk ratings are assigned using the Woodside Risk Matrix (refer to **Figure 2-6**).

The risk rating process is performed using the following steps:

Select the Consequence Level

Determine the worst case credible consequence associated with the selected event assuming all controls (preventative and mitigative) are absent or have failed (**Table 2-3**). Where more than one potential consequence applies, the highest severity consequence level is selected.

Select the Likelihood Level

Determine the description that best fits the chance of the selected consequence occurring, assuming reasonable effectiveness of the prevention and mitigation controls (**Table 2-4**).

Table 2-4: Woodside risk matrix likelihood levels

Likelihood Description						
Frequency	1 in 100,000–1,000,000 years	1 in 10,000–100,000 years	1 in 1000–10,000 years	1 in 100–1000 years	1 in 10–100 years	>1 in 10 years
Experience	**Remote**: Unheard of in the industry	**Highly Unlikely**: Has occurred once or twice in the industry	**Unlikely**: Has occurred many times in the industry but not at Woodside	**Possible**: Has occurred once or twice in Woodside or may possibly occur	**Likely**: Has occurred frequently at Woodside or is likely to occur	**Highly Likely**: Has occurred frequently at the location or is expected to occur
Likelihood Level	**0**	**1**	**2**	**3**	**4**	**5**

Calculate the Risk Rating

The risk level is derived from the consequence and likelihood levels determined above in accordance with the risk matrix shown in **Figure 2-6**. A likelihood and risk rating is only applied to environmental risks using the Woodside Risk Matrix.

This risk level is used as an input into the risk evaluation process and ultimately for prioritising further risk reduction measures. Once each risk is treated to ALARP, the risk rating articulates the ALARP baseline risk as an output of the ENVID studies.

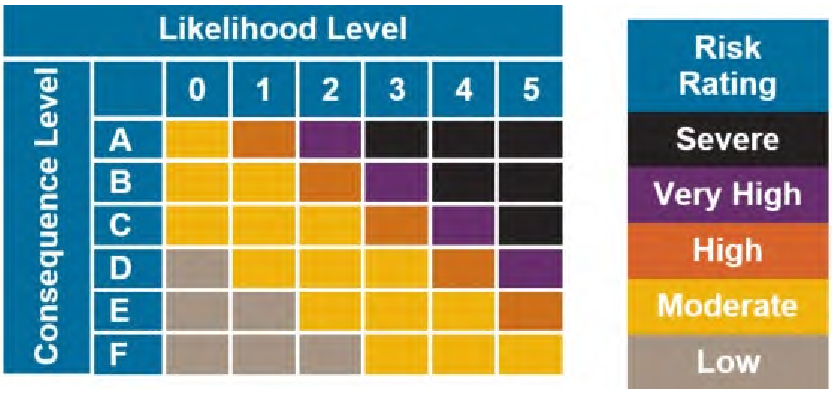

Figure 2-6: Woodside risk matrix: risk level

In support of ongoing risk management (as a key component of Woodside's Process Safety Management Framework – refer to Implementation Strategy (**Section 7**), Woodside uses the concept of 'current risk' and applies a current risk rating to indicate the current or 'live' level of risk, considering controls that are currently in place and regularly effective. Risk classification is effective in articulating potential divergence from baseline risk, such as if certain controls fail or could potentially be compromised. Current risk ratings aid the communication and visibility of the risk events, and ensures risk is continually managed to ALARP by identifying risk reduction measures and assessing acceptability.

2.7 Impact and Risk Evaluation

Environmental impacts and risks cover a wider range of issues, affected by differing species, persistence, reversibility, resilience, cumulative effects and variability in severity. Determining the degree of environmental risk and the corresponding threshold for whether a risk/impact has been reduced to ALARP and is acceptable, is evaluated to a level appropriate to the nature and scale of each impact or risk. The evaluation considers:

- the Decision Type
- the Principles of Ecologically Sustainable Development as defined under the EPBC Act
- the internal context – the proposed controls and risk level are consistent with Woodside policies, procedures and standards (**Section 5** and **Appendix A**)
- the external context – the environment consequence (**Section 6**) and stakeholder acceptability (**Section 5**) are considered
- other requirements – the proposed controls and risk level are consistent with national and international standards, laws and policies.

In accordance with Regulation 10A(a), 10A(b) and 10A(c), and 13(5)(b) of the Environment Regulations, Woodside applies the following process to demonstrate ALARP and acceptability for environmental impacts and risks appropriate to the nature and scale of each impact or risk.

2.7.1 Demonstration of ALARP

Descriptions have been provided in **Table 2-5** to articulate how Woodside demonstrates that different risks, impacts and Decision Types identified within the EP are ALARP.

Table 2-5: Summary of Woodside's criteria for demonstrating ALARP

Risk	Impact	Decision Type
Low and Moderate	***Negligible, Slight or Minor (D, E or F)***	***A***
Woodside demonstrates these lower order risks, impacts and decision types are reduced to ALARP if: • controls identified meet legislative requirements, industry codes and standards, applicable company requirements and industry guidelines • further effort towards impact/risk reduction (beyond employing opportunistic measures) is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained.		
High, Very High or Severe	***Moderate and above (A, B or C)***	***B and C***
Woodside demonstrates these higher order risks, impacts and decision types are reduced to ALARP (where it can be demonstrated using good industry practice and risk based analysis) if: • legislative requirements, industry codes and standards, applicable company requirements and industry guidelines are met • societal concerns are accounted for • the alternative control measures considered are grossly disproportionate to the benefit gained.		

2.7.2 Demonstration of Acceptability

Descriptions have been provided in **Table 2-6** to articulate how Woodside demonstrates that different risks and impacts identified within the EP are of an Acceptable level appropriate to Decision Type and level of predicted risk or impact. This process aligns with NOPSEMA's Environment Plan Decision Making Guideline (GL1721 Rev 5, June 2018).

Table 2-6: Summary of Woodside's criteria for Acceptability

Risk	Impact	Decision Type
Low and Moderate	***Negligible, Slight or Minor (D, E or F)***	***A***
Woodside demonstrates these lower order Risks, Impacts and Decision Types are 'Broadly Acceptable' if they meet: • legislative requirements		

• industry codes and standards • applicable company requirements and industry guidelines. Further effort towards reducing risk (beyond employing opportunistic measures) is not reasonably practicable without sacrifices grossly disproportionate to the benefit gained.		
High, Very High or Severe	***Moderate and above (A, B or C)***	***B and C***
Woodside demonstrates these higher order risks, impacts and decision types are 'Acceptable' if it can be demonstrated that the predicted levels of impact and/or residual risk, are: • at or below the defined acceptable level(s) for that impact or risk, and • managed to ALARP (as described in **Section 2.7.1**). Acceptable levels are defined appropriate to the nature and scale of each impact and risk and in consideration of the following criteria: • the Principles of Ecological Sustainable Development (ESD) as defined under the EPBC Act • the internal context – the proposed controls and consequence/risk level are consistent with Woodside policies, procedures and standards • the external context – consideration of the environment consequence (**Section 6**) and stakeholder acceptability (**Section 5**) • other requirements – the proposed controls and consequence/ risk level are consistent with national and international industry standards, laws and policies, and consideration of applicable plans for management and conservation advices, conventions, and significant impact guidelines (e.g. for MNES). Once acceptable levels have been defined, a statement of acceptability is made to summarise how a given impact/residual risk will be managed to at or below these levels and appropriate EPOs which are linked to these acceptable levels are established. For potential C or above consequence/impact levels where significant uncertainty exists in analysis of the risk or impact (such as, for predicted or potential high risk of significant environmental impacts, significant project risk/exposure, novel activities, lack of consensus on standards, and significant stakeholder concerns. E.g. Decision Type C), defined acceptable levels and assessment of acceptability may be required to be conducted separately for key receptors. Additionally, Very High and Severe risks require 'Escalated Investigation' and mitigation to reduce the risk to a lower and more acceptable level. If after further investigation the risk remains in the Very High or Severe category, the risk requires appropriate business engagement in accordance with Woodside's Risk Management Procedure to accept the risk. This includes due consideration of regulatory requirements.		

2.8 Environmental Performance Objectives/Outcomes, Standards and Measurement Criteria

Environmental performance objectives/outcomes, standards, and measurement criteria are defined to address the potential environmental impacts and risks and are explored in **Section 5**.

2.9 Implementation, Monitoring, Review and Reporting

An implementation strategy for the Petroleum Activities Program describes the specific measures and arrangements to be implemented for the duration of the Petroleum Activities Program. The implementation strategy is based on the principles of AS/NZS ISO 14001: Environmental Management Systems, and demonstrates:

- control measures are effective in reducing the environmental impacts and risks of the Petroleum Activities Program to ALARP and acceptable levels
- environmental performance outcomes and standards set out in the EP are met, through monitoring, recording, audit, management of non-conformance and review
- all environmental impacts and risks of the Petroleum Activities Program are periodically reviewed in accordance with Woodside's risk management procedures

- roles and responsibilities are clearly defined, and personnel are competent and appropriately trained to implement the requirements set out in this EP, including in actual or potential emergencies
- arrangements are in place for oil pollution emergencies to respond to, and monitor impacts
- environmental reporting requirements, including ‘reportable incidents’
- appropriate stakeholder consultation is undertaken throughout the activity.

The implementation strategy is presented in **Section 7**.

2.10 Stakeholder Consultation

A stakeholder assessment is performed to identify relevant persons (as defined under Regulation 11A of the Environment Regulations) to whom an activity update is issued electronically to provide a reasonable consultation period. Further details and information are provided to any stakeholder if requested.

A summary and assessment of each stakeholder response is performed and a response, where appropriate, is provided by Woodside.

The stakeholder consultation, along with the process for ongoing engagement and consultation throughout the activity, is presented in **Section 5**.

3. DESCRIPTION OF THE ACTIVITY

3.1 Overview

This section has been prepared in accordance with Regulation 13(1) of the Environment Regulations, and describes the activities to be performed as part of the Petroleum Activities Program under this EP.

3.2 Project Overview

The proposed Petroleum Activities Program comprises six 4D seismic surveys that will be acquired in different areas of the Northern Carnarvon Basin, ranging from:

- a pre-development high definition 4D Baseline survey – Scarborough 4D B1
- First Monitor surveys – Harmony 4D M1, Cimatti 4D M1 and Laverda 4D M1
- Second Monitor surveys – Pluto 4D M2 and Vincent 4D M2.

Table 3-1 provides an overview of the key characteristics for all six surveys. The commencement of the activities is subject to approvals, vessel availability and weather constraints.

3.3 Purpose of the Activity

The objective for the Petroleum Activities Program is to conduct a series of marine seismic surveys as part of a reservoir management and surveillance program. The surveys will acquire time lapse data that will be used to review subtle changes of fluid movement and gas pressure saturation in the various oil and gas reservoirs, caused by hydrocarbon being depleted through production. To obtain these time lapse images, the seismic surveys will follow as accurately as possible the sail lines acquired by previous surveys:

- Pluto 4D M2 – Pluto 4D M1/B1 MSS, acquired in 2015
- Harmony 4D M1 (Brunello field) – Harmony 3D MSS, acquired in 2014
- Scarborough 4D B1 – HEX-003 3D MSS (WA-1-R and WA-346-P), acquired in 2004
- Laverda 4D M1 – Laverda 4D MSS, acquired in 2010
- Cimatti 4D M1 – Cimatti/Enfield 4D MSS, acquired in 2010
- Vincent 4D M2 – Vincent 3D MSS, acquired in 2010.

The objective of the Scarborough 4D B1 survey is to provide an uplift in seismic imaging for the Scarborough field from the 2004 vintage seismic data.

Table 3-1: Petroleum Activities Program overview

Item	Description					
	Area A		Area B	Area C		
	Pluto 4D M2	Harmony 4D M1 (Brunello Field)	Scarborough 4D Baseline B1	Laverda 4D M1	Cimatti 4D M1	Vincent 4D M2
Petroleum Titles	WA-34-L	WA-49-L	W-1-R, WA-62-R	WA-28-L, WA-59-L	WA-28-L, WA-59-L	WA-28-L, WA-59-L
Location	North Carnarvon Basin, Exmouth Plateau	North Carnarvon Basin, Exmouth Plateau	North Carnarvon Basin	North Carnarvon Basin, Exmouth Sub-basin	North Carnarvon Basin, Exmouth Sub-basin	North Carnarvon Basin, Exmouth Sub-basin
Acquisition Area	780 km²	469 km²	2,059 km²	144 km²	87 km²	82 km²
Operational Area	3710 km²	2419 km²	5597 km²	1730 km²	1514 km²	1655 km²
Water Depths in Acquisition Area	73–1185 m	73–475 m	806–1113 m	653–895 m	483–687 m	299–558 m
Vessels	Three – one seismic acquisition vessel, one support vessel and one chase vessel.				Four – two seismic acquisition vessels (one source, one streamer), one support vessel and one chase vessel.	

3.4 Location

The six proposed surveys will be performed within three separate geographical areas, which are located in Commonwealth waters in North West Australia (denoted as polygons in **Figure 3-1**). **Table 3-2** provides the boundary coordinates for the three polygons (Areas A, B and C).

Table 3-2: Boundary coordinates for Areas A, B and C

Location Point (GDA94 Degrees Minutes Seconds)	Latitude	Longitude
Area A		
1	19°34'12.462"S	114°56'01.581"E
2	20°00'11.867"S	114°51'27.323"E
3	20°18'50.759"S	114°51'27.693"E
4	20°19'02.669"S	115°08'49.012"E
5	20°15'53.34"S	115°15'55.885"E
6	20°02'46.041"S	115°26'26.19"E
7	19°34'30.004"S	115°24'54.989"E
Area B		
1	19°23'08.078"S	113°10'55.817"E
2	19°31'10.437"S	112°58'49.251"E
3	20°04'07.021"S	112°41'50.389"E
4	20°14'43.528"S	113°05'50.122"E
5	20°06'02.861"S	113°23'11.159"E
6	19°35'25.579"S	113°39'22.485"E
Area C		
1	21°12'56.728"S	113°53'22.29"E
2	21°14'36.163"S	113°50'07.552"E
3	21°34'15.584"S	113°34'45.671"E
4	21°45'09.125"S	113°50'40.635"E
5	21°38'50.382"S	113°59'41.557"E
6	21°38'50.404"S	114°03’34.498”E
7	21°36'39.398"S	114°10'00.916"E
8	21°16'24.460"S	114°20'31.456"E

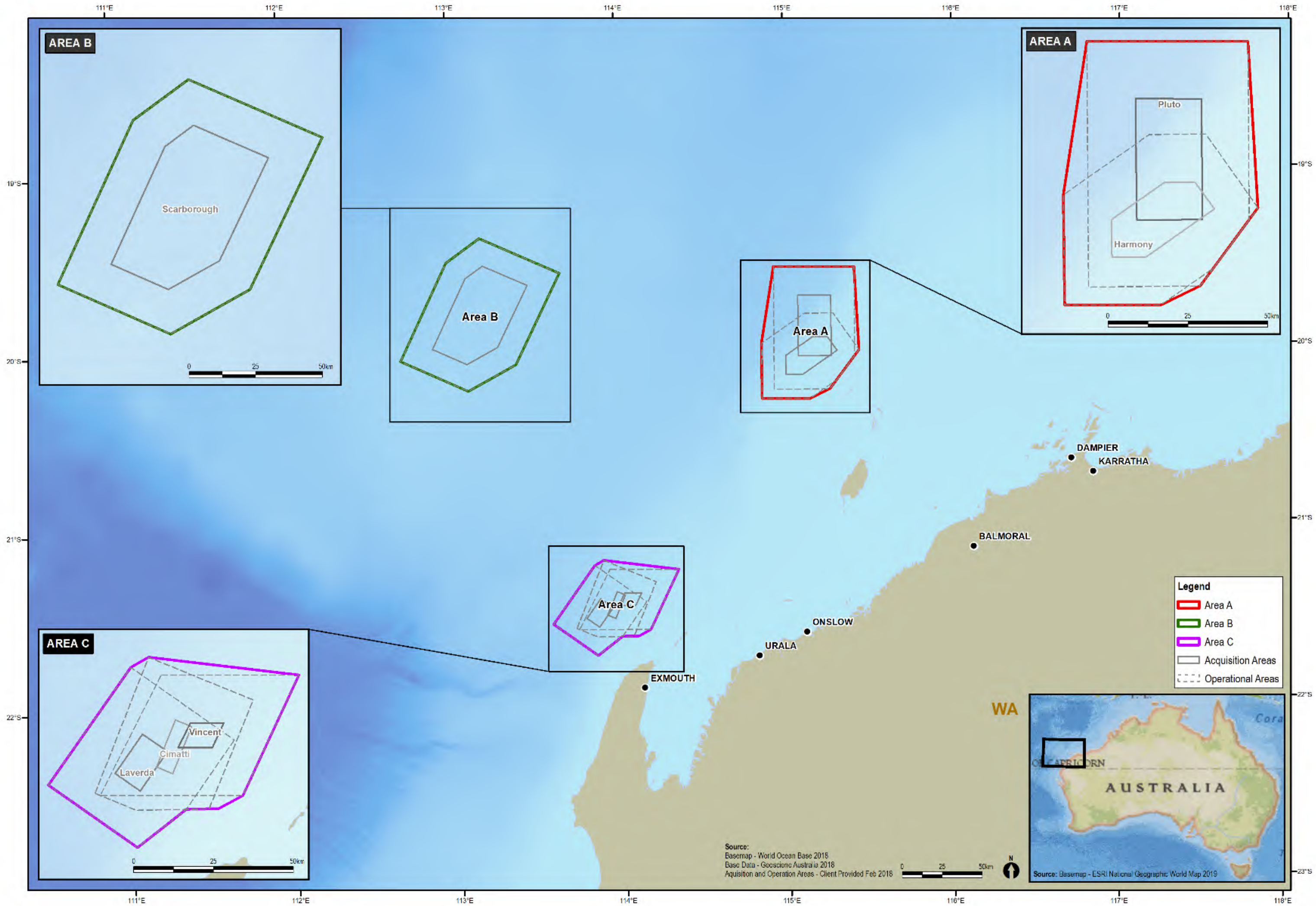

Figure 3-1: Location of Areas A, B and C

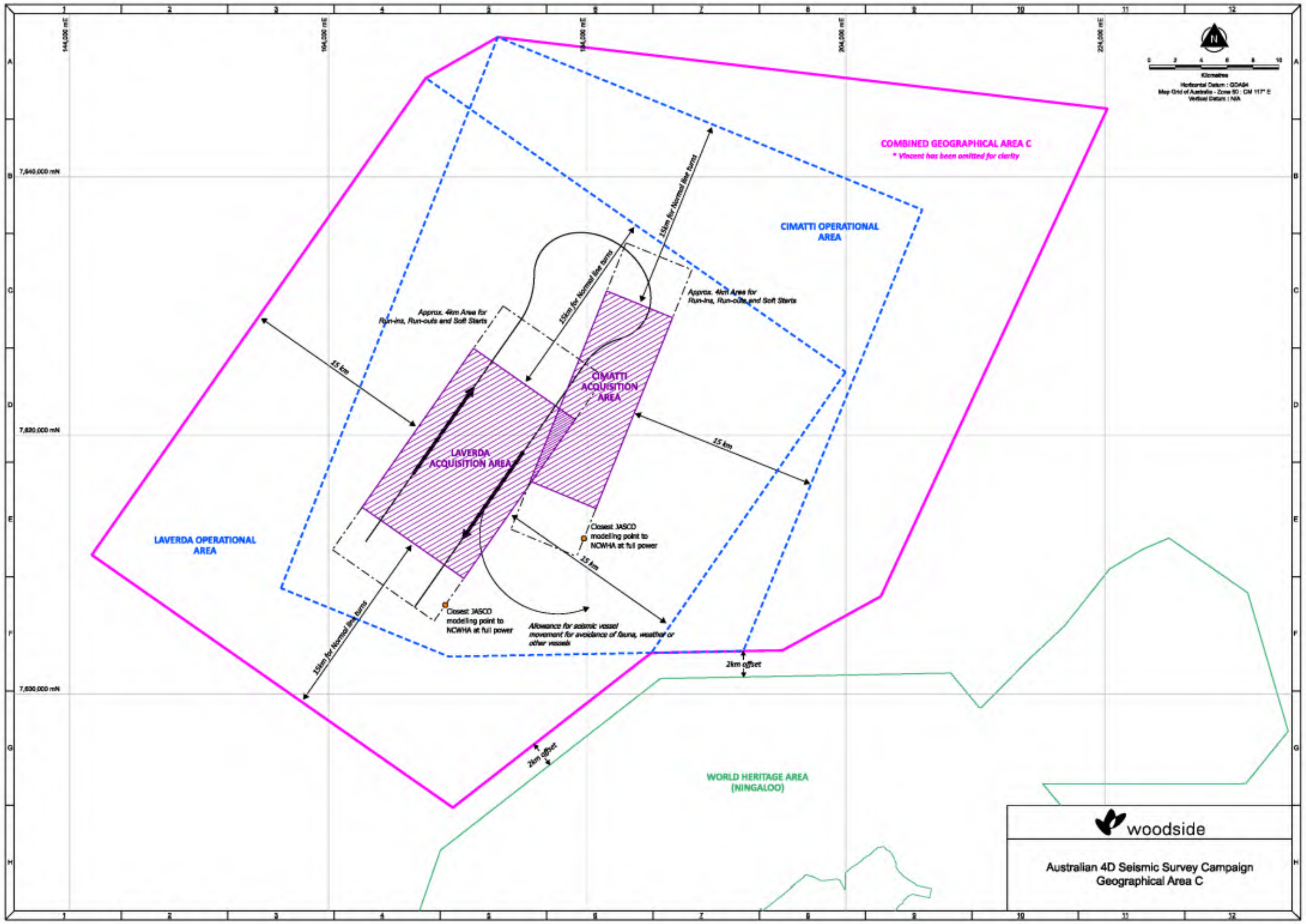

Figure 3-2: Laverda and Cimatti Operational Areas and Acquisition Areas in Area C. Note that NCWHA refers to the Ningaloo Coast WHA in the figure.

3.4.1 Area A

Area A, which encompasses the Operational Areas for the Pluto 4D M2 and Harmony 4D M1 (Brunello field) surveys, is located in the North Carnarvon Basin, Exmouth Plateau, approximately: 28 km north-west of the Montebello Islands; 17 km west of Rankin Bank; 148 km north-west of Dampier; and 150 km north-northeast of the Ningaloo Coast World Heritage Area (WHA). The south-east portion of Area A extends into the Montebello Marine Park Multiple Use Zone (**Figure 4-22**). The Montebello Marine Park is described in **Section 4.7.1**.

3.4.2 Area B

Area B, which encompasses the Operational Area for the Scarborough 4D B1 survey, is located in the North Carnarvon Basin, approximately: 217 km west-northwest of the Montebello Islands and Barrow Island; 204 km north-west of North West Cape; 248 km north-west of Onslow; and 185 km north-northeast of the Ningaloo Coast WHA. The southern corner of Area B is located about 50 km from the boundary of the Gascoyne Marine Park (**Figure 4-22**), described in **Section 4.7.2**.

3.4.3 Area C

Area C, which encompasses the Operational Areas for the Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys, is located in the North Carnarvon Basin, Exmouth Sub-basin, approximately: 110 km west-southwest of Barrow Island; 17 km north-west of North West Cape; 90 km west-northwest of Onslow; and 2 km from the boundary of the Ningaloo Coast WHA. Part of the south-east boundary of Area C is 2 km from the boundary of the Recreational Use Zone of the Ningaloo Marine Park and the south-western portion of Area C extends into the Gascoyne Marine Park Multiple Use Zone (**Figure 4-22**). These are described in **Section 4.7.2**.

3.4.4 Operational Areas

The Operational Areas for the six seismic surveys define the spatial boundaries of the Petroleum Activities Program, as described, risk-assessed and managed by this EP.

For the purposes of this EP, the following polygons will apply:

- Acquisition Areas for each survey (i.e. the area within which seismic acoustic emissions will occur for the purposes of acquiring data). The extent of the Acquisition Area for each survey is described in **Table 3-1**. Source testing (i.e. bubble tests) will occur within the Acquisition Areas for each survey.
- Operational Areas for each survey, including the Acquisition Area and a buffer (about 15 km wide) surrounding each Acquisition Area for the purpose of line turns, run-ins, run-outs and soft starts. For Area C, the Operational Areas for Laverda and Cimatti have been reduced to allow for a 2 km buffer between each survey Operational Area and the Ningaloo Coast WHA. The seismic source may be discharged at or below full capacity (power) within an approximately 4 km buffer extension to each Acquisition Area along the axes of the planned line turns for the purpose of run-ins, run-outs and soft starts (See **Table 3-4** for line orientation of each survey). The seismic source will not be discharged within the Operational Area outside this approximate 4 km buffer. The remaining approximately 11 km of the Operational Area is required for conducting line turns. The seismic source will not be discharged during line turns.

Figure 3-2 provides a graphical presentation of the above areas using Laverda and Cimatti surveys within Area C as an example, including specifying where the seismic source may be discharged within these areas and for what purpose.

The seismic vessel will be surrounded by a Safe Navigation Area (SNA). The SNA will extend to a radius of 500 m around the seismic vessel and towed equipment. The support and chase vessels will be used to ensure third party vessels are prevented from approaching or entering the SNA.

Boundary coordinates for the proposed Acquisition and Operational Areas are presented in **Table 3-3** and **Figure 3-1**. Note that geographical areas (Area A, Area B and Area C in **Figure 3-1**) have been defined for the purpose of conducting searches for identification of relevant environmental receptors (e.g. EPBC Protected Matters searches) and to support impact and risk assessment. These areas represent the combined Operational Areas for the planned seismic surveys within them.

Table 3-3: Indicative boundary coordinates for the Petroleum Activities Program Acquisition and Operational Areas

Location Point (GDA94 Degrees Minutes Seconds)	Latitude	Longitude
Pluto 4D M2		
Acquisition Area[1]		
a	19°44’02.451”S	115°04’37.853”E
b	20°04’37.104”S	115°04’37.946”E
c	20°04’39.019”S	115°16’23.684”E
d	19°44’11.842”S	115°16’28.804”E
Operational Area		
A	19°34’12.462”S	114°56’01.581”E
B	20°15’52.579”S	114°55’47.206”E
C	20°15’53.34”S	115°15’55.885”E
D	20°04’49.005”S	115°24’48.265”E
E	19°34’30.004”S	115°24’54.989”E
Harmony 4D M1 (Brunello field)		
Acquisition Area[1]		
a	20°10’49.14”S	115°00’04.08”E
b	20°10’53.22”S	115°06’11.94”E
c	20°02’52.542”S	115°18’35.669”E
d	19°58’18.234”S	115°15’08.425”E
e	19°58’17.94”S	115°09’38.28”E
f	20°04’29.34”S	115°00’03.6”E
Operational Area		
A	20°18’50.759”S	114°51’27.693”E
B	20°19’02.669”S	115°08’49.012”E
C	20°12’54.185”S	115°18’19.64”E
D	20°02’46.041”S	115°26’26.19”E
E	19°50’10.497”S	115°17’11.51”E
F	19°50’09.988”S	115°06’59.017”E
G	20°00’11.867”S	114°51’27.323”E

Location Point (GDA94 Degrees Minutes Seconds)	Latitude	Longitude
Scarborough 4D B1		
Acquisition Area[1]		
a	19°32’26.998”S	113°11’49.708”E
f	19°36’37.046”S	113°05’32.964”E
e	20°00’16.217”S	112°53’23.022”E
d	20°05’39.844”S	113°05’35.852”E
c	20°00’05.432”S	113°16’44.265”E
b	19°39’19.852”S	113°27’44.143”E
Operational Area		
A	19°23’08.078”S	113°10’55.817”E
F	19°31’10.437”S	112°58’49.251”E
E	20°04’07.021”S	112°41’50.389”E
D	20°14’43.528”S	113°05’50.122”E
C	20°06’02.861”S	113°23’11.159”E
B	19°35’25.579”S	113°39’22.485”E
Laverda 4D M1		
Acquisition Area[1]		
a	21°29'00.941"S	113°56’29.805”E
b	21°35'34.453"S	113°51’22.652”E
c	21°32'30.412"S	113°46’53.538”E
d	21°25'57.047"S	113°52’00.747”E
Operational Area		
A	21°27’14.119”S	114°08’37.184”E
B	21°38’50.383”S	113°59’41.557”E
C	21°45’09.125”S	113°50’40.635”E
D	21°34’15.584”S	113°34’45.671”E
E	21°14’36.163”S	113°50’07.567”E
Cimatti 4D M1		
Acquisition Area[1]		
a	21°31’33.609”S	113°54’25.865”E
b	21°23’39.518”S	113°58’00.971”E
c	21°24’50.059”S	114°00’56.251”E
d	21°32’45.166”S	113°57’20.863”E

Location Point (GDA94 Degrees Minutes Seconds)	Latitude	Longitude
Operational Area		
A	21°20’30.219”S	114°12’10.456”E
B	21°38’50.404”S	114°03’48.842”E
C	21°38’49.975”S	113°50’37.935”E
D	21°35’49.141”S	113°43’11.334”E
E	21°12’56.728”S	113°53’22.290”E
Vincent 4D M2		
Acquisition Area[1]		
a	21°24’12.065”S	114°00’45.066”E
b	21°28’19.742”S	113°58’24.633”E
c	21°28’26.392”S	114°04’38.121”E
d	21°24’18.387”S	114°06’47.17”E
Operational Area		
A	21°15’59.095”S	113°55’35.52”E
B	21°36’11.445"S	113°44’06.422”E
C	21°36’39.398”S	114°10’00.916”E
D	21°16’24.46”S	114°20’31.456”E

[1] The final Acquisition Areas may be subject to slight modifications as the survey scopes become better defined; however, no changes will exceed the Operational Areas as defined in this EP.

3.5 Timing

The first survey (Pluto 4D M2) is planned to commence in late December 2019 (Q4), notionally followed by Harmony 4D M1 (Brunello field), Scarborough 4D B1, Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 (**Table 3-4**). The planned duration of each survey is:

- Pluto 4D M2 (Area A) – 30 days
- Harmony 4D M1 (Area A) – 28 days
- Laverda 4D M1 (Area C) – 27 days
- Cimatti 4D M1 (Area C) – 10 days
- Vincent 4D M2 (Area C) – 9 days
- Scarborough 4D B1 (Area B) – 45 days.

It is anticipated that acquisition will start in late December 2019 (Quarter 4) or early 2020 (Quarter 1) and be concluded in Areas A and C by May 2020 and Area B by July 2020. This is subject to the EP acceptance timeline, vessel availability, operational constraints and prevailing weather conditions. Hence, the overall campaign is expected to have a duration of six to seven months.

3.6 Activity Components

3.6.1 Survey Method

The marine seismic surveys proposed are typical seismic surveys similar to most others conducted in Australian marine waters (in terms of technical methods and procedures). No unique or unusual equipment or operations are proposed. The surveys will be conducted using purpose-built seismic vessels.

During the proposed activities, the survey vessel will traverse a series of pre-determined sail lines within each survey Acquisition Area at a speed of about 7-9 km/hr. The survey lines have been defined based on the lines acquired during past surveys over each field, and survey optimisation considerations. As the vessel travels along the survey lines, a series of noise pulses (approximately every six to ten seconds depending on shot point interval) will be directed down through the water column and seabed. The released sound is attenuated and reflected at geological boundaries and the reflected signals are detected using sensitive microphones, arranged along a number of hydrophone cables (streamers) towed behind the survey vessel. The reflected sound is then processed to provide information about the structure and composition of geological formations below the seabed. A summary of the seismic survey parameters is provided in **Table 3-4**.

3.6.2 Seismic Source

As with conventional marine seismic surveys, the proposed Petroleum Activities Program plans to use a seismic source array within the Acquisition Area for each survey, consisting of several air-powered sources to generate acoustic pulses by periodically discharging compressed air into the water column. Energy from these pulses reflects from the boundaries between geological layers in the sub-surface; the reflected energy of seismic traces is recorded by a series of receivers located in the towed streamers.

The seismic source will comprise an airgun array with a volume ranging from 2650 cubic inches (in^3) to 3150 in^3 (refer **Table 3-4**) with an operating pressure of about 13,800 kPa (2000 psi). The array configuration and capacity that will be used for each survey is determined by the characteristics of the arrays previously used for either 4D or 3D data acquisition over each field. In other words, the survey parameters have to match those previously used as closely as possible, to provide for time lapse images that are comparable with each other.

To obtain accurate time lapse data, sail lines will follow as accurately as possible the sail lines acquired during the previous 4D surveys over the Pluto, Brunello (Harmony 4D M1), Laverda, Cimatti and Vincent fields. The proposed Scarborough survey will be a new 4D baseline, acquired based on a new sail line plan (refer to **Section 3.3**). Measuring subtle changes in the 4D signals requires very accurate positioning of the acoustic source (shot point) and streamers (receiver points). To allow increased accuracy in future 4D seismic analysis, additional lines may also be executed within the Acquisition Areas for each survey. These additional lines will be acquired in exactly the same way as the current 4D requirements (e.g. line orientation, streamer length).

The source array will be towed at a depth of 6–8 m (±1 m). The source arrays will be fired alternately with a shot point interval ranging between 12.5 to 18.75 m horizontal distance (refer **Table 3-4**). Five of the six surveys will use a dual source configuration ('flip-flop' discharge), while the Scarborough 4D B1 survey will use a triple source configuration ('flip-flop-flap' discharge).

The 3150 in^3 and 2650 in^3 seismic sources produce far-field source levels up to a maximum of 255 dB re 1 μPa^2m^2 (PK) and per-pulse source sound exposure levels (SEL) of 229–230 dB re 1 μPa^2m^2 (at 0–2000 Hz) directly beneath the array.

Table 3-4: Survey acquisition parameters

	Parameter	Pluto 4D M2	Harmony 4D M1 (Brunello field)	Scarborough 4D B1	Laverda 4D M1	Cimatti 4D M1	Vincent 4D M2
General parameters	Acquisition Area	780 km²	469 km²	2059 km²	144 km²	87 km²	82 km²
	Operational Area	3710 km²	2419 km²	5597 km²	1730 km²	1514 km²	1655 km²
	Max. sail line length	~38 km	~35 km	~60 km	~15 km	~16 km	~11 km
	Line separation (nominal)	300 m	250 m	450 m	150 m	200 m	200 m
	Line Orientation	0° / 180° North - South	55° / 235° North East - South West	25° / 205° North East - South West	35° / 215° North East - South West	22° / 202° North East - South West	90° / 270° East - West
	Water depths in Acquistion Area	73–1185 m	73–475 m	806–1113 m	653–895 m	483–687 m	299–558 m
	Acquisition period[1]	Q4 2019 to Q1 2020	Q4 2019 to Q1 2020	Q1 2020 to Q3 2020	Q1 2020 to Q2 2020	Q1 2020 to Q2 2020	Q1 2020 to Q2 2020
	Planned survey duration[1]	28 days	20–28 days	45 days	23 days	11 days	12–13 days
Acoustic emissions	Source configuration	Dual source (flip/flop)	Dual source (flip/flop)	Triple source (flip/flop/flap)	Dual source (flip/flop)	Dual source (flip/flop)	Dual source (flip/flop)
	Airgun array capacity (approximate)	3150 in³	3090 in³	3150 in³	2650 cui	3150 in³	3150 in³
	Operating pressure	2000 psi	2000 psi	2000 psi	2000 psi	2000 psi	2000 psi
	Airgun array tow depth	6–8 m (±1 m)	6–8 m (±1 m)	6–8 m (±1 m)	6–8 m (±1 m)	6–8 m (±1 m)	6–8 m (±1 m)
	Shot point interval	18.75 m	18.75 m	12.5 m	12.5 m	12.5 m	12.5 m
	Peak frequency range	2–200 Hz	2-200 Hz	2-200 Hz	2-200 Hz	2-200 Hz	2–200 Hz
Acoustic reception	No. of streamers (approximate)	12	12	12	6-12	10-12	10–12
	Streamer length (approximate)	+7000 m	7000 m	8000 m	5000 m	5000 m	5000 m
	Streamer spacing	100 m	50 m	75 m	50 m	100 m	100 m
	Streamer depth (approximate)	18 m	15 m	15 m	15–18 m	15–18 m	15–18 m

[1] *The acquisition period and duration for the Petroleum Activities Program is subject to EP acceptance, business approval to commence, vessel availability, operational constraints and prevailing weather conditions.*

3.6.3 Receiver Technology

The proposed Petroleum Activities Program will use a seismic vessel to tow 10 to 12 solid streamers. The streamers will be towed at a depth of about 15–18 m, with streamer spacing (separation) of 50–100 m (**Table 3-4**). Recent advances in cable technology have led to a new generation of seismic streamers, moving away from the traditional fluid-filled cable to a solid cable, constructed from extruded foam or gel where the requirement for fluid has been reduced. This move to solid streamers subsequently reduces the risk of streamers releasing fluid to the environment.

The streamers contain steering devices in the form of remote controlled wings, which enable both precise depth control and horizontal steering. Horizontal streamer steering reduces feather (where the streamer tends to veer offline due to wind and currents) correction and enables safe streamer separation control and active steering. Streamer recovery devices (SRDs) will be fitted to the streamers. If the streamers go below about 50 m depth, the SRDs automatically deploy inflatable air bags to raise the streamer to the surface for retrieval.

3.6.4 Project Vessels

Table 3-5 outlines typical parameters of the vessels that will be used during each 4D survey.

Vessels are also required to operate in accordance with the seismic contractor’s HSE policies, reviewed as part of Woodside’s assurance process.

The seismic vessel and towed array, comprising the airgun array and streamer array which includes header buoys, starboard and port spreaders or vanes, streamers and tail buoys, are surrounded by an SNA. The SNA will extend to a radius of 500 m around the seismic vessel and towed equipment. The support and chase vessels will be used to ensure third party vessels are prevented from approaching or entering the SNA.

Table 3-5: Typical vessel specifications

Specification	Seismic Vessel	Support Vessel	Chase Vessel
Registered tonnage	~13,000–15,000	~3000	<400
Length overall	~110 m	~65 m	~22 m
Breadth	~40 m	~20 m	~6 m
Draft (max)	8 m	7 m	~2 m
Persons on board	80	50	4–12
Fuel type	Marine diesel oil (MDO)	MDO	MDO

Three project vessels (seismic, support and chase vessels) are expected to be required for the Pluto 4D M2, Harmony 4D M1 (Brunello field), Scarborough 4D B1 and Laverda 4D M1 surveys. For the Cimatti 4D M1 and Vincent 4D M2 surveys, an additional seismic vessel may be required, as these two surveys may be acquired using a ‘push reverse’ acquisition technique. Push reverse acquisition involves using separate seismic source and streamer vessels, with the vessel towing the streamer spread positioned in front of the source vessel. Two-vessel push reverse acquisition maximises 4D repeatability and minimises 4D infill in a survey area known for strong currents.

The support vessel will accompany the seismic vessel to re-supply it with fuel and other logistical and operational supplies (including taking the seismic vessel under tow if required). An additional chase vessel will be used during each survey to manage interactions with shipping and fishing activities, if required.

Potable water, primarily for accommodation and associated domestic areas, will be generated on the seismic and support vessels using a reverse osmosis system. This process will produce brine, which is diluted and discharged at the sea surface in accordance with the controls detailed in **Section 6.6.6**.

The project vessels will also discharge deck drainage from open drainage areas, bilge water from closed drainage areas, putrescible waste and treated sewage and grey water. Any hazardous and non-hazardous waste will be appropriately stored and transported to shore for disposal.

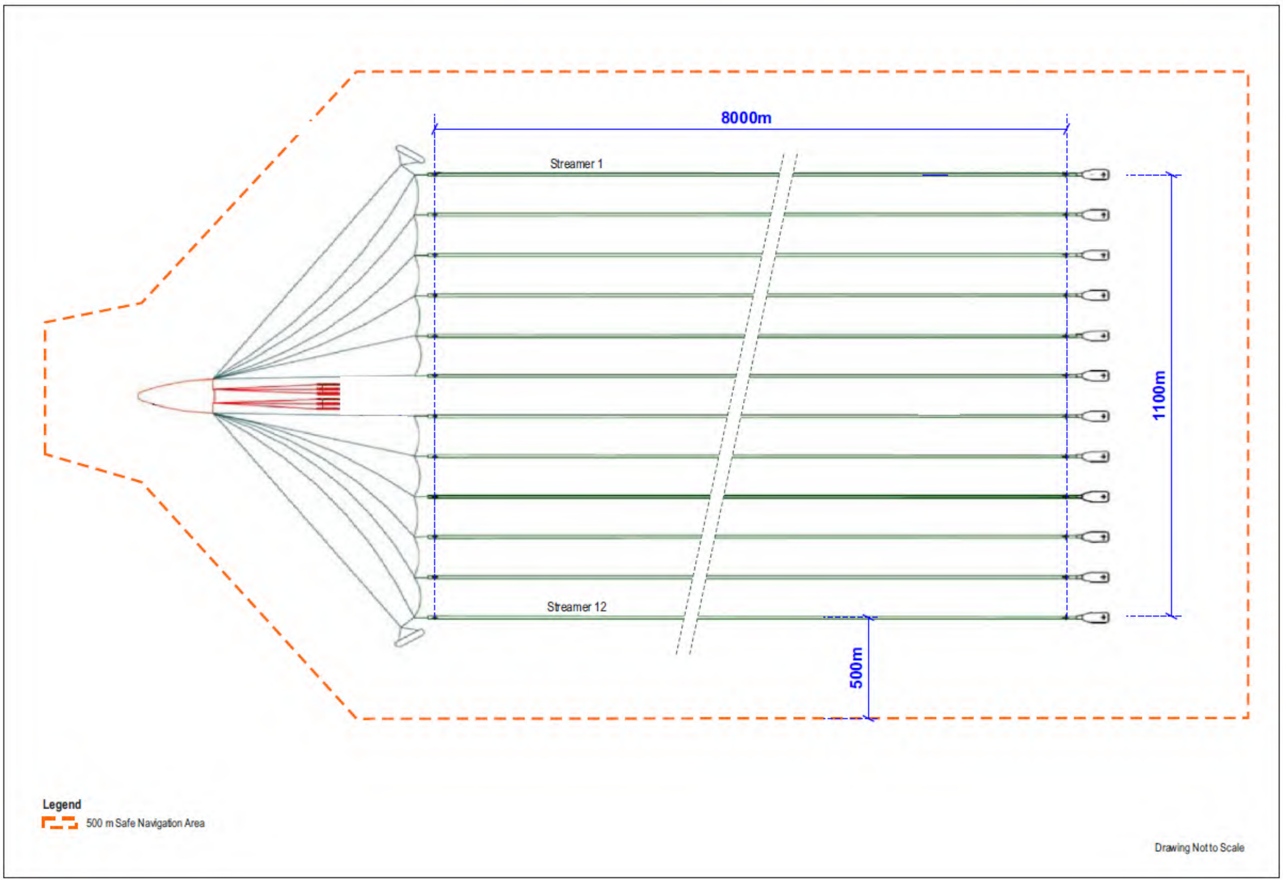

Figure 3-3: Seismic array Safe Navigation Area (Note that streamer lengths for each survey will be based on Table 3-4)

3.6.5 Helicopters

Crew changes, if required during the 4D campaign, will be conducted (depending on timing) either via a combination of a helicopter operating out of the Karratha heliport or Exmouth Aerodrome linking up with the seismic vessel, or potentially via support or chase vessel port(s) of call.

3.6.6 Refuelling

At-sea refuelling (bunkering) of the seismic vessel may occur, depending on fuel consumption during each survey and transits between each Operational Area.

4. DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 Overview

In accordance with Regulations 13(2) and 13(3) of the Environment Regulations, this section describes the existing environment that may be affected by the activity (planned and unplanned activities, as defined in **Section 2.4.2** and described in **Section 3**), including details of the particular relevant values and sensitivities of the environment. These have been used for the risk assessment. The existing environment is described in terms of the three Areas (A, B and C), as well as the environment that may be affected by the activity (EMBA). The EMBA boundary is a conservative 100 km perimeter around each Operational Area based on a diesel spill resulting from a vessel collision. It also encompasses the seismic noise emissions from Areas A, B and C (identified as the largest potential 'footprint' for the Petroleum Activities Program).

4.2 Summary of Key Existing Environment Characteristics

Table 4-1 summarises the key existing environment characteristics, in line with the process of identifying and describing the existing environment relating to the 'nature and scale' of the activity (refer **Section 2.4.2**). The key existing environment characteristics in **Table 4-1** are described for Area A, B and C, and the waters surrounding these areas that may be directly impacted by the activities.

Table 4-1: Summary of key existing environment characteristics for Areas A, B and C

	Sensitive Receptor	EP Section	Description		
			Area A	Area B	Area C
Physical Environment	Climate and Meteorology	4.4.1	• Dry tropical climate with hot summers and mild winters. • Rainfall typically occurs during the wet season, with highest falls observed during late summer. • Winds vary seasonally, with a tendency for winds from the south-west during summer months (September to March) and the south-east in autumn and winter months (April to August). • Tropical cyclone activity can occur between November and April and is most frequent during December to March.		
Physical Environment	Oceanography	4.4.2	• Primarily influenced by the Indonesian Throughflow (ITF) and Holloway Current.	• Primarily influenced by the ITF and Holloway Current. • The Area lies within the Exmouth Plateau Key Ecological Feature (KEF) and is a region of upwelling.	• Primarily influenced by the Leeuwin Current, Leeuwin Undercurrent and Ningaloo Current. • Canyons in Area C are an area of upwelling.
Physical Environment	Bathymetry	4.4.2	• Located on the middle of the continental shelf in depths ranging from 40 m–1390 m. • Bisected by a steep slope separating the upper and lower continental slope. • Seabed generally comprises a relatively flat and featureless habitat either side of the steep slope.	• Located entirely on the Exmouth Plateau KEF in depths ranging from 960 m–1240 m. • The Exmouth Plateau KEF may consist of hard substrate, including pinnacles and canyons. However, this is more characteristic of the northern region of the KEF, which is outside of Area C.	• Located in water depths ranging from 150 m–1200 m. • Canyons linking the Cuvier Abyssal Plain and Cape Range Peninsula KEF are located in the Area and it is a region of upwelling.
Physical Environment	Marine Sediment	4.4.3	• Dominated by soft sediment (fine to coarse sands). • Hard substrate may occur in association with the Ancient Coastline at 125 m Depth Contour KEF.	• Mostly fine grained sediments with a lack of hard substrate. • Some geomorphic features (pinnacles and canyons) may provide hard substrate.	• Upper slope habitat in the Area is generally composed of coarser and/or more consolidated sediments as compared to the mid-slope.
Physical Environment	Air Quality	4.4.4	There is limited air quality data for the Northwest Province and North West Marine Region (NWMR). However, ambient air quality within Areas A, B and C is expected to be of high quality.		
Habitats	Critical Habitat – EPBC Listed	4.5.1	No Critical Habitats or Threatened Ecological Communities, as listed under the EPBC Act, are known to occur within Areas A, B or C.		
Habitats	Marine Primary Producers	4.5.1	Given the depth of water within Area A (40 m–1380 m), Area B (960 m–1240 m) and Area C (150 m–1200 m), benthic primary producer groups are not expected to occur.		
Habitats	Lifecycle Stages 'Critical' Habitats	4.5.1	Refer to biologically important areas (BIAs) and species descriptions for details of lifecycle stages 'critical' habitats.		
Habitats	Other Communities/ Habitats	4.5.1	***Benthic Communities*** • Low density communities of bryozoans, molluscs and echinoids. • Deep water areas of soft substrate typically support a low abundance, low richness and low diversity of burrowing organisms, such as polychaete worms and smaller crustaceans. ***Plankton*** • Phytoplankton within the Area are expected to reflect the conditions of the NWMR; there is a tendency for offshore phytoplankton communities in the NWMR to be characterised by smaller taxa (e.g. bacteria). • Zooplankton within the Area is expected to be similar to offshore waters in the Northwest Province and may include organisms that complete their lifecycle as plankton (e.g. copepods, euphausiids) as well as larval stages of other taxa such as fishes, corals and molluscs. ***Pelagic and Demersal Fish Populations*** • Fish assemblage species richness in the region has been shown to decrease with depth as well as positively correlate with habitat complexity, with more complex habitat supporting greater species richness and abundance than bare areas. • Fish fauna are not expected to be abundant in the Area, and diversity is expected to be limited due to depth and the lack of hard substrate/habitat complexity.	***Benthic Communities*** • Mainly echinoderms (e.g. sea cucumbers and sea stars), with infaunal bioturbators likely present; however, abundance is generally low. ***Plankton*** • Productivity is generally considered to be low due to overriding low-nutrient tropical waters. • Upwelling associated with the boundaries of the Exmouth Plateau is thought to periodically increase productivity. ***Pelagic and Demersal Fish Populations*** • Fish fauna are not expected to be abundant and diversity is expected to be limited due to depth and the expected lack of hard substrate/habitat complexity. • Increased productivity associated with upwelling at the boundaries of the Exmouth Plateau may result in increased fish abundance and diversity, particularly during upwelling events.	***Benthic Communities*** • Generally low density communities of bryozoans, molluscs and echinoids. • Surveys within the Area indicate benthic communities (including in the canyons) are similar to those in the wider NWMR. • Diverse sponge communities may be found adjacent to the Area in the Commonwealth waters of the Ningaloo Marine Park. ***Plankton*** • Biological productivity occurs in the Area due to upwelling of deeper nutrient-rich waters through canyon systems at the head of the Cape Range Canyon. • Peak primary productivity occurs along the shelf edge of the Ningaloo Reef in late summer/early autumn. • Pelagic and demersal fish populations. • Seasonal aggregations of pelagic species such as whale sharks and large billfish. • The merging of northward and southward flowing currents is thought to be responsible for the representation of both temperate and tropical species within the bioregion.

	Sensitive Receptor	EP Section	Description		
			Area A	Area B	Area C
Protected Species	BIAs	4.5.2	• Pygmy blue whale migration – annual seasonal migration past Exmouth towards Indonesia (April to August), returning southerly following the WA coastline (October to late January). • Flatback turtle internesting – turtle internesting buffer zone BIA at Montebello/Browse Island (peak period in December and January). • Whale shark foraging – foraging occurs northward from the Ningaloo Marine Park along the 200 m isobath (July to November). • Wedge-tailed shearwater breeding (August to April).	• No overlapping BIAs. The closest BIA is the pygmy blue whale migration BIA, located about 27 km south-east from the Area.	• Pygmy blue whale foraging – a BIA for pygmy blue whale foraging occurs off the coast of Exmouth and lies within the migration BIA. • Humpback whale migration – annual seasonal migration along the WA coastline with peak past Exmouth travelling northward (June – July), returning southerly along the same route (August to November). The BIA transects the south-eastern side of Area C. • Flatback turtle internesting – internesting BIA occurs at Muiron Islands and the Ningaloo coast, where nesting occurs from October to March each year with a peak in December and January. Area C overlaps a portion of the outer region of the BIA. • Loggerhead turtle internesting – internesting BIA at the Muiron Islands and the Ningaloo coast, where nesting occurs from November to May each year with no defined peak (Department of Environment and Energy (DoEE), 2017). Area C overlaps with a portion of the outer region of the BIA. • Green turtle internesting – internesting BIAs occur at the Muiron Islands and North West Cape where nesting peaks from November to March each year (DoEE, 2017). Area C overlaps a minor portion of the outer region of both BIAs. • Hawksbill turtle internesting – internesting BIA occurs along the Ningaloo coast and Jurabi coast where nesting peaks from October to February each year (DoEE, 2017). Area C overlaps a minor portion (~4%) of the outer region of the BIA.
	Marine Mammals	4.5.2	Species overlapping the Area: ***Sei whale*** • May infrequently occur within the Area, mainly during winter months when the species may move away from Antarctic feeding areas. ***Pygmy blue whale*** • Likely to occasionally occur within the Area, particularly during their annual migrations. When individuals do occur in the Area, it is likely there will be only one or a few individuals and their time in the area will be brief. • Pygmy blue whale migration BIA overlaps the Area. ***Humpback whale*** • May occur in the southern portion of the Area during the annual migration period (northerly migration May to November, with a peak in June and July; southern migration from August to November). Unlikely to occur in the Area outside of the migration period. ***Bryde's whale*** • Presence in the Area is likely to be a remote occurrence and limited to a few individuals. ***Killer whale*** • Given the wide distribution of killer whales and their preference for colder waters, the Area is unlikely to represent an important habitat for this species. ***Sperm whale*** • Presence in the Area is likely to be a rare occurrence and limited to a few individuals infrequently transiting the area.	Species overlapping the Area: ***Sei whale*** • May infrequently occur within the Area, mainly during winter months when the species may move away from Antarctic feeding areas. ***Pygmy blue whale*** • Likely to occasionally occur within the Area, particularly during their annual migrations. When individuals do occur in the Area, it is likely there will be only one or a few individuals and their time in the area will be brief. ***Humpback whale*** • Unlikely to occur within the Area due to their preference for more shallow coastal water. ***Bryde's whale*** • Presence in the Area is likely to be a remote occurrence and limited to a few individuals. ***Killer whale*** • Given the wide distribution of killer whales and their preference for colder waters, the Area is unlikely to represent an important habitat for this species. ***Sperm whale*** • Presence in the Area is likely to be a rare occurrence and limited to a few individuals infrequently transiting the area.	Species overlapping the Area: ***Sei whale*** • May infrequently occur within the Area, mainly during winter months when the species may move away from Antarctic feeding areas. ***Pygmy blue whale*** • Likely to occur within the Area, particularly during their annual migrations. When individuals do occur in the Area, it is likely there will be only one or a few individuals and their time in the area will be brief. ***Humpback whale*** • Likely to occur in the southern portion of the Area during the annual migration period (northerly migration May to November, with a peak in June and July; southern migration from August to November). Unlikely to occur in the Area outside of the migratory period. ***Antarctic minke whale*** • Presence in the Area is unlikely. ***Fin whale*** • Likely to infrequently occur within the Area, mainly during winter months when the species may move away from Antarctic feeding areas. ***Killer whale*** • Given the wide distribution of killer whales and their preference for colder waters, the Area is unlikely to represent an important habitat for this species.

	Sensitive Receptor	EP Section	Description		
			Area A	Area B	Area C
			Indo-Pacific humpback dolphin • Unlikely to occur due to preference for shallow (<20 m) coastal habitats. ***Spotted bottlenose dolphin*** • Unlikely to occur due to preference for shallow (<10 m) coastal habitats.		***Sperm whale*** • Presence in the Area is likely to be a rare occurrence and limited to a few individuals infrequently transiting the area. ***Spotted bottlenose dolphin*** • Unlikely to occur due to preference for shallow (<10 m) coastal habitats.
	Marine Turtles	**4.5.2**	• Five species of threatened marine turtles (loggerhead, green, leatherback, hawksbill and flatback) may occur in the Area. • The Area does not contain any known critical habitat for any species of marine turtle. • The Area partially overlaps an internesting buffer (60 km) for flatback turtles around Montebello Islands, listed as 'habitat critical' to the survival of marine turtles. • The Area partially overlaps an internesting buffer (60 km) BIA for flatback turtles around Montebello Islands. • Presence of marine turtles within the Area is likely to be infrequent and limited to individuals or small numbers transiting through the area.	• Five species of threatened marine turtles (loggerhead, green, leatherback, hawksbill and flatback) may occur in the Area. • The Area does not contain any known critical habitat for any species of marine turtle. • The Area is not within or adjacent to any marine turtle BIAs or 'habitat critical' to the survival of a marine turtle species. • Presence of marine turtles within the Area is likely to be rare and limited to small numbers transiting through the area.	• Five species of threatened marine turtles (loggerhead, green, leatherback, hawksbill and flatback) may occur in the Area. • The Area does not contain any known critical habitat for any species of marine turtle. • The Area partially overlaps an internesting buffer (20 km) for loggerhead turtles and green turtles around the Ningaloo coastline, listed as 'habitat critical' to the survival of a marine turtle species. • The Area partially overlaps an internesting buffer (60 km) BIA for flatback turtles around Muiron Islands. • Marine turtles may be present as transitory individuals within the Area but are unlikely to be frequent due to depths and absence of foraging habitat.
	Sea snakes	**4.5.2**	• The short-nosed sea snake (critically endangered) was identified as potentially occurring within the Area. • Given the offshore location and water depths, sea snakes may be present in the Area in low numbers.	• No threatened or migratory sea snake species were identified as occurring within the Area • Given the offshore location and deeper water depths of the Area, sea snake sightings are likely to be infrequent and to comprise of only small numbers of individuals	• The short-nosed sea snake (critically endangered) was identified as potentially occurring within the Area. • Given the offshore location and deeper water depths of the Area, sea snake sightings are likely to be infrequent and to comprise of only small numbers of individuals.
	Seahorses and Pipefish	**4.5.2**	• Uncommon in deeper continental shelf waters (50–200 m) and therefore unlikely to occur within Areas A, B or C.		
	Sharks, Sawfish and Rays	**4.5.2**	• The Area does not contain any known critical habitat for any species of shark or ray. • The presence of EPBC listed sharks and rays is likely to be infrequent and limited to individuals or small numbers transiting through the Area.	• The Area does not contain any known critical habitat for any species of shark or ray. • The presence of EPBC listed sharks and rays is likely to be infrequent and limited to individuals or small numbers transiting through the Area.	• The Area does not contain any known critical habitat for any species of shark or ray. • The presence of EPBC listed sharks is likely to be infrequent and limited to individuals or small numbers transiting through the Area. • Giant and reef manta rays (listed as Migratory under the EPBC Act) are known to be both resident and seasonal visitors to Ningaloo Reef and therefore may be present within the Area, particularly during periods of increased productivity (March to August).
	Oceanic Seabirds and/or Migratory Shorebirds	**4.5.2**	• Thirteen seabird or migratory shorebird species protected under the EPBC Act were identified as potentially occurring within the Area (red knot, common sandpiper, common noddy, sharp-tailed sandpiper, pectoral sandpiper, lesser, frigatebird, great frigatebird, curlew sandpiper, southern giant-petrel, eastern curlew, Australian fairy tern, streaked shearwater, osprey). • No critical habitat associated with these species has been identified for the Area.	• Seven seabird or migratory shorebird species protected under the EPBC Act were identified as potentially occurring within the Area (red knot, common sandpiper, common noddy, sharp-tailed sandpiper, pectoral sandpiper, lesser frigatebird, southern giant-petrel).	• Fourteen seabird or migratory shorebird species protected under the EPBC Act were identified as potentially occurring within the Area (red knot, common sandpiper, common noddy, sharp-tailed sandpiper, pectoral sandpiper, lesser, frigatebird, great frigatebird, curlew sandpiper, southern giant-petrel, eastern curlew, soft-plumaged petrel, Australian fairy tern, streaked shearwater, osprey). • No critical habitat associated with these species has been identified for the Area.
Socio-economic	**Cultural Heritage**	**4.6.1**	• There are no known sites of Indigenous or European cultural or heritage significance within or immediately adjacent to the Area.	• There are no known sites of Indigenous or European cultural or heritage significance within or immediately adjacent to the Area.	• There are no known sites of Indigenous or European cultural or heritage significance within the Area. • 2 km from the Area is the Ningaloo Coast National Heritage Area and Ningaloo Marine Area (Commonwealth waters) Commonwealth Heritage Place. • 2 km from the Ningaloo Coast World Heritage Area. • Occurrence of terrestrial Indigenous heritage sites along the Cape Range Peninsula, 16 km south of Area C.

<table>
<tr><th rowspan="2">Sensitive Receptor</th><th rowspan="2">EP Section</th><th colspan="3">Description</th></tr>
<tr><th>Area A</th><th>Area B</th><th>Area C</th></tr>
<tr><td>Ramsar Wetlands</td><td>4.6.2</td><td colspan="3">There are no Ramsar wetlands within or adjacent to the Areas.</td></tr>
<tr><td>Fisheries – Commercial</td><td>4.6.3</td><td>Commonwealth fisheries
• Southern Bluefin Tuna Fishery
• Western Skipjack Fishery
• Western Tuna and Billfish Fishery
• North West Slope Trawl Fishery.
State fisheries
• Mackerel Managed Fishery
• South West Coast Salmon Managed Fishery
• West Coast Deep Sea Crustacean Managed Fishery
• Pearl Oyster Managed Fishery
• Marine Aquarium Managed Fishery
• Specimen Shell Managed Fishery
• Onslow Prawn Managed Fishery
• Pilbara Demersal Scalefish Managed Fisheries.
There are no aquaculture leases within or adjacent to the Area.</td><td>Commonwealth fisheries
• Southern Bluefin Tuna Fishery
• Western Skipjack Fishery
• Western Tuna and Billfish Fishery.
State fisheries
• Mackerel Managed Fishery
• South West Coast Salmon Managed Fishery
• West Coast Deep Sea Crustacean Managed Fishery
• Marine Aquarium Managed Fishery.
There are no aquaculture leases within or adjacent to the Area.</td><td>Commonwealth fisheries
• Southern Bluefin Tuna Fishery
• Western Skipjack Fishery
• Western Tuna and Billfish Fishery
• North West Slope Trawl Fishery.
State fisheries
• Mackerel Managed Fishery
• South West Coast Salmon Managed Fishery
• West Coast Deep Sea Crustacean Managed Fishery
• Pearl Oyster Managed Fishery
• Marine Aquarium Managed Fishery
• Specimen Shell Managed Fishery
• Western Coast Rock Lobster Managed Fishery
• Pilbara Demersal Scalefish Managed Fisheries.
There are no aquaculture leases within or adjacent to the Area.</td></tr>
<tr><td>Fisheries – Traditional</td><td>4.6.4</td><td colspan="3">There are no traditional or customary fisheries within or adjacent to the offshore Areas.</td></tr>
<tr><td>Tourism and Recreation</td><td>4.6.5</td><td>• No tourism or recreation activities are known to take place within the Area due to water depths and distance offshore.</td><td>• No tourism or recreation activities are known to take place within the Area due to water depths and distance offshore.</td><td>• No tourism activities are known to take place specifically within the Area.
• Annual local billfish tournaments are known to occur in January and March that may occur within the Area.</td></tr>
<tr><td>Shipping</td><td>4.6.6</td><td>• No AMSA marine fairways pass through the Area; however, Australian Maritime Safety Authority (AMSA) data indicates moderate to heavy traffic occurs in the central-eastern region of the Area.</td><td>• Light to moderate shipping activity in the eastern portion of the Area.
• Located about 8 km west of an AMSA marine fairway.</td><td>• Light to moderate shipping activity in the eastern portion of the Area.
• Overlap with an AMSA marine fairway at the north-west corner of the Area, with relatively light shipping traffic within the corridor.</td></tr>
<tr><td>Oil and Gas Infrastructure</td><td>4.6.7</td><td>• Located within an area of established oil and gas operations in the broader NWMR.
• The Pluto Platform and associated infrastructure is located within the Area.
• The Wheatstone Platform and associated infrastructure is located within the Area.</td><td>• No commissioned oil and gas infrastructure occur within the Area.</td><td>• Located within an area of established oil and gas operations in the broader NWMR.
• The Ngujima–Yin FPSO and associated infrastructure is located within the Area.
• The Ningaloo Vision FPSO and associated infrastructure is located within the Area.</td></tr>
<tr><td>Defence</td><td>4.6.8</td><td>• Partial overlap with the Learmonth Military Flying Training practice area at the south-west portion of the Area.</td><td>• Overlaps with the Learmonth Military Flying Training practice area.
• Overlaps with the Learmonth Military Flying Training/Firing practice area.</td><td>• Partially overlaps with the Learmonth Military Flying Training practice area.
• Partially overlaps with the Learmonth Military Flying Training/Firing practice area.</td></tr>
<tr><td>Values and Sensitivities</td><td>4.7</td><td>Area overlaps with the:
• Montebello Islands Australian Marine Park
• Continental Slope Demersal Fish Communities KEF
• Ancient Coastline at 125 m Depth Contour KEF.
• Exmouth Plateau KEF</td><td>• Area overlaps with the Exmouth Plateau KEF.</td><td>Area overlaps with the:
• Gascoyne Australian Marine Park
• Continental Slope Demersal Fish Communities KEF
• Ancient Coastline at 125 m Depth Contour KEF
• Commonwealth Waters Adjacent to Ningaloo Reef KEF
• Canyons Linking the Cuvier Abyssal Plain and Cape Range Peninsula KEF.
• Exmouth Plateau KEF</td></tr>
</table>

4.3 Regional Context

Areas A, B and C are located in Commonwealth waters and lie within three provincial bioregions in the NWMR, as defined in the Integrated Marine and Coastal Regionalisation of Australia (IMCRA v4.0) (Department of Environment and Heritage (DEH), 2006). Area A is located on both the upper and lower continental slope within the Northwest Province (62%) and the Northwest Shelf Province (38%). Area B is located entirely within the Northwest Province. Area C overlaps three bioregions: the Northwest Province (91%), Central Western Shelf Transition (6%) and Northwest Shelf Province (3%).

The Northwest Province is part of the wider NWMR (**Figure 4-1**) as defined under the IMCRA v4.0 (DEH, 2006). The Northwest Province is located offshore (beyond the continental shelf break) between Exmouth and Port Hedland and covers a total area of 188,730 km² (Department of Environment, Water, Heritage and the Arts (DEWHA), 2008; Heap et al., 2005).

The Northwest Province is characterised by the following biophysical features (DEWHA, 2008):

- Climatic conditions are transitional between dry tropics to the south and humid tropics to the north.
- There are strong seasonal winds and moderate tropical cyclone activity.
- The Province is entirely on the continental slope, between the shallower continental shelf and the Abyssal Plain.
- Several topographic features exist such as the Exmouth Plateau, Montebello Trough and other terraces and canyons (several of which are associated with KEFs; refer to **Section 4.7.4**). Area C partially overlaps the Montebello Trough.
- Surface ocean circulation is strongly influenced by the ITF via the Eastern Gyre and the Leeuwin Current (and associated undercurrent). During summer when the ITF is weaker, south-west winds cause intermittent reversals in currents. These events may be associated with occasional weak shelf upwellings.
- Deeper surface waters are tropical year-round and highly stratified during summer months (thermocline occurring at water depths between 30 and 60 m). In winter, surface waters are well mixed with thermoclines occurring deeper around 120 m depth.
- There is a transitional boundary between tropical and temperate marine biological communities.
- There is a relatively high endemism of demersal fish species associated with the continental slope.
- Pelagic food webs, potentially enhanced by upwelling associated with seabed features, support larger fauna such as fishes, sharks and dolphins.
- Soft sediment seabeds dominate benthic habitats, with associated epifauna communities such as filter and deposit feeders.
- Significant migratory routes, resident populations, breeding and/or feeding grounds are present for a number of EPBC Act listed Threatened and Migratory marine species, including humpback whales, pygmy blue whales, marine turtles, whale sharks and seabirds.

The Northwest Shelf Province is characterised by the following biophysical features (DEWHA, 2008):

- Climatic conditions are transitional between dry tropics to the south and humid tropics to the north.

- There are strong seasonal winds and moderate tropical cyclone activity.
- Deeper surface waters are tropical year-round and highly stratified during summer months (thermocline occurring at water depths between 30 and 60 m). In winter, surface waters are well mixed with thermoclines occurring deeper around 120 m depth.
- Surface ocean circulation is strongly influenced by the ITF via the Eastern Gyre. During summer when the ITF is weaker, south-west winds cause intermittent reversals in currents. These events may be associated with occasional weak shelf upwellings.
- The seabed in the region consists of sediments that generally become finer with increasing water depth, ranging from sand and gravels on the continental shelf to mud on the slope and Abyssal Plain. About 60–90% of the sediments in the region are carbonate derived (Brewer et al., 2007). The distribution and resuspension of sediments on the inner shelf is strongly influenced by the strength of tides across the continental shelf as well as episodic cyclones. Further offshore, on the mid to outer shelf and on the slope, sediment movement is primarily influenced by ocean currents and internal tides, the latter causing resuspension and net downslope deposition of sediments (Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), 2012a).
- The region has high species richness but a relatively low level of endemism, i.e. species particular to the region in comparison to other areas of Australian waters. Furthermore, most of the region's species are tropical and are recorded in other areas of the Indian Ocean and Western Pacific Ocean.
- Benthic communities within the region range from nearshore benthic primary producer habitats such as seagrass beds, coral communities and mangrove forests to offshore soft sediment seabed habitats associated with low density sessile and mobile benthos such as sponges, molluscs and echinoids (with noted areas of sponge hotspot diversity).
- Internationally significant migratory routes, resident populations, breeding and/or feeding grounds are present for a number of EPBC Act listed Threatened and Migratory marine species, including humpback whales, pygmy blue whales, marine turtles, whale sharks and seabirds.

The Central Western Shelf Transition is characterised by the following biophysical features (DEWHA, 2008):

- There is a dry tropical climate with high seasonal cyclone frequency (December to April).
- It is located on the continental shelf from the North West Cape to Coral Bay, and includes both State and Commonwealth waters from 0–80 m.
- It is strongly influenced by the interactions between the Leeuwin Current, Leeuwin Undercurrent and Ningaloo Current.
- Southward flowing surface currents and northward flowing undercurrents converge, resulting in a representation of both tropical and temperate species within the bioregion.
- The proximity of the shelf break to the coast is a significant feature, driving upwelling and productivity.
- Canyons in the slope, including the Cape Range Canyon, channel upwellings toward Ningaloo Reef.

- The Ningaloo Reef comprises a significant portion of the bioregion, and stretches over 260 km from Red Bluff to the North West Cape.
- Seasonal and resident iconic species associated with Ningaloo Reef are present, including marine turtles, dugongs, whale sharks, manta rays and humpback whales.
- Sponge and filter-feeding communities in deeper waters around Ningaloo Reef are thought to be significantly different to adjacent marine regions. Therefore, the bioregion may contain areas of high and unique sponge biodiversity.

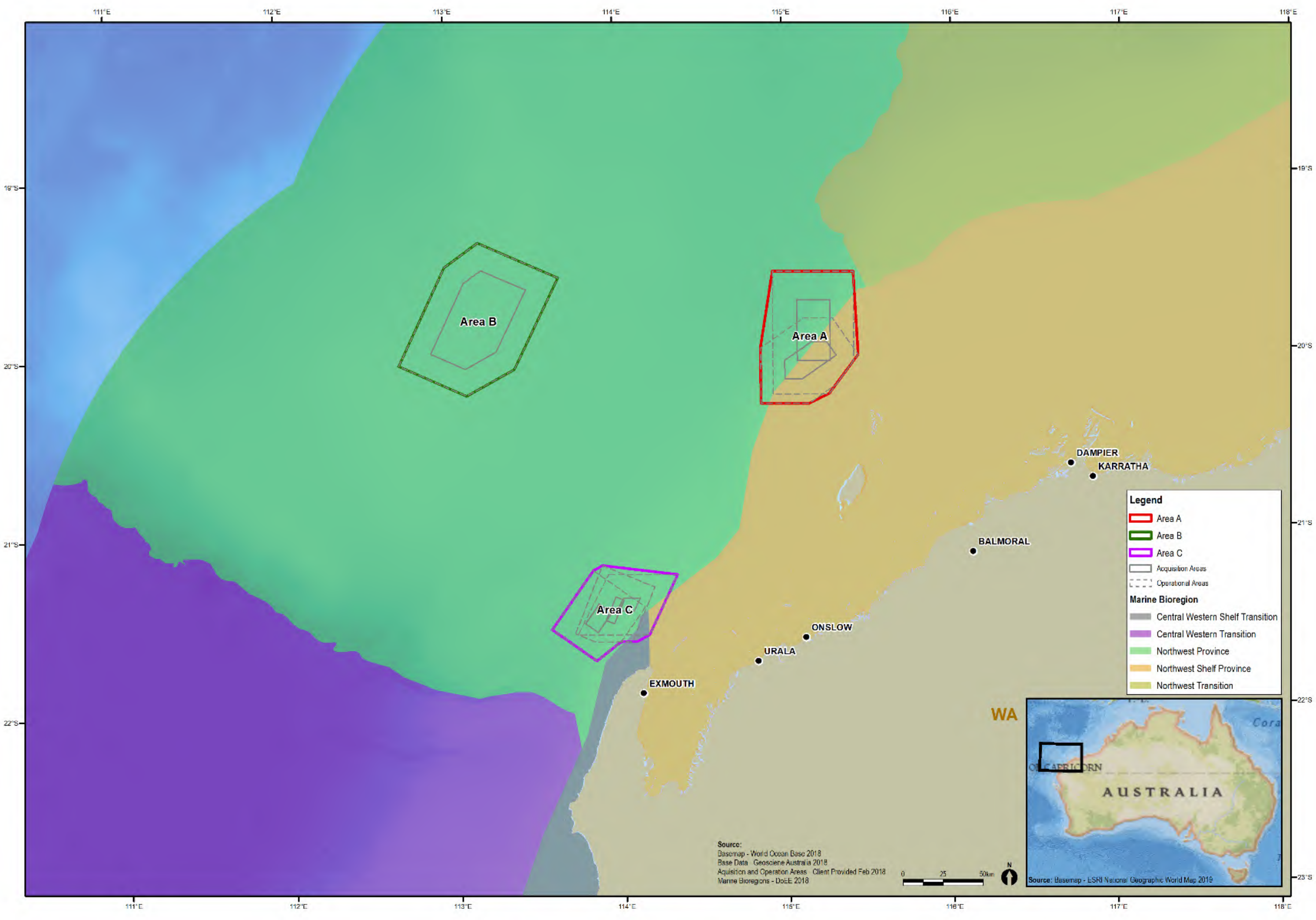

Figure 4-1: Provincial scale marine regions within Area A, B and C, and the location of the Areas (IMCRA Version 4.0, DEH, 2006)

4.4 Physical Environment

4.4.1 Climate and Meteorology

4.4.1.1 Seasonal Patterns

The climate of the NWMR is dry tropical, exhibiting a hot summer season from October to April and a milder winter season between May and September (**Figure 4-2**) (Bureau of Meteorology (BoM), 2017). There are often distinct transition periods between the summer and winter regimes, which are characterised by periods of relatively low winds (Pearce et al., 2003).

The region experiences a tropical monsoon climate, with distinct wet (January to July) and dry (August to November) seasons. Rainfall in the region typically occurs during the wet season, with highest falls observed during late summer, often associated with the passage of tropical low pressure systems and cyclones (Pearce et al., 2003).

Air temperatures in the region, as measured at the Barrow Island meteorological station (about 48 km south-east from Area A) and Exmouth meteorological station (Learmonth airport, about 233 km south-east from Area B and 63 km south-east from Area C) follow similar seasonal trends, shown in **Figure 4-2** and **Figure 4-3**.

At Barrow Island, average monthly maximum temperatures during summer reach 34 ºC in February, falling to an average maximum of 24 ºC in July (BoM, 2019). Average minimum temperatures range from 27 ºC in March to 18 ºC in July (BoM, 2019).

At Exmouth, average monthly maximum temperatures during summer reach 38 ºC in January, falling to an average maximum of 24 ºC in July (BoM, 2019). Average minimum temperatures range from 24 ºC in February to 11 ºC in July (BoM, 2019).

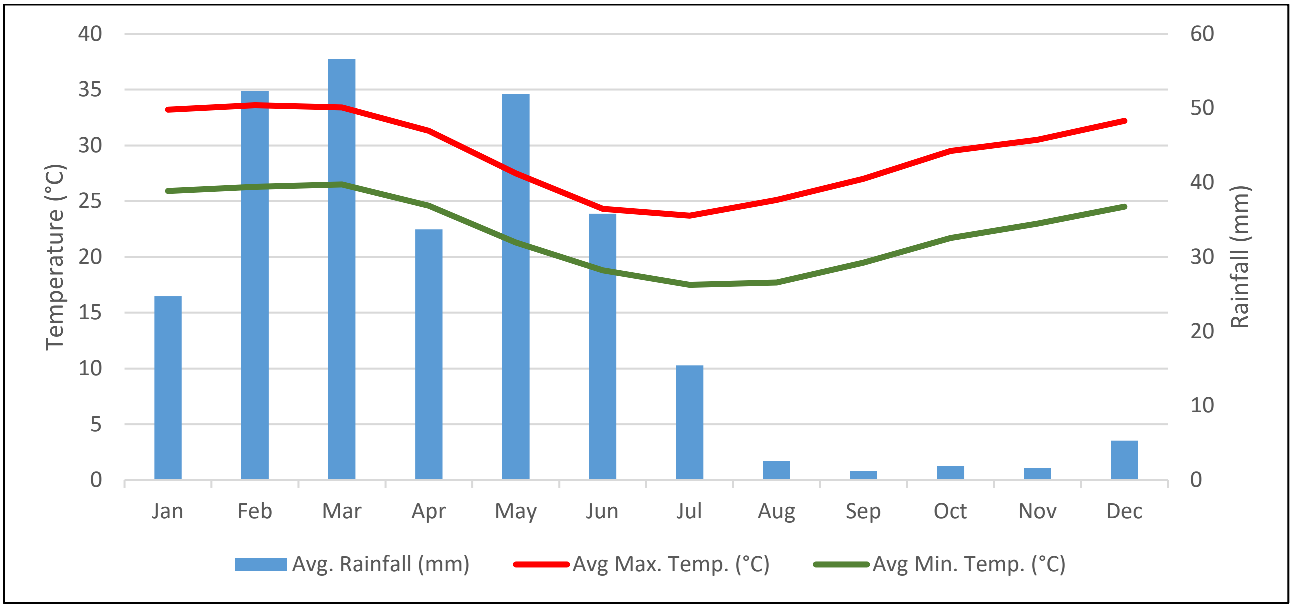

Figure 4-2: Mean monthly average maximum and minimum temperature and mean rainfall from 1999 to 2019 at Barrow Island (BoM, 2019)

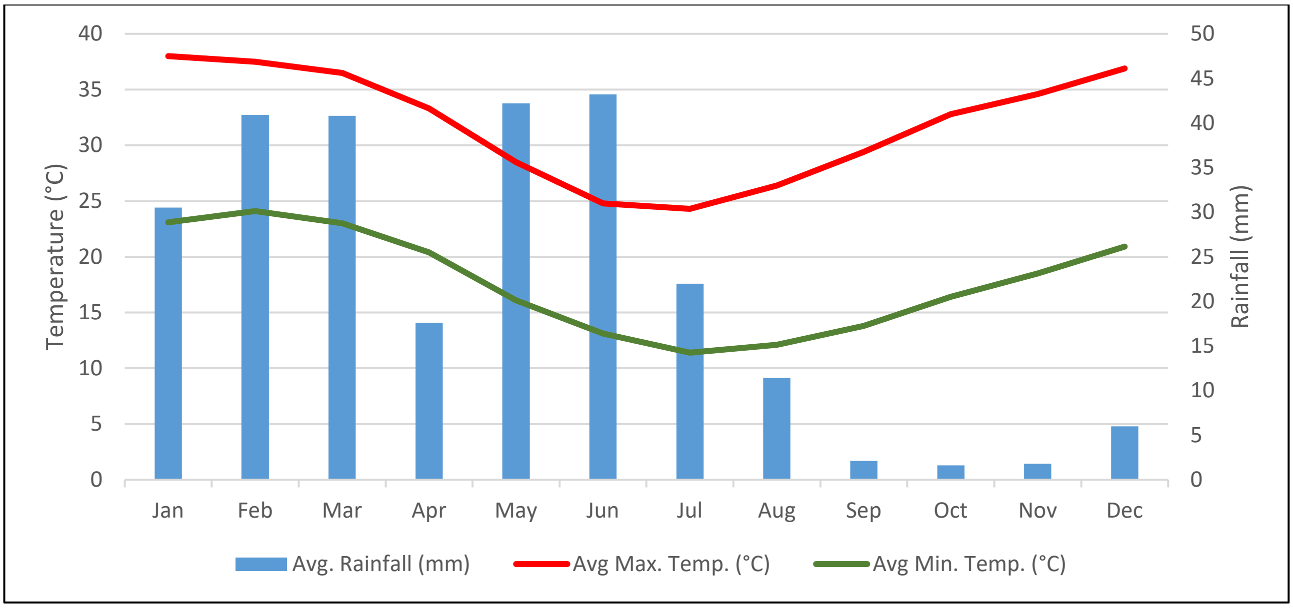

Figure 4-3: Mean monthly average maximum and minimum temperature and mean rainfall from 1999 to 2019 at Exmouth (Learmonth Airport) (BoM, 2019)

4.4.1.2 Wind

Winds vary seasonally, with a tendency for winds from the south-west during summer months (September to March) and the south-east in autumn and winter months (April to August). The summer south-westerly winds are driven by high pressure cells that pass from west to east over the Australian continent. During winter months, the relative position of the high pressure cells moves further north, leading to prevailing south-easterly winds blowing from the mainland (Pearce et al., 2003). Winds typically weaken and are more variable during the transitional period between the summer and winter regimes, generally in April and August.

4.4.1.3 Tropical Cyclones

Tropical cyclones are relatively frequent for the NWMR, with the Pilbara coast experiencing more cyclonic activity than any other region of the Australian mainland coast (BoM n.d.) (**Figure 4-4**). Tropical cyclone activity can occur between November and April and is most frequent during December to March (i.e. considered the peak period), with an annual average of about one storm per month. Cyclones are less frequent in November and April.

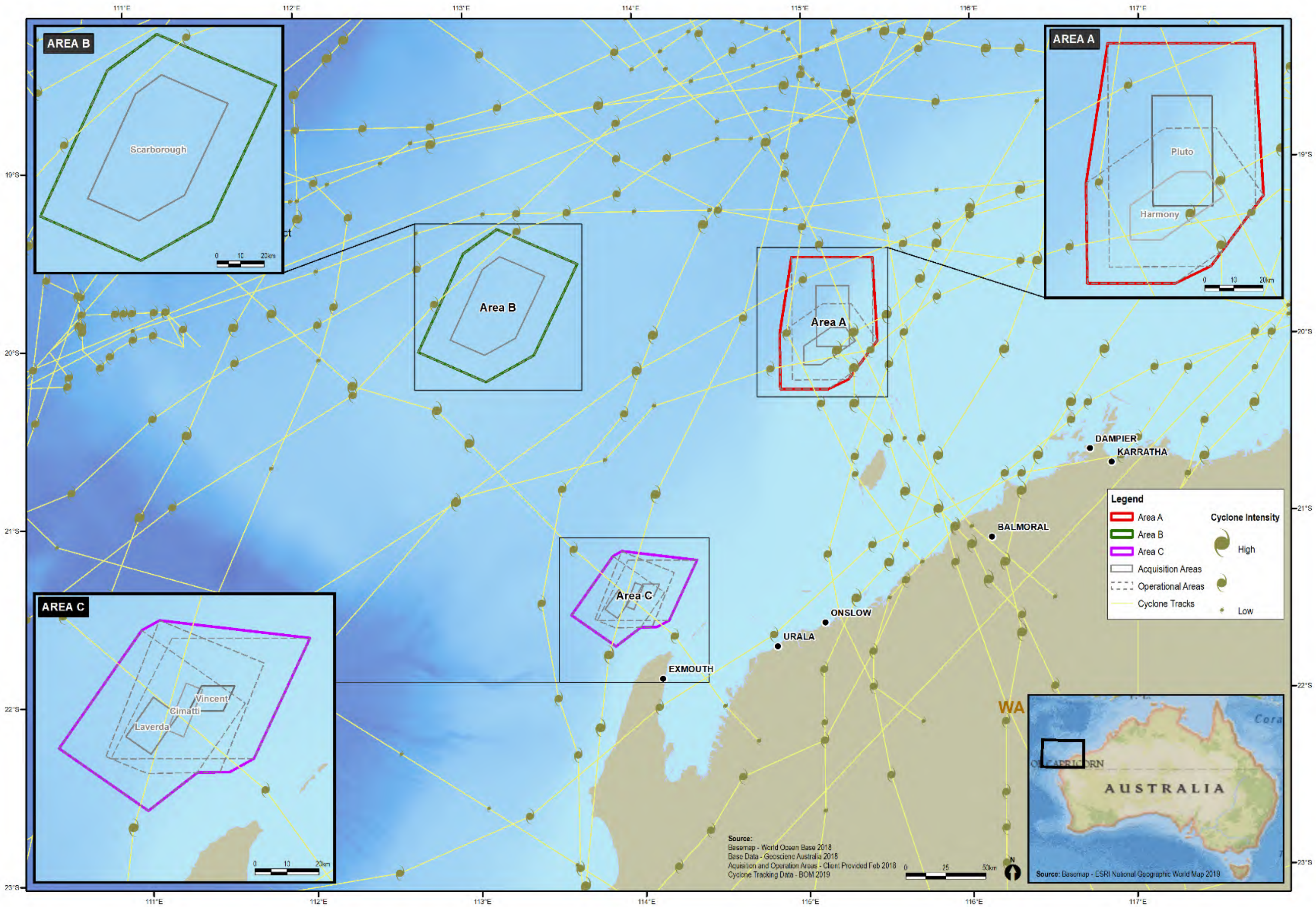

Figure 4-4: Cyclone tracks within the NWMR

4.4.2 Oceanography

4.4.2.1 Currents and Tides

The large-scale ocean circulation of the NWMR is primarily influenced by the ITF (Meyers et al., 1995; Potemra et al., 2003), and the Leeuwin Current (Batteen et al., 1992; Godfrey and Ridgway, 1985; Holloway and Nye, 1985; James et al., 2004; Potemra et al., 2003) (**Figure 4-5**). Both of these currents are significant drivers of the NWMR ecosystems. The currents are driven by pressure differences between the equator and the higher density cooler and more saline waters of the Southern Ocean, strongly influenced by seasonal change and El Niño and La Niña episodes (DSEWPaC, 2012a). The ITF and Leeuwin Current are strongest during late summer and winter (Holloway and Nye, 1985; James et al., 2004). Flow reversals to the north-east associated with strong south-westerly winds are typically weak and short lived but can generate upwelling of cold, deep water onto the shelf (Condie et al., 2006; Holloway and Nye, 1985; James et al., 2004).

The Leeuwin Current flows southward along the edge of the continental shelf and is primarily a surface flow (up to 150 m deep). It is strongest during winter (Cresswell, 1991). The Ningaloo Current flows in the opposite direction to the Leeuwin Current, running northward along the outside of Ningaloo Reef and across the inner shelf from September to mid-April (**Figure 4-5**). When the Northwest Monsoon terminates in March, an 'extended Leeuwin Current', currently known as the Holloway Current, develops, flowing south-east along the Northwest Shelf (DSEWPaC, 2012a).

In addition to the synoptic-scale current dynamics, tidally-driven currents are a significant component of water movement in the NWMR. Wind-driven currents become dominant during the neap tide (Pearce et al., 2003). In summer, the stratified water column and large tides can generate internal waves over the upper slope of the NWMR (Craig, 1988). As these waves pass the shelf break at about 125 m depth, the thermocline may rise and fall by up to 100 m in the water column (Holloway, 1983; Holloway & Nye, 1985). Internal waves of the NWMR are confined to water depths between 70 m and 1000 m; the dissipation energy from such waves can enhance mixing in the water column (Holloway et al., 2001).

Tides in the NWMR are semi-diurnal and have a pronounced spring-neap cycle, with tidal currents flooding towards the south-east and ebbing towards the north-west (Pearce et al., 2003). The NWMR exhibits a considerable range in tidal height, from microtidal (<2 m) south-west of Barrow Island to macrotidal (>6 m) north of Broome (Brewer et al., 2007; Holloway, 1983). Storm surges and cyclonic events can also significantly raise sea levels above predicted tidal heights (Pearce et al., 2003).

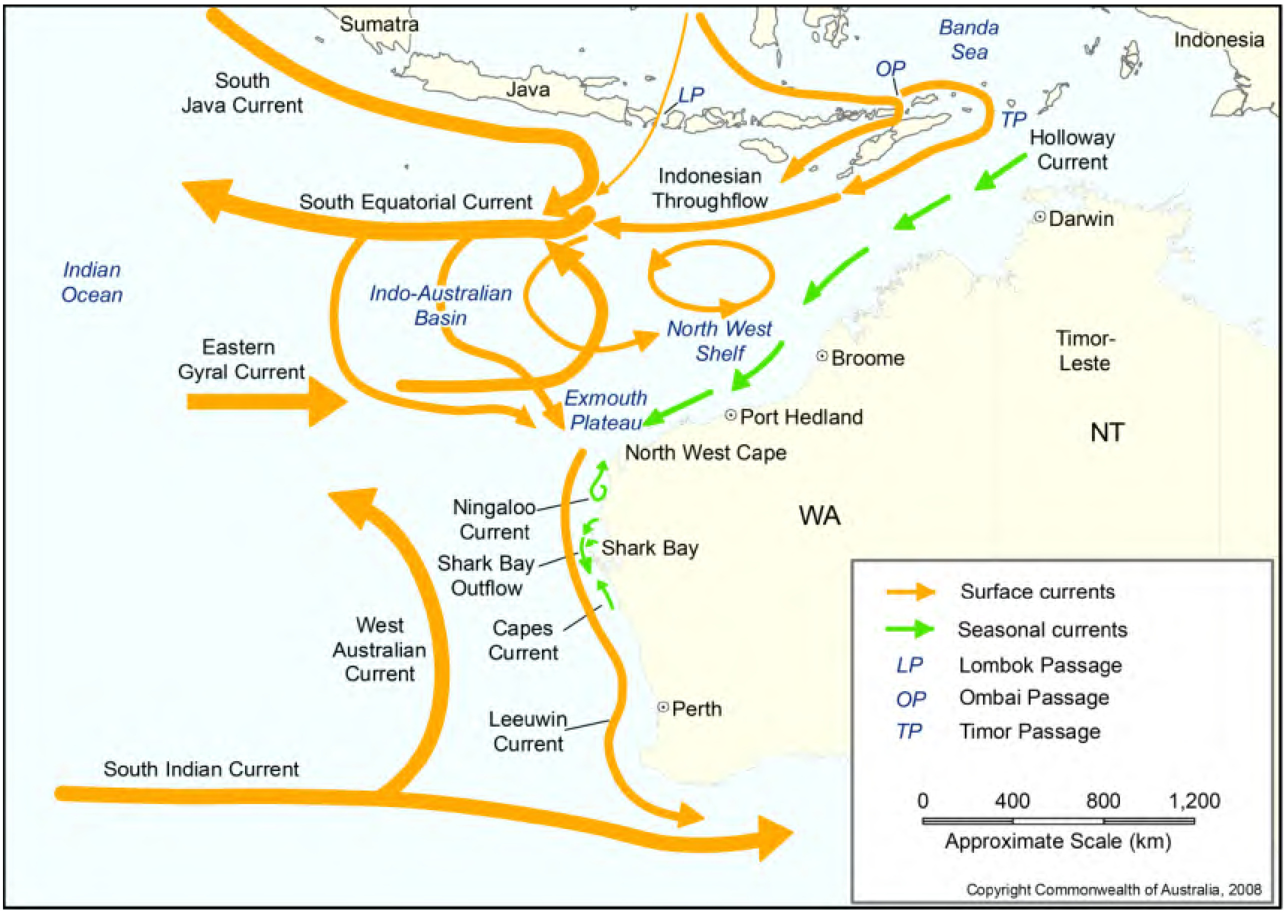

Figure 4-5: Generalised schematic of ocean circulation for wider marine region (DEWHA, 2008)

4.4.2.2 Wave Height

Datawell waverider buoys measured wave height from 1993 to 2005 near the Pluto Platform (within Area A), recording a maximum measured non-cyclonic significant wave height of 6.2 m and a combined non-cyclonic and cyclonic maximum wave height of 11.4 m.

4.4.2.3 Seawater Characteristics

The offshore, oceanic seawater characteristics of Areas A, B and C exhibit seasonal and water depth variation in temperature and salinity, which are greatly influenced by major currents in the region (**Figure 4-5**). Surface waters are relatively warm year-round, with temperatures reaching 30 °C in summer and dropping to 22 °C in winter (Pearce et al., 2003). Below the thermocline, water temperature will typically continue to decrease; depth and near-seabed temperatures are expected to be very low (<6 °C). Water quality in the NWMR is regulated by the ITF, a low-salinity water mass that plays a key role in initiating the Leeuwin Current (DSEWPaC, 2012a). It brings warm, low-nutrient, low-salinity water from the western Pacific Ocean through the Indonesian archipelago to the Indian Ocean. It is the primary driver of the oceanographic and ecological processes in the region (DEWHA, 2008). South of the NWMR, the Leeuwin Current continues to bring warm, low-nutrient, low-salinity water further south. Eddies formed by the Leeuwin Current transport nutrients and plankton communities offshore (DEWHA, 2008). During summer, the Leeuwin Current typically weakens and the Ningaloo Current develops, facilitating upwellings of cold, nutrient-rich waters onto the Northwest Province (DSEWPaC, 2012a). The bathypelagic zone is characterised by cold, oxygen and nutrient-rich water that receives very little (<1%) sunlight. Below the thermocline, water temperature typically continues to decrease with depth; near-seabed temperatures are expected to be very low (<6 °C).

4.4.2.4 Bathymetry

The bathymetry of the NWMR is characterised by four distinct zones: the inner continental shelf, the middle continental shelf, the outer shelf/continental slope and the Abyssal Plain. These divisions are made based on water depth and geomorphic features in the region (Heap and Harris, 2008). The inner continental shelf is the area from the coast to about 30 m water depth. The middle continental shelf is the area between 30 and 120 m water depth. Several deep-sea geomorphic features in the form of Abyssal Plains, marginal plateaus and sub-marine canyons provide broad-scale, biologically important seabed habitat. These have been defined as KEFs by the Commonwealth Government and are described in **Section 4.7.4**.

The North West Shelf (NWS), containing about half of Area A and a small easterly section of Area C, encompasses more than 60% of the continental shelf in the NWMR (Baker et al., 2008), gradually sloping from the coastline to the shelf break at the edge of the region. It includes water depths of 0–200 m. About half the NWS is in water depths of 50–100 m (DEWHA, 2008). The NWS includes a number of seafloor features such as submerged banks and shoals, and valley features that are thought to be morphologically distinct from other features of these types in different regions of the NWMR (DEWHA, 2008).

Area A

Area A is located on the middle of the continental shelf in depths ranging between about 40 and 1400 m. Area A is bisected (south-west to north-east) by a steep slope separating the upper and lower continental slope. Beyond this steep slope at the north-west portion of Area A, the seabed is relatively flat and featureless. High resolution bathymetric data indicates an undulating cemented surface, expressed at the seabed as a series of ridges (**Figure 4-6**).

Several steps and terraces caused by Holocene sea level changes are present in the NWMR. The most prominent of these features occurs as an escarpment along the NWS and Sahul Shelf at a depth of 125 m. This escarpment is related to an ancient sub-aerially exposed land surface and coastline (beach and dune deposits), known as the ancient coastline. A description of the Ancient Coastline KEF is provided in **Section 4.7.4**.

Area B

Area B is located entirely on the Exmouth Plateau, in water depths ranging from about 800 to 1200 m. The Exmouth Plateau is a distinctive geomorphic feature containing topographic features including terraces, canyons and pinnacles (DEWHA, 2008). The topography of the Exmouth Plateau is thought to modify deep water flow and contribute to upwelling of deep nutrient-rich waters, as well as provide conduits for moving sediment from the plateau surface to the abyss (DoEE n.d.). The Exmouth Plateau is a listed KEF and is described in **Section 4.7.4**.

Area C

Area C is located in water depths of about 150 to 1100 m. Geophysical surveying of permit area WA-28-L, located in Area C, indicates that the area consists of a relatively flat and featureless seabed at a depth of about 390 m. This contrasts with the area to the south of WA-28-L where seabed topography includes an extensive area of mega ripples and canyon features, such as the east/west oriented Enfield Canyon and the generally north/south running Enfield Escarpment (Woodside, 2014). The canyons linking the Cuvier Abyssal Plain and Cape Range Peninsula KEF is located partially within Area C and is described in **Section 4.7.4**.

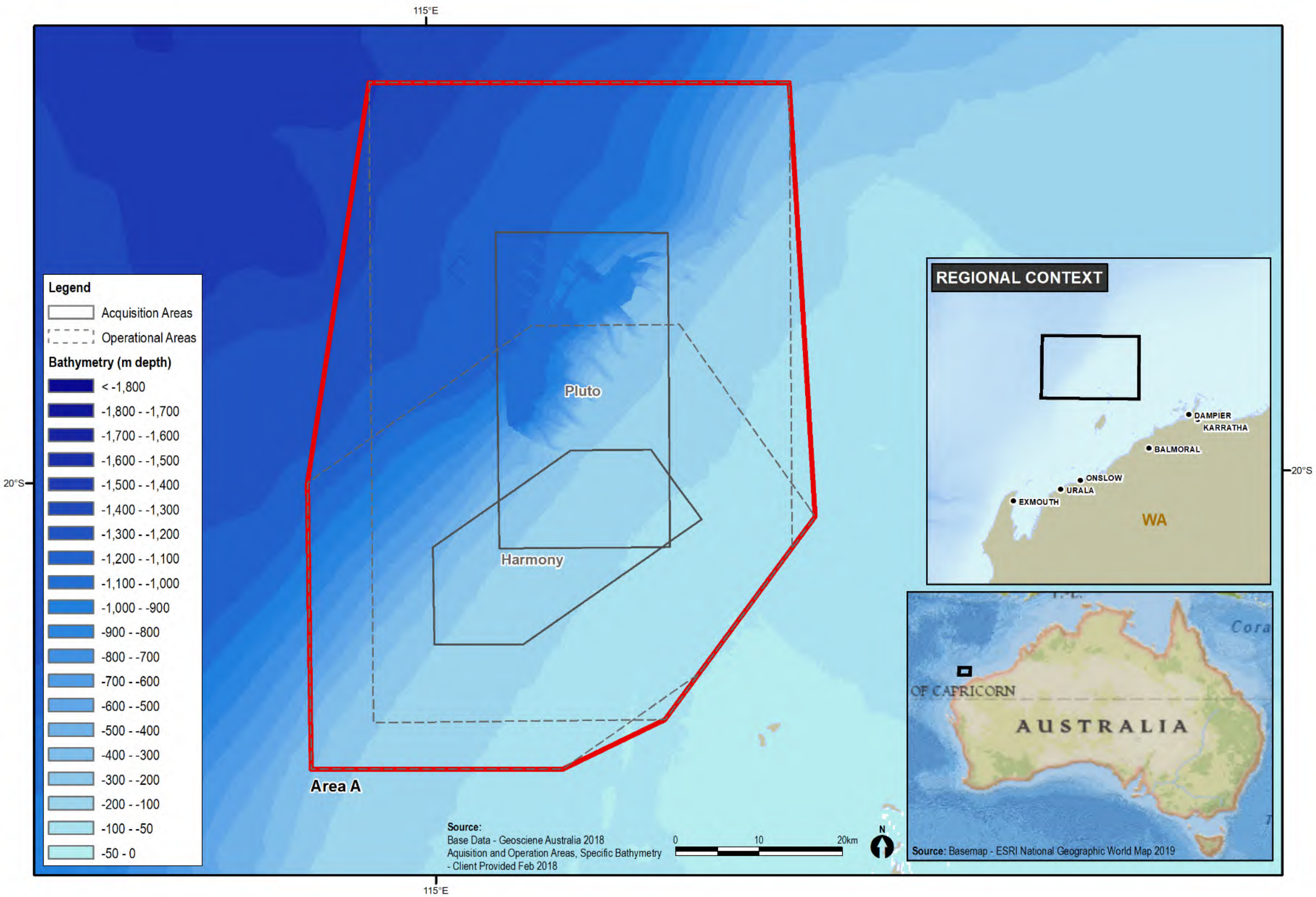

Figure 4-6: Bathymetry and seabed features of Area A (includes data from Pluto Deep Bathymetry Model AUV 3D)

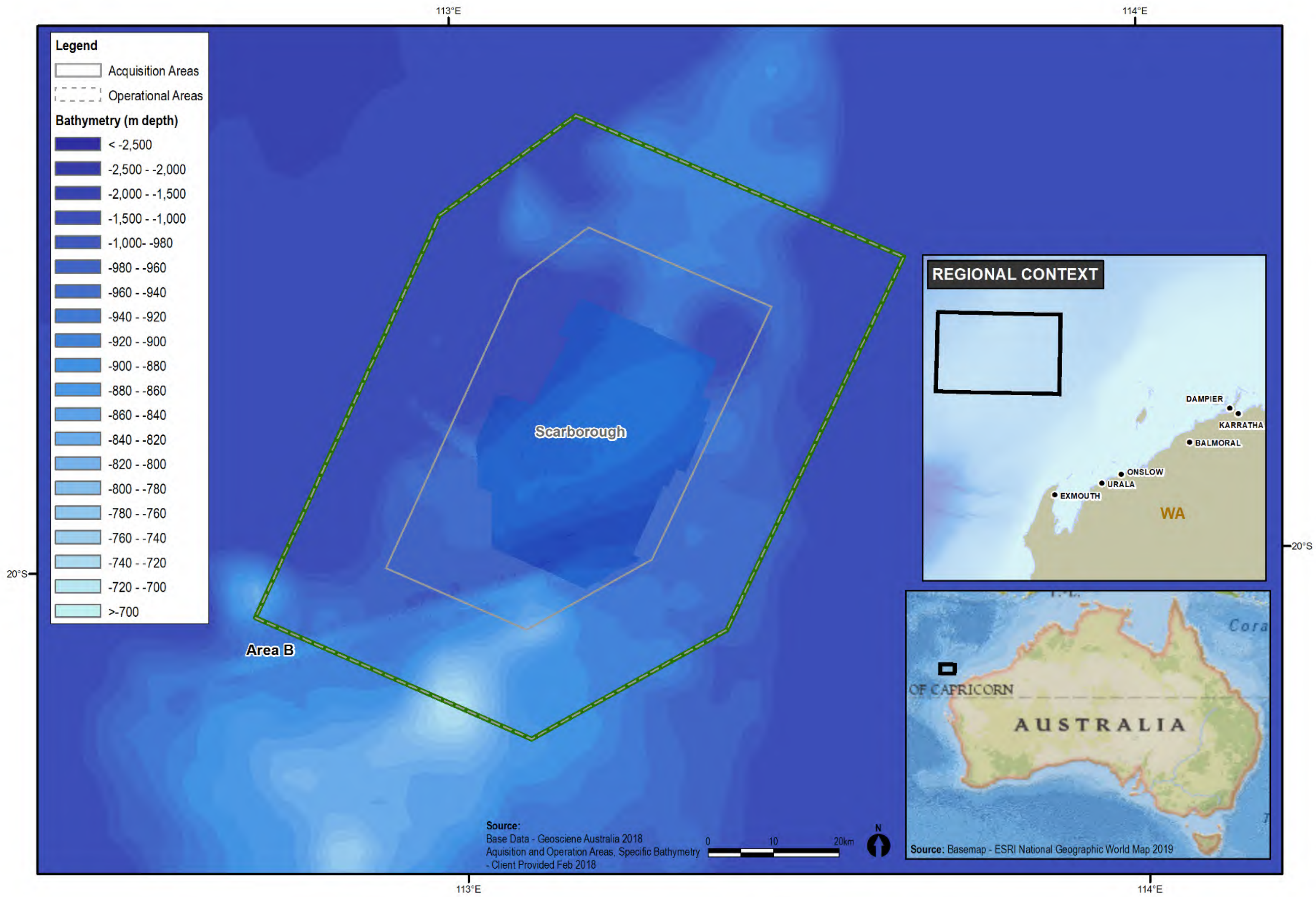

Figure 4-7: Bathymetry and seabed features of Area B (includes data from Scarborough Deep Bathymetry Model AUV 3D)

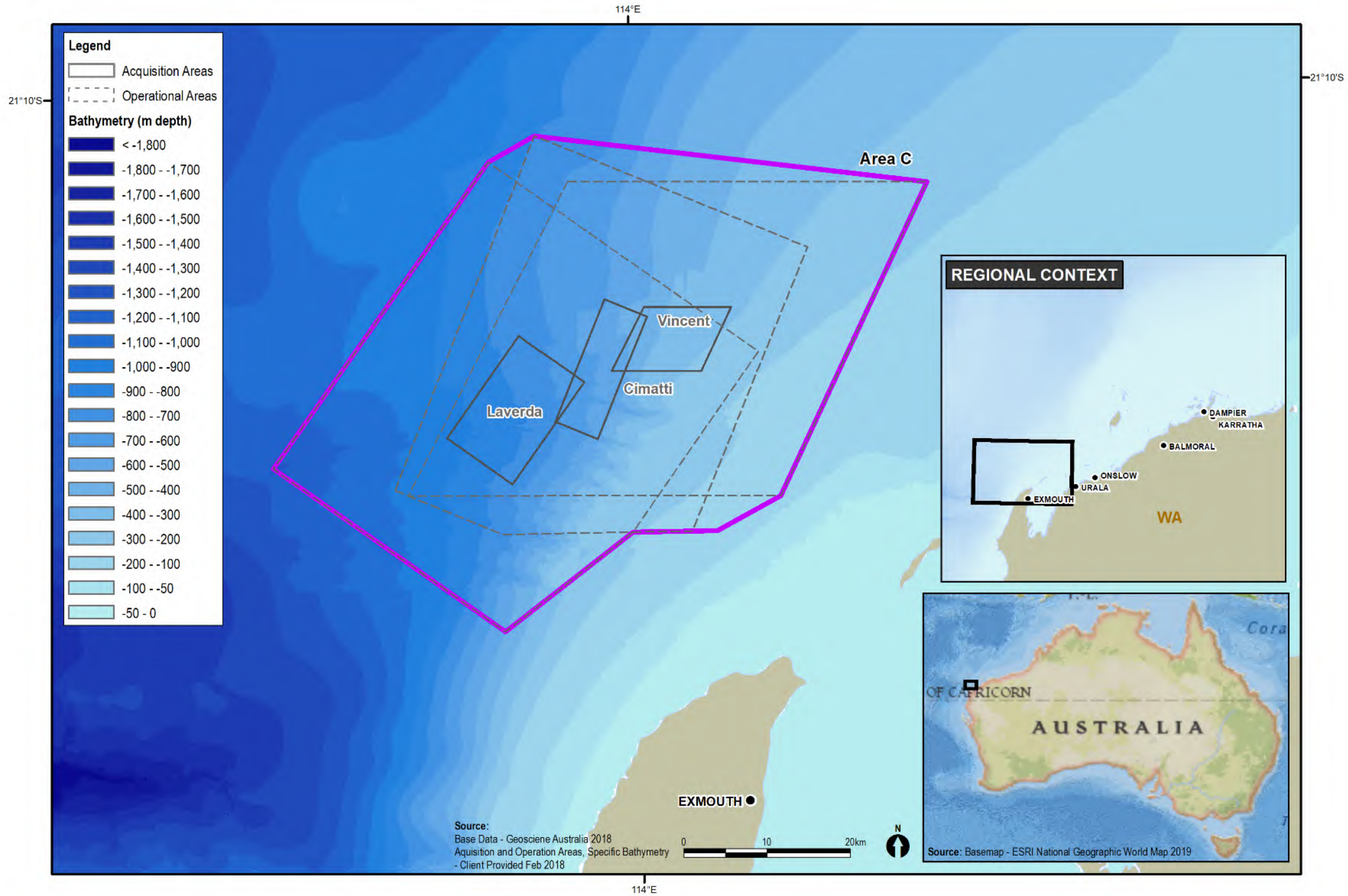

Figure 4-8: Bathymetry and seabed features of Area C (includes data from Exmouth Deep Bathymetry Model AUV 3D)

4.4.3 Marine Sediment

Beyond the shelf break of the NWMR, the proportion of fine sediments increases along the continental slope towards the Exmouth Plateau and the Abyssal Plain (Baker et al., 2008). Deepwater sediments in the Northwest Province largely comprise fine carbonate sands and silts derived from marine detritus from the water column above (Brewer et al., 2007; DEWHA, 2008). Areas along the edge of the Exmouth Plateau likely consist of deep, soft sediments travelling down the slope from shallower waters which have accumulated over the years. Sediment differentiation within the NWS occurs on a north-south gradient. Within the southern area of the NWS, sediment texture is relatively homogenous and dominated by sands, with a small proportion of gravels. Seabed sediments of the continental slope in the NWS are generally dominated by carbonate silts and muds.

Area A is dominated by soft sediment (fine to coarse sands) (Neptune Geomatics, 2010; RPS, 2010a, 2011a), similar to previous surveys within the Northwest Shelf Province and nearby fields at similar water depths (RPS Bowman Bishaw Gorham, 2004; Chevron, 2005, 2010; RPS, 2010b, 2011b). Seabed relief in areas of bare sediment consists mainly of ‘small ripples’ less than 0.1 m high, which is consistent with tidally-driven bottom currents. Sediments at Woodside’s nearby Balnaves Development field, in 135 m water depth, are fine silt and mud (RPS, 2011b). Sediments in the nearby area of the Wheatstone Platform, in 70–250 m water depths, are fine to medium sands with shell and coral fragments (Chevron, 2010).

A survey for Permit Area WA-1-R, located within Area B, found the seabed to be relatively uniform and smooth and indicative of the wider area. Deepwater areas of soft substrate typically support a low abundance, richness and diversity of benthic communities. Areas of hard substrate typically support more diverse epibenthic communities (Heyward et al., 2001). The deep water and the presence of mostly fine grained sediments with a lack of hard substrate suggests abundances and diversity will be low.

A sediment classification scheme of the Vincent Development area (based on acoustic data), located in Area C, indicated that the upper slope habitat (in depths of about 200 to 500 m) were generally composed of coarser and/or more consolidated sediments as compared to the mid-slope (500 to 1000 m). Sediments within the Enfield Canyons were found to comprise sand, silt, clays and fines.

4.4.4 Air Quality

There is a lack of air quality data for the Northwest Province and greater offshore NWMR air shed. Due to the extent of the open ocean area and the activities that are currently conducted within the Northwest Province, it is considered the ambient air quality in Areas A, B and C, and wider offshore NWMR, will be of high quality.

4.5 Biological Environment

4.5.1 Habitats

4.5.1.1 Critical Habitat – EPBC Listed

No Critical Habitats or Threatened Ecological Communities as listed under the EPBC Act are known to occur within Areas A, B or C, as indicated by the EPBC Act Protected Matters Report extracted on 17 July 2019 (**Appendix C**).

Marine Primary Producers

Seabed communities in deeper shelf waters receive insufficient light to sustain ecologically-sensitive primary producers, such as seagrasses, macroalgae or reef-building corals. Given the water depths in Area A (41 m–1390 m), Area B (884 m–1233 m) and Area C (166 m–1182 m), these benthic primary producer habitats will not occur, but are present in the wider region in locations such as Ningaloo Reef, Exmouth Gulf, the Muiron Islands, sections of the Pilbara coastline, the Browse and Montebello Island group and other islands along the Pilbara coastline.

Coral Reef

Coral reef habitats have a high diversity of corals and associated fish and other species of both commercial and conservation importance. Given the water depth range over Area A (41–1390 m), Area B (884–1233 m) and Area C (166 m–1182 m), coral reefs are not expected within Areas A, B or C. It is acknowledged that coral reef habitats are an integral part of the marine environment nearby Areas A, B or C, including:

- Ningaloo Marine Park (2 km south-east of Area C)
- Rankin Bank (16 km east of Area A)
- Muiron Islands (18 km south-east of Area C)
- Montebello Islands (27 km south-east of Area A)
- Barrow Island (48 km south of Area A).

Hard corals in the region typically have a distinct spawning season, with most species spawning during autumn (March/April) (Rosser and Gilmour, 2008; Simpson et al., 1993a). Further information about locations with coral reef habitats is provided in **Section 4.7**.

Seagrass Beds/Macroalgae

Seagrass beds and benthic macroalgae reefs are a main food source for many marine species and also provide key habitats and nursery grounds (Heck et al., 2003; Wilson et al., 2010). In the northern half of Western Australia, these habitats are restricted to sheltered and shallow waters due to large tidal movement, high turbidity, large seasonal freshwater run-off and cyclones (Department of Fisheries (DoF), 2011). No seagrass beds or macroalgae occur in Areas A, B or C as the seabed receives insufficient photosynthetically active radiation to support such communities. However, seagrass beds and macroalgae habitats are present along nearby islands and the mainland, and are widely distributed in shallow coastal waters that receive sufficient light to support them. The nearest suitable seagrass/macroalgae habitat from Area A is about 13 km to the south-east at the Montebello Islands. The nearest suitable seagrass/macroalgae habitat from Area B occurs about 14 km to the south in the Exmouth Gulf. Area C is located at least 115 km from the nearest known seagrass/macroalgae habitat (Montebello Islands). Further information about locations with seagrass and macroalgae habitats is provided in **Section 4.7**.

Mangroves

Mangrove systems provide complex structural habitats that act as nurseries for many marine species as well as nesting and feeding sites for many birds, reptiles and insects (Robertson and Duke, 1987). Mangroves also maintain sediment, nutrient and water quality within habitats and minimise coastal erosion. These coastal habitats are not found within or adjacent to Areas A, B or C, but can be found in the wider region in locations such as Ningaloo Reef, Exmouth Gulf and the Pilbara shoreline. Further information about locations with mangrove habitats is provided in **Section 4.7**.

Lifecycle Stages 'Critical' Habitats

Spawning, Nursery, Resting and Feeding Areas

Critical habitats for species conservation include spawning, nursery, resting and feeding areas. These critical habitats will vary for each species. Species-specific spawning timings and distribution for a number of key fish species within Areas A, B and C, as provided by DoF, are outlined in **Table 4-2**.

Figure 4-9 and **Figure 4-10** demonstrate the species distribution (depth range) of the blue spotted emperor, red emperor, ruby snapper, goldband snapper, Rankin cod and Spanish mackerel in the Pilbara bioregion.

Any critical habitat for protected species within Areas A, B or C, as identified by the EPBC Protected Matters Search (**Appendix C**), are outlined in **Section 4.5.2** within the relevant species sections, or within **Section 4.7**.

Table 4-2: Fish spawning timing in the North Coast bioregion

Key fish species within zone	Spawning times	Distribution	Likelihood of spawning
Goldband snapper (*Pristipomoides multidens*)	September to May (peaks January to April)	Adult goldband snapper occur in continental shelf waters at depths of 50–200 m (Steve Newman, personal communication, April 2019), often forming large schools in proximity to shoals, areas of hard flat bottom and offshore reefs. Goldband snapper are serial spawners and likely spawn every few days throughout the spawning period.	Given the known depth range of goldband snapper, spawning may occur in the shallower portions of Areas A and C. Due to water depths outside the habitat range, spawning will not occur within Area B. Temporal overlap occurs between peak spawning and the proposed surveys in Area A, and general spawning in Area C.
Rankin cod (*Epinephelus multinotatus*)	June to December	Rankin cod are a demersal species distributed along the warm coastal waters of North-west Western Australia from the Abrolhos Islands to Cape Leveque. Adult Rankin cod are found at depths of 10–150 m (Steve Newman, personal communication, April 2019), usually in association with drop-offs and deep rocky reefs, while juveniles are generally found in inshore coral reefs.	Given the known depth range of Rankin cod, spawning may occur in the shallower portions of Areas A and C. Due to water depths outside the habitat range, spawning will not occur within Area B. Temporal overlap occurs between Rankin cod spawning and the proposed surveys, limited to the month of December.
Red emperor (*Lutjanus sebae*)	August to May (peaks in October and March)	Red emperor are widely distributed across the continental shelf and found in depths of 10–180 m (Steve Newman, personal communication, April 2019). The species is associated with reefs, lagoons, epibenthic communities, limestone sand flats and gravel patches (Newman et al., 2018; DoF, 2013). During the spawning period, females release multiple batches of eggs over a wide area.	Given the known depth range of red emperor, spawning may occur in the shallower portions of Areas A and C. Due to water depths outside the habitat range, spawning will not occur within Area B. Temporal overlap occurs between general and/or peak spawning and proposed surveys in Areas A and C.

Key fish species within zone	Spawning times	Distribution	Likelihood of spawning
Spanish mackerel (*Scomberomorus commerson*)	September to January	Spanish mackerel are a widely distributed pelagic species found throughout Indo-West Pacific waters in depths of up to at least 50 m (Steve Newman, personal communication, April 2019). Spanish mackerel spawning occurs in coastal waters. They are serial spawners. Alongshore dispersal of eggs maintains genetic homogeneity. Oil within the eggs keeps them near the surface where water temperatures are higher and where hatchlings have greater access to plankton. Eggs hatch 24 hours after fertilisation.	Given the known depth range of Spanish mackerel, spawning may occur in the shallower portions of Areas A and C. Due to water depths outside the habitat range, spawning will not occur within Area B. Temporal overlap occurs between Spanish mackerel spawning and the proposed surveys in Area A.
Blue-spotted emperor (*Lethrinus punctulatus*)	June to April (two peak periods July to October, March)	The blue-spotted emperor is distributed primarily in WA waters from around Geraldton to Darwin. The species is found in depths from 5–110 m (Steve Newman, personal communication, April 2019), often in association with shallow reef, sand and mud areas. Low levels of heterogeneity indicate extensive connectivity between populations over large distances (Johnson et al., 1993; Moran et al., 1993).	Given the known depth range of blue-spotted emperor, spawning may occur in the shallower portions of Area A. Due to water depths outside the habitat range, spawning is unlikely to occur in Area C and will not occur within Area B. Temporal overlap occurs between Area A and the 11-month spawning period of the blue spotted emperor. No temporal overlap occurs between Area A and the peak spawning period of the blue-spotted emperor.
Ruby snapper (*Etelis carbunculus*)	December to April (peak January to March)	The ruby snapper is distributed in tropical waters of the Indo-West and Central Pacific oceans. They are known to inhabit continental shelf and slope waters in depths of150–480 m (Australian Museum, 2018; Steve Newman personal communication, April 2019).	

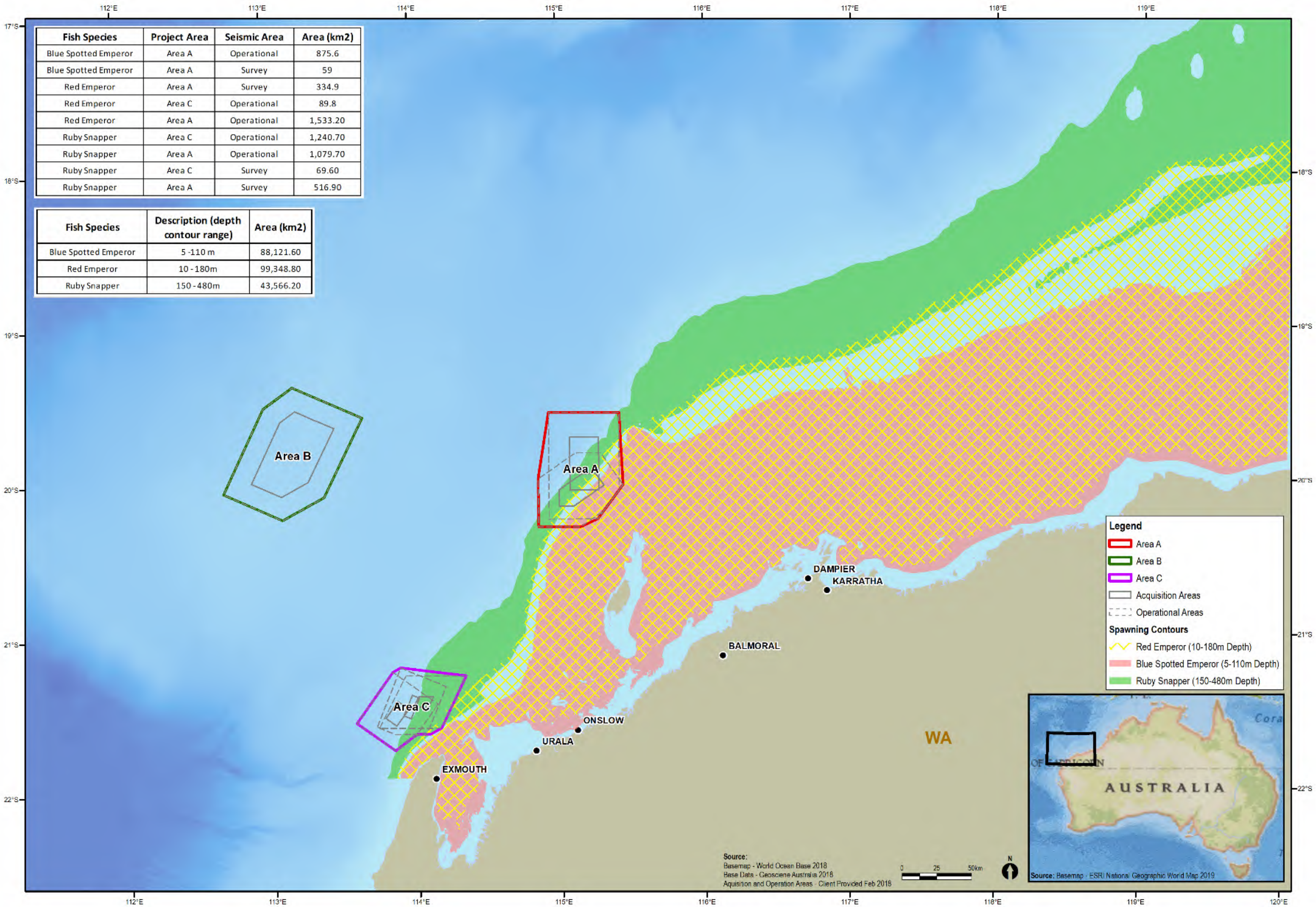

Figure 4-9: Species distribution (depth range) of blue spotted emperor, red emperor and ruby snapper in the Pilbara bioregion

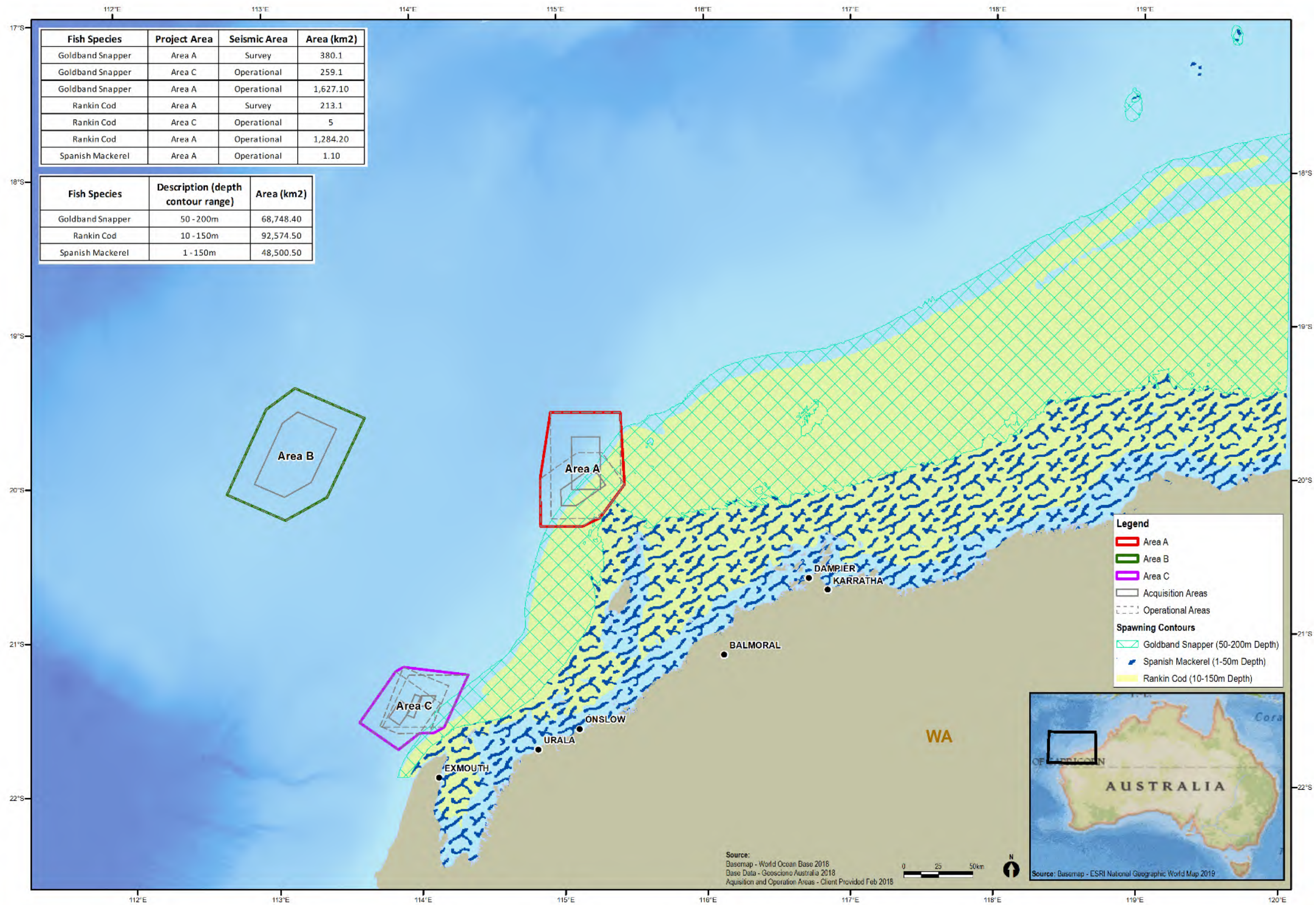

Figure 4-10: Species distribution (depth range) of goldband snapper, Rankin cod and Spanish mackerel in the Pilbara bioregion

Migration Corridors

Many marine species including cetaceans, whale sharks and migratory seabirds and shorebirds migrate seasonally between feeding, breeding and nursery habitats via migration corridors. Any migration corridor for a protected species that passes through Areas A, B or C is outlined in **Section 4.5.2** within the relevant species section.

4.5.1.2 Other Communities/Habitats

Benthic Communities

Area A

Area A is located on both the upper and lower continental slope within the Northwest Province and the Northwest Shelf Province. Benthic slope communities of the Northwest Province comprise both tropical and temperate species with a north-south gradient (Brewer et al., 2007). In general, benthic fauna are closely associated with substrate type, with deep water areas of soft substrate like those found in Area A typically supporting a low abundance, richness and diversity of benthic communities, and areas of hard substrate typically supporting more diverse epibenthic communities (Heyward et al., 2001). Although little information exists on benthic communities over the Northwest Province, the presence of soft sediments and limited hard substrate suggests the region may support some patchy distributions of filter feeders and other epifauna, including mobile epibenthos (e.g. sea cucumbers, ophiuroids, echinoderms, polychaetes and sea-pens (Brewer et al., 2007). The benthic communities in the Northwest Shelf Province have been described as supporting low density communities of bryozoans, molluscs and echinoids. Between Port Hedland and the North West Cape, a number of high diversity fish communities have been identified (Fox and Beckley, 2005). Typical fish species between depths of 100 and 200 m include goatfish, lizardfish, ponyfish and threadfin bream.

Area A overlaps with the Ancient Coastline at 125 m Depth Contour KEF, which is believed to be characterised by rocky escarpments that provide biologically important habitat in areas otherwise dominated by soft sediments (further detailed in **Sections 4.7.1** and **4.7.4**).

At Rankin Bank (about 16 km from Area A), filter feeders also make up about 3% of the benthic cover, with sponges among the most abundant filter feeders (Australian Institute of Marine Science (AIMS), 2014). Benthic communities at Rankin Bank are similar to those recorded at other shoals in the NWMR (AIMS, 2014) and are considered to be representative of the broader benthic communities within the region.

Area B

A deep water remotely operated vehicle (ROV) survey conducted by Woodside in waters between 821 and 2038 m depths off the coast of WA identified benthic associated species across four distinct sites. At the survey location most consistent with the depths, sediment and geomorphology of Area B, benthic fauna encountered were mainly echinoderms (e.g. sea cucumbers and sea stars) (Bryce et al., 2015). Distinct signs of infaunal bioturbators and potential mounds created by burrowing fish were also noted; however, abundance was found to be generally low (Bryce et al., 2015). Benthic filter feeders and other epifauna and infauna are likely to inhabit Area B; however, water depths and the presence of mostly fine grained sediments with a lack of hard substrate suggest abundances and diversity will be low, and consistent with much of the broader Northwest Province.

Area B lies within the Exmouth Plateau KEF, an area that contributes to the productivity of the region driven by upwelling of deep nutrient-rich waters. The plateau’s surface is rough and undulating at 900–1000 m depth (DoEE n.d.). The Exmouth Plateau is generally an area of low habitat heterogeneity; however, it is likely to be an important area of biodiversity as it provides an extended area offshore for communities adapted to depths of around 1000 m (DoEE n.d.). The Exmouth Plateau KEF is discussed in detail in **Section 4.7.4**.

Area B overlaps entirely with the Northwest Province. Benthic communities typically associated with the Northwest Province are described above (Area A).

Area C

Area C overlaps three bioregions: the Northwest Province (91%), Central Western Shelf Transition (6%) and Northwest Shelf Province (3%). Benthic communities typically associated with the Northwest Province and Northwest Shelf Province have been described above (Area A).

Benthic fish communities typically associated with the Central Western Shelf Transition include both tropical and temperate species, due to the southward-flowing surface currents bringing tropical Indo-Pacific organisms into the bioregion. However, the presence of the northward-flowing Leeuwin Undercurrent also transports temperate species from more southern areas (DEWHA, 2008; Brewer et al., 2007). North West Cape has therefore been described as a boundary point for a transition in demersal shelf and slope fish communities from tropical dominated communities to the north and temperate communities to the south (DEWHA, 2008; Last et al., 2005).

The continental slope between North West Cape and the Montebello Trough has been identified as one of the most diverse slope habitats of Australia, with over 508 fish species and the highest number of endemic species (76) of any Australian slope habitat. However, the reasons for this high level of endemism are not understood (DEWHA, 2008). The soft-bottom habitat of the canyons is also likely to support important assemblages of epibenthic species (DEWHA, 2008).

2 km from Area C, the Commonwealth waters of Ningaloo Marine Park have been identified as an area of high sponge diversity (Department of Conservation and Land Management (CALM), 2005; Rees et al., 2004). Filter feeder communities in the wider region are primarily located in the deeper waters of the Ningaloo Reef system as well as the Muiron Islands and nearshore waters of the Pilbara Islands.

Plankton

Phytoplankton within Areas A, B and C are generally expected to reflect the conditions of the NWMR. Primary productivity of the NWMR appears to be largely driven by offshore influences (as reported by Brewer et al., 2007), with periodic upwelling events and cyclonic influences driving coastal productivity with nutrient recycling and advection. There is a tendency for offshore phytoplankton communities in the NWMR to be characterised by smaller taxa (e.g. bacteria), whereas shelf waters are dominated by larger taxa such as diatoms (Hanson et al., 2007).

Area A

Zooplankton within Area A is expected to be similar to offshore waters in the Northwest Shelf Province and may include organisms that complete their lifecycle as plankton (e.g. copepods, euphausiids) as well as larval stages of other taxa such as fishes, corals and molluscs. Peaks in zooplankton, such as mass coral spawning events (typically in March and April) (Rosser and Gilmour, 2008; Simpson et al., 1993), and fish larvae abundance (CALM, 2005) can occur throughout the year.

Area B

Overall biological productivity above the Exmouth Plateau is generally considered to be low, primarily due to the overriding influence of low nutrient tropical waters (DEWHA, 2008). However, the plateau can force upwelling of deeper nutrient-rich waters and result in periods of increased productivity. Satellite imagery has identified the northern and southern, boundaries of the plateau as areas of increased productivity (DEWHA, 2008). However, these areas lie outside of Area B, which lies towards the centre of the plateau.

Area C

Along the shelf edge of the Ningaloo Reef 2 km from Area C, peak primary productivity occurs in late summer/early autumn. It also links to a larger biologically productive period in the area that includes mass coral spawning events, and peaks in zooplankton and fish larvae abundance (CALM, 2005) with periodic upwelling throughout the year. The canyons linking the Cuvier Abyssal Plain and Cape Range Peninsula KEF (see **Section 4.7.4**) are believed to support the productivity and species richness of Ningaloo Reef through upwelling at the canyon heads creating conditions for enhanced productivity (DSEWPaC, 2012a). The narrow shelf width near the canyons (about 10 km), combined with the interaction of the Leeuwin Current, Leeuwin Undercurrent and the Ningaloo Current, also facilitate upwelling of nutrient-rich waters and helps drive productivity in the region.

Pelagic and Demersal Fish Populations

Fish species in the NWMR comprise small and large pelagic fish as well as demersal species. Small pelagic fish inhabit a range of marine habitats, including inshore and continental shelf waters. They feed on pelagic phytoplankton and zooplankton and represent a food source for a wide variety of predators including large pelagic fish, sharks, seabirds and marine mammals (Mackie et al., 2007). Large pelagic fish in the NWMR include commercially targeted species such as mackerel, wahoo, tuna, swordfish and marlin. Large pelagic fish are typically widespread, found mainly in offshore waters and often travel extensively.

Area A

Two KEFs have been identified within Area A: the Continental Slope Demersal Fish Communities and the Ancient Coastline at 125 m Depth Contour. The continental slope demersal fish communities are a listed KEF due to notable diversity of the demersal fish assemblages and high levels of endemism (DSEWPaC, 2012a). The Ancient Coastline at the 125 m Depth Contour KEF provides a hard substrate in an otherwise soft sediment environment and therefore may provide sites for sessile organisms such as sponges corals, crinoids, molluscs, echinoderms (DoEE n.d.). Both the continental slope and ancient coastline KEFs are discussed in detail in **Section 4.7.4**.

The Montebello Australian Marine Park (overlapping Area A) and Rankin Bank (16 km east of Area A) have also been identified as supporting high demersal fish richness and abundance, despite their isolated locations. Further information about the fish communities of the Montebello Australian Marine Park (AMP) and Rankin Bank and other areas supporting diverse fish assemblages within the waters surrounding Area A is provided in **Section 4.7**.

Pelagic fish occurrence within Area A is generally expected to reflect the conditions of the wider offshore NWMR.

Area B

Fish assemblage species richness in the NWMR has been shown to decrease with depth (Last et al., 2005) and positively correlate with habitat complexity, with more complex habitat supporting greater species richness and abundance than bare areas (Gratwicke and Speight, 2005). Area B comprises predominantly featureless, flat, soft sediment seabed that may have hard substrates associated with the Exmouth Plateau KEF. Consequently, the fish fauna are not expected to be abundant and diversity is expected to be limited due to depth and the expected lack of hard substrate/habitat complexity.

At the northern and southern shelf break regions of the Exmouth Plateau, outside of Area B, strong tidal activity and internal waves cause upwellings of deep water and increased productivity, as observed from satellite images of chlorophyll concentrations (Brewer et al., 2007). As a result, these areas have been shown to support high catch rates of commercial fish, although evidence suggests these high productivity events are sporadic (Brewer et al., 2007). These events may result in increased fish abundance and diversity inside Area B. However, overall pelagic and demersal fish populations within Area B are still expected to be of low abundance and diversity.

Area C

Area C contains known locations associated with high levels of fish abundance, including diverse demersal communities occurring within KEFs (Continental Slope Demersal Fish Communities, the Ancient Coastline at 125 m Depth Contour, and Canyons Linking the Cuvier Abyssal Plain and the Cape Range Peninsula), as well as large pelagic species occurring in association with Ningaloo Reef. **Section 4.7.4** describes demersal fish communities associated with these KEFs.

Diversity of demersal fish assemblages on the continental slope is among the highest in Australia (>500 species; up to 76 of these are endemic), with the North West Cape region cited as a transition between tropical and temperate demersal and continental slope fish assemblages (Last et al., 2005). The canyons on the slope of this bioregion act as conduits for transporting sediment and channelling deeper waters up onto the slope and towards the adjacent shelf (DEWHA, 2008). In particular, biological productivity at the head of the Cape Range Canyon is thought to support aggregations of pelagic species such as whale sharks and is thought to be a significant contributor to the biodiversity of the adjacent Ningaloo Reef (DEWHA, 2008). Pelagic species in Area C may also include billfish species that are important recreational game fishing targets, including blue marlin and sailfish (see **Section 4.6.5** for information about tourism and recreation).

4.5.2 Species

4.5.2.1 Protected Species

The EPBC Act Protected Matters Search Tool has been used to identify listed species that may occur within and within 100 km of Areas A, B and C. It should be noted that the EPBC Act Protected Matters Search Tool is a general database that conservatively identifies areas in which protected species have the potential to occur. Information about species in the wider region is included in **Section 4.7**. The species described in both this section and **Section 4.7** inform the assessment of unplanned events in **Section 6.7** that are not confined to the three Areas (i.e. hydrocarbon spills).

A total of 42 EPBC Act listed species considered to be MNES (i.e. listed as Threatened or Migratory) were identified as potentially occurring within Areas A, B and C (**Table 4-3**). The full list of marine species identified from the Protected Matters Search is provided in the EPBC Protected Matters Search Report (**Appendix C**).

An additional bird species, the wedge-tailed shearwater, was found to have overlapping BIAs with Areas A and B; however, it is not considered an MNES. The wedge-tailed shearwater is considered a species of conservation value but is not currently listed as a threatened or migratory species. BIAs overlapping Areas A, B and C for this species are described in **Section 4.5.2**, but the species was excluded from further consideration.

Table 4-3: EPBC Act listed threatened and migratory marine species potentially occurring within Area A, B or C

Species Name	Common Name	Threatened Status	Migratory Status	Area A	Area B	Area C
Mammals						
Balaenoptera borealis	Sei whale	Vulnerable	Migratory	Y	Y	Y
Balaenoptera musculus	Blue whale	Endangered	Migratory	Y	Y	Y
Balaenoptera physalus	Fin whale	Vulnerable	Migratory	Y	Y	Y
Megaptera novaeangliae	Humpback whale	Vulnerable	Migratory	Y	Y	Y
Balaenoptera bonaerensis	Antarctic minke whale	N/A	Migratory		Y	Y
Balaenoptera edeni	Bryde's whale	N/A	Migratory	Y	Y	Y
Orcinus orca	Killer whale	N/A	Migratory	Y	Y	Y
Physeter macrocephalus	Sperm whale	N/A	Migratory	Y	Y	Y
Balaena glacialis australis	Southern right whale	Endangered	Migratory			Y
Sousa chinensis	Indo-pacific humpback dolphin	N/A	Migratory	Y		
Tursiops aduncus (Arafura/Timor Sea populations)	Spotted bottlenose dolphin (Arafura/Timor Sea populations)	N/A	Migratory	Y		Y
Dugong dugon	Dugong	N/A	Migratory	Y		Y
Reptiles						
Caretta caretta	Loggerhead turtle	Endangered	Migratory	Y	Y	Y
Chelonia mydas	Green turtle	Vulnerable	Migratory	Y	Y	Y
Dermochelys coriacea	Leatherback turtle	Endangered	Migratory	Y	Y	Y
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Migratory	Y	Y	Y
Natator depressus	Flatback turtle	Vulnerable	Migratory	Y	Y	Y
Aipysurus apraefrontalis	Short-nosed sea snake	Critically endangered	N/A	Y		Y
Sharks and Rays						
Carcharodon carcharias	White shark, great white shark	Vulnerable	Migratory	Y	Y	Y
Isurus oxyrinchus	Shortfin mako	N/A	Migratory	Y	Y	Y

Species Name	Common Name	Threatened Status	Migratory Status	Area A	Area B	Area C
Isurus paucus	Longfin mako	N/A	Migratory	Y	Y	Y
Anoxypristis cuspidata	Narrow sawfish	N/A	Migratory	Y		Y
Manta alfredi	Reef manta ray	N/A	Migratory	Y		Y
Manta birostris	Giant manta ray	N/A	Migratory	Y	Y	Y
Pristis clavata	Dwarf sawfish	Vulnerable	Migratory	Y		Y
Pristis zijsron	Green sawfish	Vulnerable	Migratory	Y		Y
Rhincodon typus	Whale shark	Vulnerable	Migratory	Y		Y
Carcharias taurus	Grey nurse shark (west coast population)	Vulnerable	N/A	Y		Y
Lamna nasus	Porbeagle mackerel shark	N/A	Migratory			Y
Avifauna						
Calidris canutus	Red knot, knot	Endangered	Migratory	Y	Y	Y
Actitis hypoleucos	Common sandpiper	N/A	Migratory	Y	Y	Y
Anous stolidus	Common noddy	N/A	Migratory	Y	Y	Y
Calidris acuminata	Sharp-tailed sandpiper	N/A	Migratory	Y	Y	Y
Calidris melanotos	Pectoral sandpiper	N/A	Migratory	Y	Y	Y
Fregata ariel	Lesser frigatebird	N/A	Migratory	Y	Y	Y
Fregata minor	Great frigatebird	N/A	Migratory	Y		
Calidris ferruginea	Curlew sandpiper	Critically endangered	Migratory	Y		Y
Macronectes giganteus	Southern giant-petrel	Endangered	Migratory	Y	Y	Y
Numenius madagascariensis	Eastern curlew	Critically endangered	Migratory	Y		Y
Pterodroma mollis	Soft-plumaged petrel	Vulnerable	N/A			Y
Sternula nereis	Australian fairy tern	Vulnerable	N/A	Y		Y
Ardenna carneipes	Flesh-footed shearwater	N/A	Migratory			Y
Calonectris leucomelas	Streaked shearwater	N/A	Migratory	Y		Y

Species Name	Common Name	Threatened Status	Migratory Status	Area A	Area B	Area C
Pandion haliaetus	Osprey	N/A	Migratory	Y		Y
Limosa lapponica	Bar-tailed godwit	Vulnerable	N/A	Y		
Apus pacificus	Fork-tailed swift	N/A	Migratory	Y		
Arfenna pacifica	Wedge-tailed shearwater	N/A	Migratory	Y		
Thallasarche impavida	Campbell albatross	Vulnerable	N/A			Y
Hydroprogne caspia	Caspian tern	N/A	Migratory			Y
Onychoprion anaethetus	Bridled tern	N/A	Migratory			Y
Sterna dougalii	Rosete tern	N/A	Migratory			Y

4.5.2.2 Listed Threatened Species Recovery Plans

The requirements of the species recovery plans and conservation advices (**Table 4-4**) will be considered to identify any requirements that may apply to the risk assessment (**Section 5**). Recovery plans are enacted under the EPBC Act and remain in force until the species is removed from the threatened list. Conservation advice provides guidance on immediate recovery and threat abatement activities that can be performed to facilitate the conservation of a listed species or ecological community.

Table 4-4 outlines the recovery plans and conservation advices relevant to those species identified by the EPBC Protected Matters Search (**Table 4-3**) as potentially occurring within or using habitat in Areas A, B or C and summarises the key threats to those species.

Table 4-4: Conservation advice for EPBC Act listed species considered during environmental risk assessment and their relevance to Areas A, B and C

Species/ sensitivity	Recovery plan/ conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant conservation actions	Relevant Area(s)
All vertebrate fauna				
All vertebrate fauna	Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (Department of Environment (DoEE), 2018)	Marine debris	Identify offshore installations such as oil rigs as a potential source of marine debris.	A, B and C
Marine Mammals				
Sei Whale	Conservation advice *Balaenoptera borealis* sei whale (Threatened Species Scientific Committee, 2015a)	Noise interference	Assess and manage acoustic disturbance.	A, B and C
		Vessel disturbance	Assess and manage physical disturbance and development activities.	A, B and C
Blue Whale	Conservation management plan for the blue whale: *A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999* 2015–2025 (Commonwealth of Australia, 2015a)	Noise interference	Assess and address anthropogenic noise.	A and C
		Vessel disturbance	Minimise vessel collision.	
Fin Whale	Conservation advice *Balaenoptera physalus* fin whale (Threatened Species Scientific Committee, 2015b)	Noise interference	Once the spatial and temporal distribution (including BIAs) of fin whales is further defined, assess the impacts of increasing anthropogenic noise (including seismic surveys, port expansion, and coastal development) on this species.	A, B and C

Species/ sensitivity	Recovery plan/ conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant conservation actions	Relevant Area(s)
		Vessel disturbance	Develop a national vessel strike strategy that investigates the risk of vessel strikes on fin whales and also identifies potential mitigation measures. Ensure all vessel strike incidents are reported in the National Vessel Strike Database.	A, B and C
Humpback Whale	Approved Conservation Advice for *Megaptera novaeangliae* (humpback whale) (Threatened Species Scientific Committee, 2015c)	Noise interference	For actions involving acoustic impacts (such as pile driving, explosives) on humpback whale calving, resting, feeding areas, or confined migratory pathways site, conduct specific acoustic modelling (including cumulative noise impacts).	A, B and C
		Vessel disturbance	Ensure the risk of vessel strike on humpback whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required, appropriate mitigation measures are implemented to reduce the risk of vessel strike.	A
Southern Right Whale	Conservation management plan for the southern right whale: a recovery plan under the *Environment Protection and Biodiversity Conservation Act 1999* 2011–2021 (DSEWPaC, 2012b)	Noise interference	Assess and address anthropogenic noise: shipping, industrial and seismic surveys.	C
		Vessel disturbance	Address vessel collisions.	
Reptiles				
Loggerhead Turtle, Hawksbill Turtle, Green Turtle and Flatback Turtle	Recovery plan for marine turtles in Australia (DoEE, 2017)	Vessel disturbance	Vessel interactions identified as a threat; no specific management actions relating to vessels prescribed in the plan.	A, B and C
		Light pollution	Minimise light pollution. Identify the cumulative impact on turtles from multiple sources of onshore and offshore light pollution.	
		Acute chemical discharge (oil pollution)	Ensure spill risk strategies and response programs include management for turtles and their habitats.	

Species/ sensitivity	Recovery plan/ conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant conservation actions	Relevant Area(s)
		Noise interference, identified as: • moderate consequence and unknown likelihood of occurrence for green turtle NWS stock • minor consequence and possible likelihood of occurrence for hawksbill turtle WA stock • minor consequence and likely likelihood of occurrence for loggerhead turtle WA stock and flatback turtle Pilbara stock.	Seismic noise identified as a threat; no specific management actions in relation to vessels prescribed in the plans.	
Leatherback Turtle, Leathery Turtle	Approved conservation advice for *Dermochelys coriacea* (Leatherback Turtle) (Threatened Species Scientific Committee, 2008a) Recovery plan for marine turtles in Australia (DoEE, 2017)	Vessel disturbance	No explicit relevant management actions; vessel strikes identified as a threat.	A, B and C
Short-nosed Sea snake	Approved Conservation Advice for *Aipysurus apraefrontalis* (Short-nosed Sea Snake) (DSEWPaC, 2011)	Habitat degradation/ modification	None applicable.	A and C
Sharks and Rays				
Great White Shark	Recovery plan for the white shark (*Carcharodon carcharias*) (DSEWPaC, 2013)	No additional threats identified (ex. marine debris)	None applicable.	A, B and C
Dwarf Sawfish, Green Sawfish	Approved conservation advice for *Pristis clavata* (dwarf sawfish) (Threatened Species Scientific Committee, 2009)	Habitat degradation/ modification	No explicit relevant management actions; habitat loss, disturbance and modification identified as threats.	A and C

Species/ sensitivity	Recovery plan/ conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant conservation actions	Relevant Area(s)
	Approved Conservation Advice for Green Sawfish (Threatened Species Scientific Committee, 2008b)		No explicit relevant management actions; habitat loss, disturbance and modification identified as threats.	
	Sawfish and river shark multispecies recovery plan (Commonwealth of Australia, 2015b)		Identify risks to important sawfish and river shark habitat and measures needed to reduce those risks.	A and C
Whale Shark	Conservation advice *Rhincodon typus* whale shark (Threatened Species Scientific Committee, 2015d)	Vessel disturbance	Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whales shark aggregations and along the northward migration route that follows the northern Western Australian coastline along the 200 m isobath.	A and C
	Whale shark (*Rhincodon typus*) recovery plan 2005–2010[4] (DEH, 2005a)	Habitat degradation/ modification	No explicit relevant management actions; seasonal aggregations of Ningaloo recognised as important habitat.	
Grey Nurse Shark (west coast population)	Recovery Plan for the Grey Nurse Shark (*Carcharias taurus*) (DoEE, 2014)	No additional threats identified (ex. marine debris)	None applicable.	A and C
Seabirds				
Red Knot	Conservation advice *Calidris canutus* red knot (Threatened Species Scientific Committee, 2016a)	Habitat degradation/ modification	No explicit relevant management actions; oil pollution recognised as a threat.	A, B and C
Curlew Sandpiper	Conservation advice *Calidris ferruginea* curlew sandpiper (DoE, 2015a)	Habitat degradation/ modification (oil pollution)	No explicit relevant management actions; oil pollution recognised as a threat.	A and C
Eastern Curlew	Conservation advice *Numenius madagascariensis* eastern curlew (DoE, 2015b)			A and C
Southern Giant-Petrel	National recovery plan for threatened albatrosses and giant petrels 2011–2016 (DSEWPaC, 2011a)	No additional threats identified (ex. marine debris)	No explicit relevant management actions; oil pollution recognised as a threat.	A, B and C

[4] While the whale shark (*Rhincodon typus*) recovery plan ceased to be in effect on 1 October 2015, the conservation advice in this plan was considered to inform the context of the environmental risk assessment for the Petroleum Activities Program.

Species/ sensitivity	Recovery plan/ conservation advice (date issued)	Key threats identified in the recovery plan/ conservation advice	Relevant conservation actions	Relevant Area(s)
Soft-plumaged Petrel	Conservation advice *Pterodroma mollis* soft-plumage petrel (Threatened Species Scientific Committee, 2015e)	Habitat degradation and modifications	No explicit relevant management actions.	Area C
Australian Fairy Tern	Conservation advice for *Sterna nereis* (Fairy tern) (Threatened Species Scientific Committee, 2011)	Habitat degradation/ modification (oil pollution)	Ensure appropriate oil-spill contingency plans are in place for the subspecies' breeding sites which are vulnerable to oil spills.	A and C
Common Sandpiper, Red Knot, Pectoral Sandpiper, Sharp-tailed Sandpiper	Wildlife conservation plan for migratory shorebirds (Commonwealth of Australia, 2015c)	Habitat degradation/ modification (oil pollution)	No explicit relevant management actions; oil spills recognised as a threat.	A, B and C

4.5.2.3 Biologically Important Areas

A review of the Conservation Values Atlas identified BIAs for several species that spatially overlap Areas A and/or C. No BIAs were identified within Area B. The closest BIA to Area B is the pygmy blue whale migration BIA, located about 27 km to the east (**Figure 4-11**). BIAs are further detailed within relevant species descriptions below.

Area A

Area A overlaps the following BIAs:

- Pygmy blue whale migration – annual seasonal migration with peak past Exmouth towards Indonesia (April to August), southerly return following the WA coastline (October to late January) (**Figure 4-11**).
- Flatback turtle internesting – turtle internesting buffer zone BIA at Montebello/Browse Island (peak period in December and January) (**Figure 4-13**).
- Whale shark foraging – foraging occurs northward from the Ningaloo Marine Park along the 200 m isobath (July to November) **(Figure 4-15**).
- Wedge-tailed shearwater breeding (August to April).

Area C

Area C overlaps the same BIAs identified as occurring in Area A (excluding the flatback turtle internesting buffer at Montebello/Browse islands). In addition to these, Area C also overlaps with the following BIAs:

- Pygmy blue whale foraging – a BIA for pygmy blue whale foraging occurs off the coast of Exmouth and lies within the migration BIA (**Figure 4-11**).
- Humpback whale migration – annual seasonal migration along the WA coastline with peak past Exmouth travelling northward (June to July), southerly return along the same route (August to November). The BIA transects the south-eastern side of Area C (**Figure 4-12**).

- Flatback turtle internesting – internesting BIA occurs at Muiron Islands and the Ningaloo coast, where nesting occurs from October to March each year with a peak in December and January. Area C overlaps a portion of the outer region of the BIA.
- Loggerhead turtle internesting – internesting BIA at the Muiron Islands and the Ningaloo coast, where nesting occurs from November to May each year with no defined peak (DoEE, 2017). Area C overlaps a portion of the outer region of the BIA (**Figure 4-14)**.
- Green turtle internesting – internesting BIAs occur at the Muiron Islands and North West Cape where nesting peaks from November to March each year (DoEE, 2017). Area C overlaps a minor portion of the outer region of both BIAs (**Figure 4-14)**.
- Hawksbill turtle internesting – internesting BIA occurs along the Ningaloo coast and Jurabi coast where nesting peaks from October to February each year (DoEE, 2017). Area C overlaps a minor portion (~4%) of the outer region of the BIA (**Figure 4-14**).

A number of BIAs occur adjacent to Area A and/or C, including:

- Humpback whale resting BIA at Exmouth Gulf, located 18 km south-east of Area C (**Figure 4-12**).
- Flatback multi-use (foraging/mating/nesting) BIA at the Montebello Islands and Browse Island located 25 and 44 km from Area A, respectively, and a nesting BIA along the Pilbara coast located 46 km from Area C (**Figure 4-13**).
- Hawksbill turtle mating, nesting, foraging and migration BIAs (**Figure 4-14**).
- Loggerhead turtle nesting BIAs during summer nesting period (**Figure 4-14**).
- Green turtle multi-use (foraging/internesting/mating/nesting) and basking BIAs (**Figure 4-14**).
- Whale shark foraging at Ningaloo Reef (high density prey, used April to May), 8 km south of Area C (**Figure 4-15**).
- Dugong multi-use (breeding/calving/foraging/nursing) BIA at Exmouth Gulf, located 8 km from Area C.
- BIAs for:
    - Australian fairy tern breeding (July to October) and foraging, located 17 km and 7 km from Areas A and C respectively
    - roseate tern breeding (mid-March to July) and foraging, located 23 and 57 km from Areas A and C respectively
    - wedge-tailed shearwater foraging (in association with nesting BIAs August to April), located 21 and 10 km from Areas A and C respectively.

4.5.2.4 Seasonal Sensitivities of Protected Species

Periods of the year coinciding with key environmental sensitivities, including EPBC Act listed Threatened and/or Migratory species potentially occurring within Areas A, B and C are presented in **Table 4-5**. These relate to breeding, foraging or migration of the indicated fauna. Please note **Table 4-5** is broadly applicable to Areas A and C.

The following species were listed in the EPBC Act Protected Matters Search (see **Table 4-3** and **Appendix C**) but have been excluded from **Table 4-5**:

- Sei, fin and sperm whales may transit the area during mainly winter months. However, definitive seasonality for these species is not available.

- Southern right whales may uncommonly transit the area during winter months. However, a definitive seasonality for the species is not available and sightings in the region are rare.
- Indo-Pacific humpback and spotted bottlenose dolphins have not been included, as information is not available to support a definitive seasonality in the NWMR.
- Leatherback turtles are excluded, as there are no known nesting or foraging sites.
- Short-nosed sea snakes are excluded, as no known seasonality exists for this species.
- White sharks have not been included, as information is not available to support a definitive seasonality in the NWMR. Seasonal presence of white sharks is generally associated with high density of a prey population (e.g. pinniped colonies). The nearest significant pinniped colony is the Abrolhos Islands (Commonwealth Marine Reserve over 700 km south of Area A), where Australian sea lions are present year-round.
- Short and long fin mako sharks have not been included as seasonality is not defined, as they are highly mobile pelagic species and can be present at any time, but are not known to have significant populations with regular migratory routes or breeding/foraging aggregations within Areas A, B or C.
- Grey nurse sharks have not been included, given they are not considered migratory and no clear aggregation sites have been identified off WA.
- Narrow, dwarf and green sawfishes are not included, given their preference for nearshore, shallow water habitats. They are not expected to be present within Area A, B or C.
- Various shore and seabird species are excluded as no seasonality has been defined within Areas A, B or C or surrounds.

Table 4-5: Key environmental sensitivities and timings for fauna potentially occurring in Areas A, B or C as identified in the EPBC Protected Matters Search (indicative)

Species	January	February	March	April	May	June	July	August	September	October	November	December
Acquisition in Area A	Planned	Planned	Potential	Potential	Potential							Planned
Acquisition in Area B	Potential	Potential	Potential	Potential	Potential	Planned	Planned					Potential
Acquisition in Areas C (Cimatti and Vincent)			Potential	Planned	Planned							
Acquisition in Area C (Laverda)			Planned	Planned								
Blue whale – northern migration (Exmouth, Montebello, Scott Reef)[1]				Present	Peak	Peak	Present	Present				
Blue whale – southern migration (Exmouth, Montebello, Scott Reef)[2]	Present									Present	Peak	Peak
Humpback whale – northern migration (Jurien Bay to Montebello)[3]					Present	Peak	Peak	Present	Present	Present	Present	
Humpback whale – southern migration (Jurien Bay to Montebello)[4]								Present	Present	Present	Present	
Green turtle – various nesting areas[5]	Peak	Peak	Present								Present	Present
Flatback turtle – various nesting areas[5]	Peak	Present	Present							Present	Present	Peak
Loggerhead turtle – various nesting areas[5]	Peak	Present	Present	Present	Present						Present	Peak
Hawksbill turtles – various nesting areas[6]	Present	Present								Present	Present	Present
Manta rays – presence/aggregation/ breeding (Ningaloo)[7]			Present	Present	Present	Present	Present	Present				
Whale shark* – foraging/aggregation near Ningaloo[8]			Present	Peak	Peak	Present	Present	Present	Present	Present	Present	
Caspian tern – breeding (Ningaloo)[9]						Present	Present	Present	Present	Present	Present	
Crested tern – breeding (Ningaloo)[9]			Present	Present	Present	Present	Present	Present				
Fairy tern – breeding (Ningaloo)[9]							Present	Present	Present			
Osprey – breeding (Ningaloo)[9]				Present	Present	Present	Present	Present	Present	Present		
Roseate tern – breeding (Ningaloo)[9]								Present	Present	Present	Present	Present
Wedge-tailed shearwater – various breeding sites[9]	Present	Present	Present	Present				Present	Present	Present	Present	Present

Planned (dark grey)	Planned survey acquisition
Potential (light grey)	Potential survey acquisition
Present (yellow)	Species may be present in the region.
Peak (red)	Peak period. Presence of animals reliable and predictable each year.

References for species seasonal sensitivities:

1. *DSEWPaC, 2012a; McCauley and Jenner, 2010; McCauley, 2011*
2. *DSEWPaC, 2012a; McCauley and Jenner, 2010*
3. *CALM, 2005; Environment Australia, 2002; Jenner et al., 2001a; McCauley and Jenner, 2001*
4. *McCauley and Jenner, 2001*

5. *DoEE, 2017; Chevron, 2015; CALM, 2005; DSEWPaC, 2012a*
6. *DoEE, 2017; Chevron, 2015*
7. *Environment Australia, 2002*
8. *CALM, 2005; Environment Australia, 2002*
9. *DSEWPaC, 2012c; Environment Australia, 2002.*

**Periods of sensitivity include whale shark foraging off the Ningaloo Coast and foraging northward from the Ningaloo Marine Park along the 200 m isobath.*

4.5.2.5 Marine Mammals

Cetaceans – Whales

Blue Whale

The EPBC Protected Matters Search identified the blue whale as potentially occurring within all three Areas. There are two recognised subspecies of blue whale in the Southern Hemisphere, which are both recorded in Australian waters. These are the southern (or 'true') blue whale (*Balaenoptera musculus*) and the ‘pygmy' blue whale (*Balaenoptera musculus brevicauda*) (DoEE n.d.). In general, southern blue whales occur in waters south of 60°S and pygmy blue whales occur in waters north of 55°S (i.e. not in the Antarctic) (DEH, 2005b). On this basis, nearly all blue whales sighted in the NWMR are likely to be pygmy blue whales. The 2015 Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015a) has delineated the distribution area of blue whales in Australian waters and identified a number of BIAs for WA waters (migratory corridor and foraging areas).

Pygmy blue whale migration is thought to follow deep oceanic routes (DEWHA, 2008). In the NWMR, pygmy blue whales migrate along the 500–1000 m depth contour on the edge of the slope, where they are likely to feed opportunistically on ephemeral krill aggregations (DEWHA, 2008). This area has been defined by the DoEE as a BIA for the species and spatially overlaps the south-west portion of Areas A and C (**Figure 4-11**). Sea noise loggers at various locations along the WA coast have detected an annual northbound migration past Exmouth and the Montebello Islands between April and August, and southbound migration from October to the end of December, peaking in later November to early December north of the Montebello Islands (McCauley and Jenner, 2010; McCauley and Duncan, 2011; Double et al., 2012).

Recent satellite tagging (2009–2012) of pygmy blue whales in the Rottnest Trough during March and April confirmed whales generally travel within the migration BIA, often travelling relatively close to the coastline through Area C, before continuing into depths over 200 m (and commonly over 1000 m), west of Area A and east of Area B (Double et al., 2012) (**Figure 4-11**). This data was revisited in 2014 and showed that tagged whales migrated northwards post-tag deployment. The tagged whales travelled relatively near to the Australian coastline (100.0 ± 1.7 km) in water depths of 1369.5 ± 47.4 m, until reaching the North West Cape, after which they travelled offshore (238.0 ± 13.9 km) into progressively deeper water (2617.0 ± 143.5 m). Whales reached the northern terminus of their migration and potential breeding grounds in Indonesian waters by June (Double et al., 2014). Although the BIA for this species has been defined as the migration corridor centred between the 500 m and 1000 m depth contours, this data suggests individuals transit the deeper waters to the west of Area A and east of Area B between mid-April to early August (**Figure 4-11**) during the northern migration.

An additional pygmy blue whale BIA for foraging occurs at Ningaloo Reef/North West Cape. The Blue Whale Conservation Management Plan 2015–2025 (Commonwealth of Australia, 2015a) describes this BIA as a possible foraging area, where evidence for feeding is based on limited or direct observations or indirect evidence, such as prey occurring close to the whale or satellite tracks showing circling tracks. This foraging BIA partially overlaps the southern extent of Area C, with an overlap of about 18 km², or less than 1% of the foraging BIA. Satellite tracks of the pygmy blue whale's northern migration (Double et al., 2012a, 2014) indicate most tagged whales (n=3) continue past the North West Cape with little directional variation, while one tagged whale showed circling tracks (**Figure 4-11**). As such, it is likely that pygmy blue whales feed opportunistically while transiting the region.

Based on acoustic data, pygmy blue whales are likely to travel alone or in small groups. Typically, solitary whales have been recorded calling on noise loggers, although larger groups of calling animals were occasionally detected. For example, 78% of pygmy blue whale calls recorded around Scott Reef between 2006 and 2009 were from lone whales, 18% were from two whales and 4% were from three or more whales (McCauley and Duncan, 2011). The maximum number of individuals calling at one time was five.

In summary, pygmy blue whales are likely to occur within Areas A and C, particularly during their defined annual migrations. Area B lies 13 km north-east of the migration BIA; however, species presence within Area B is possible, albeit in relatively lower numbers. When individuals do occur in Areas A, B or C, it is likely there will be only one or a few individuals and their time in the area will be brief.

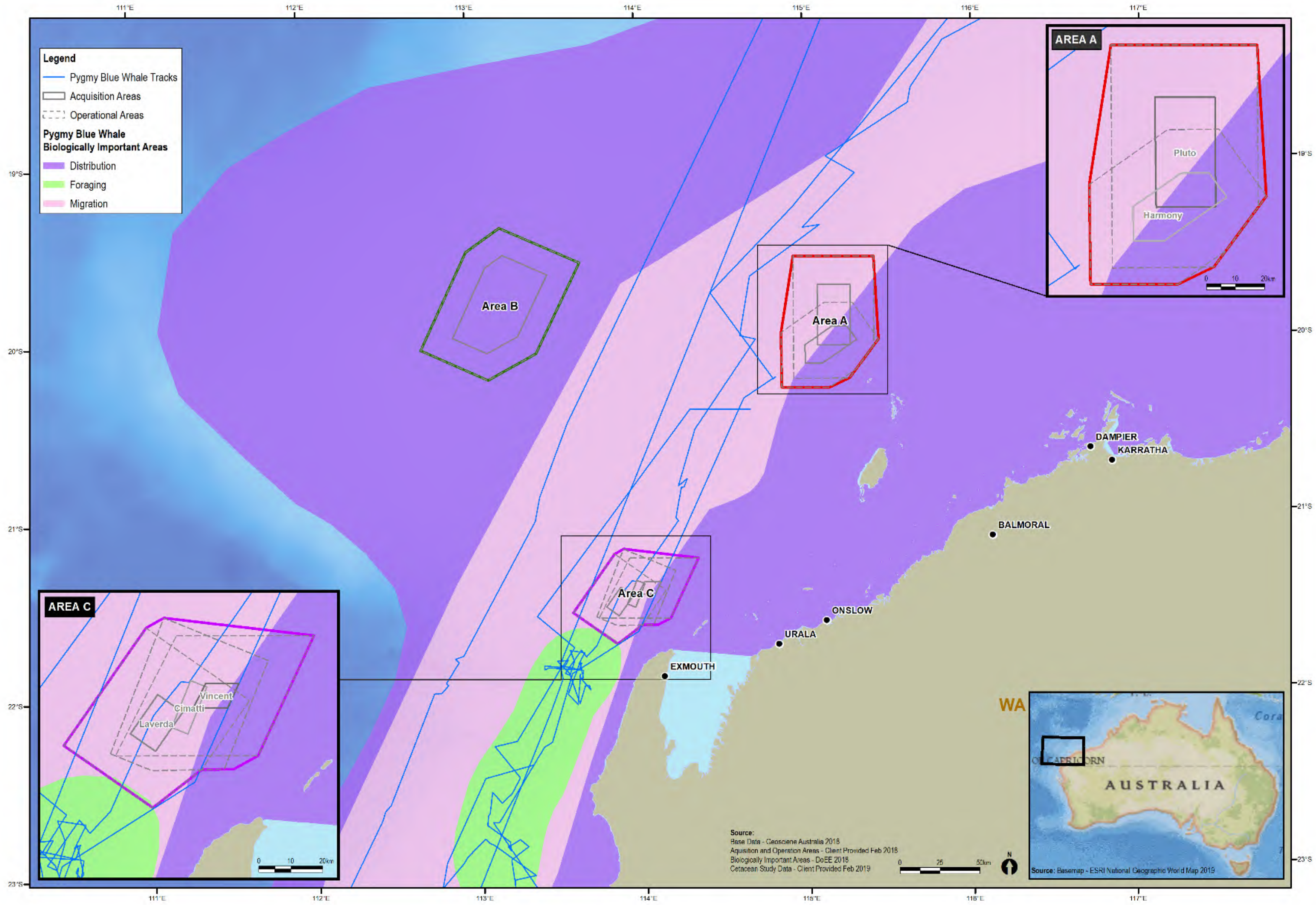

Figure 4-11: Pygmy blue whale satellite tracks and BIAs (after Double et al., 2012b, 2014)

Humpback Whale

The EPBC Protected Matters Search identified the humpback whale as potentially occurring within all three Areas. Humpback whales are moderately large baleen whales, with a maximum recorded length of 17.4 m and an average weight of 25 to 30 tonnes (DoE, 2013). They occur throughout Australian waters, as two genetically distinct, east and west populations; both populations' distributions are influenced by migratory pathways and aggregation areas for resting, breeding and calving. In the west, humpback whales migrate north to breeding grounds in Camden Sound of the west Kimberley, between May and November, after feeding in Antarctic waters during the summer months (Jenner et al., 2001b). Calving typically occurs between mid-August and early September, within nearer shelf waters of Camden Sound (about 850 km from Area A). The whales' southern migration runs between August and November, with females and calves being the last to leave the breeding grounds.

From North West Cape, north bound humpback whales travel along the edge of the continental shelf passing to the west of the Muiron, Barrow and Montebello islands (**Figure 4-12**). The southern migratory route follows a relatively narrow track between the Dampier Archipelago and Montebello Islands. The humpback migration BIA overlaps with the south-east portion of Area C and comes within 2 km of Area A. The migration BIA is located about 140 km from Area B. Exmouth Gulf and Shark Bay are known resting/aggregation areas for southbound humpback whales. In particular, Exmouth Gulf is where cow/calf pairs may stay for up to two weeks. The Exmouth Gulf and the resting BIA is located about 18 km from Area C, 167 km from Area A and 203 km from Area B.

Woodside has conducted marine megafauna aerial surveys that have confirmed that the temporal distribution of migrating humpback whales off North West Cape has remained consistent since baseline surveys were first conducted in 2000 to 2001. Most of the whales occurred in depths less than 500 m, with the greatest density of whales concentrated in water depths of 200 to 300 m. Only small numbers of whales were observed to occur in the deeper offshore waters. These survey results are consistent with satellite tagging studies (Double et al., 2010, 2012b) (**Figure 4-12**). The humpback whale population that migrates along the WA coast was been estimated to be as large as 33,300 in 2008 (Salgado-Kent et al., 2012). Humpback whales are likely to occur within Area C, particularly during their northern and southern migrations past Exmouth. The northern migration between Jurien Bay to Montebello Islands occurs from May to November, and peaks in June and July. The southern migration occurs from August to November (note proposed survey dates are between late December and July and do not overlap with peak migration times). Whales may also occur in Area A, particularly during their northern and southern migrations, albeit in relatively lower numbers (**Figure 4-12**).

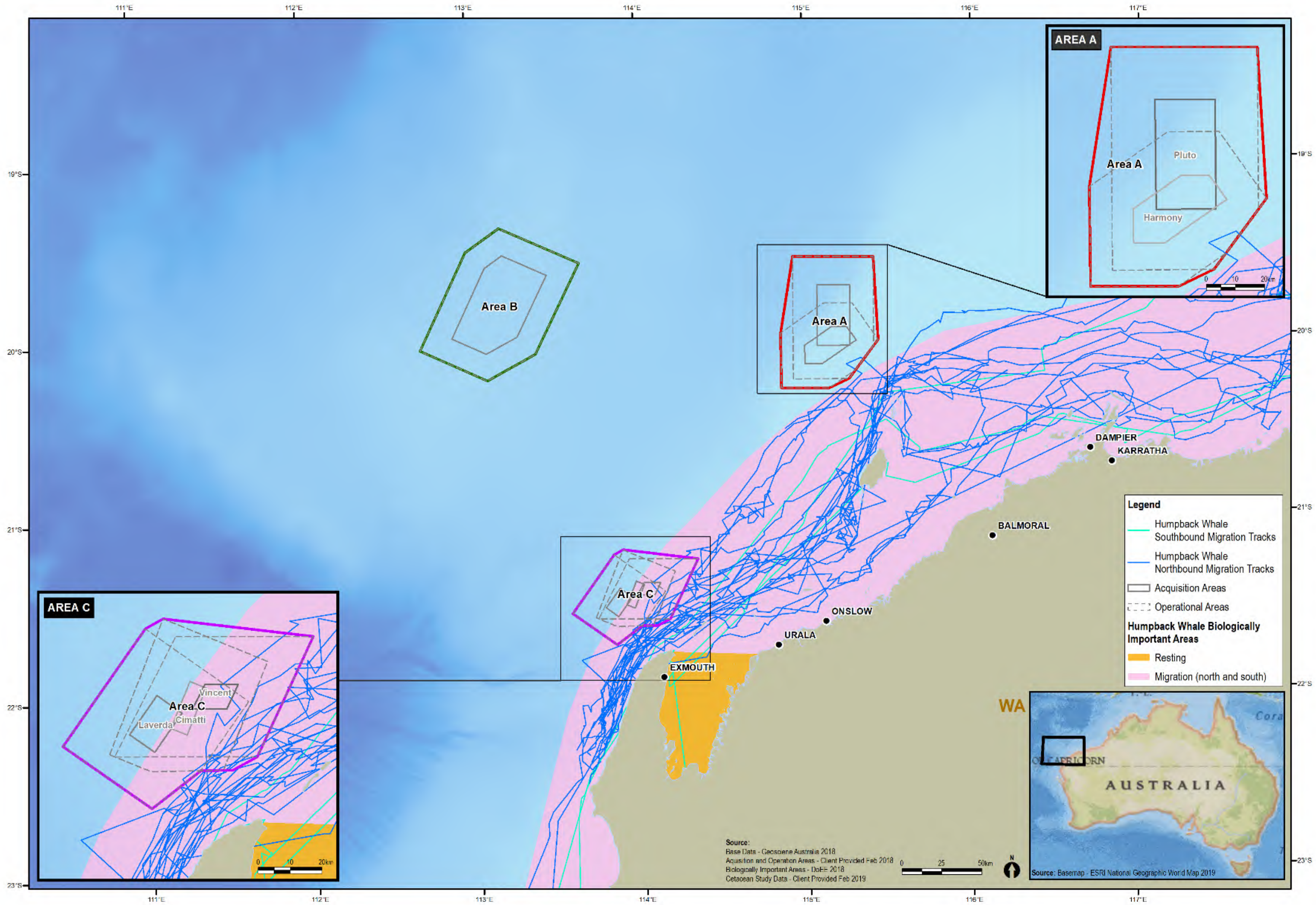

Figure 4-12: Humpback whale satellite tracks and BIA (Double et al., 2010, after 2012a)

Sei Whale

The EPBC Protected Matters Search identified the sei whale as potentially occurring within all three Areas. The sei whale is a baleen whale which, like many species of baleen whales, was significantly reduced in numbers by commercial whaling operations. The species has a worldwide oceanic distribution, and is expected to migrate seasonally between low latitude wintering areas and high latitude summer feeding grounds (Bannister et al., 1996a; Prieto et al., 2012). Sei whales have been infrequently recorded in Australian waters (Bannister et al., 1996b), which could be due to the similarity in appearance of sei whales and Bryde's whales leading to incorrect recordings.

There are no known mating or calving areas, or other BIAs for sei whales in Australian waters (DoE, 2016a). The species prefers deep waters, and typically occurs in oceanic basins and continental slopes (Prieto et al., 2012); records of the species occurring on the continental shelf (<200 m water depth) are uncommon in Australian waters (Bannister et al., 1996a). Given Areas A, B and C are located in deeper waters on the continental slope, sei whales are likely to infrequently occur within these Areas, mainly during winter months when the species may move away from Antarctic feeding areas.

Fin Whale

The EPBC Protected Matters Search identified the fin whale as potentially occurring within all three Areas. The fin whale is a large baleen whale with a cosmopolitan distribution in all ocean basins between 20°S and 75°S (DEH, 2005b). The global population of fin whales was reduced significantly by commercial whaling, with the species being targeted due to its large size and broad distribution. Like other baleen whales, fin whales migrate annually between high latitude summer feeding grounds and lower latitude over-wintering areas (Bannister et al., 1996a).

Fin whales are thought to follow oceanic migration paths, and are uncommonly encountered in coastal or continental shelf waters. The Australian Antarctic waters are important feeding grounds for fin whales but there are no known mating or calving areas in Australian waters (Morrice et al., 2004). There are no known BIAs for fin whales in NWMR. As such, the species is likely to infrequently occur within Areas A, B and C, mainly during winter months when the species may move away from Antarctic feeding areas.

Antarctic Minke Whale

The EPBC Protected Matters Search identified the Antarctic minke whale as potentially occurring within Areas B and C, but not within Area A. Antarctic minke whales inhabit all oceans in the Southern Hemisphere. Their summer range is close to Antarctica, but they move further north in winter, including along the Australian east and west coasts (Bannister et al., 1996a). Antarctic minke whales have only been observed as far north as 21°S along the east coast of Australia (equivalent to Karratha on the west coast) and it is thought the species follows a similar migration on the WA coast, migrating to about 20°S to feed and possibly breed (Bannister et al., 1996a). However, detailed information about timing and location of migrations and breeding grounds in WA is not well known. There are no known BIAs for Antarctic minke whales in the NWMR.

Given the wide distribution of Antarctic minke whales, Areas A, B or C are not likely to represent important habitat for this species. Their presence is likely to be a remote occurrence and limited to a few individuals infrequently transiting the area.

Bryde's Whale

The EPBC Protected Matters Search identified the Bryde's whale as potentially occurring within all three Areas. Bryde's whales are distributed widely throughout tropical and sub-tropical waters. Bryde's whales have been identified as occurring in both oceanic and inshore waters, with the only key localities recognised in WA being in the Abrolhos Islands and north of Shark Bay (Bannister et al., 1996a). Two movement behaviours are recognised for Bryde's whales: inshore and offshore. Data suggests offshore whales may migrate seasonally, heading towards warmer tropical waters during the winter; however, information about migration is not well known (McCauley and Duncan, 2011). There are no known BIAs for Bryde's whales in the NWMR.

Bryde's whales tend to transit seasonally through a broad area of the continental shelf, including Areas A, B and C and surrounding waters (McCauley and Duncan, 2011; RPS, 2012b). This species has been detected within the Northwest Shelf Province from mid-December to mid-June, peaking in late February to mid-April (RPS, 2012b). Given the known distribution of the Bryde's whales, it is likely that transitory individuals may occur within Areas A, B and C. However, these areas are unlikely to represent important habitat for this species.

Sperm Whale

The EPBC Protected Matters Search identified the sperm whale as potentially occurring within all three Areas. The sperm whale has a worldwide distribution in deep waters (greater than 200 m) off continental shelves and sometimes near shelf edges, averaging 20–30 nautical miles offshore (Bannister et al., 1996a). Although both sexes range through temperate and tropical waters, only adult males occur in the higher latitudes. There is limited information about sperm whale distribution in Australian waters; however, they are usually found in deep offshore waters, with more dense populations close to continental shelves and canyons (DoE, 2013b). There are no known BIAs for sperm whales in the NWMR.

Sperm whales have been recorded in deep waters off North West Cape (Jenner et al., 2010) and appear to occasionally venture into shallower waters in other areas. Surveys conducted within the Browse Floating LNG Development area recorded no sperm whales during aerial and vessel surveys in 2008 or 2009 (Jenner et al., 2009; Jenner and Jenner, 2009a, 2009b; Woodside, 2014) or from sea noise logger recordings within the Scott Reef area from 2006 to 2009 (McCauley, 2009). The only key locality recognised in WA waters for sperm whales is along the southern coastline between Cape Leeuwin and Esperance (Bannister et al., 1996a).

The species is known to migrate northwards in winter and southwards in summer but detailed information about the distribution and migration patterns of sperm whales off the WA coast is not available. Given the wide distribution of sperm whales, Areas A, B and C are unlikely to represent important habitat for this species. Their presence is likely to be a rare occurrence and limited to a few individuals infrequently transiting the area.

Southern Right Whale

The EPBC Protected Matters Search identified the southern right whale as potentially occurring within all three Areas. The southern right whale occurs primarily in waters between about 20°S and 60°S and moves from high latitude feeding grounds in summer to warmer, low latitude, coastal locations in winter (Bannister et al., 1999). Southern right whales aggregate in calving areas along the south coast of WA, such as Doubtful Island Bay, east of Israelite Bay and to a lesser extent Twilight Cove (DSEWPaC, 2012e). During the calving season between May and November, female southern right whales that are either pregnant or with calf can be present in shallow protected waters along the entire southern WA coast and west up to about Two Rocks, north of Perth. Sightings in more northern waters are relatively rare; however, they have been recorded as far north as Exmouth (Bannister et al., 1996a).

Southern right whales were identified as potentially occurring within Area C. However, given the species prefers temperate waters and has rarely been recorded north of Exmouth, southern right wales are highly unlikely to occur in Areas A, B or C during the surveys.

Cetaceans – Dolphins and Porpoises

Killer Whale

The EPBC Protected Matters Search identified the killer whale as potentially occurring within all three Areas. Killer whales are found in all of the world's oceans, from the Arctic and Antarctic regions to tropical seas (DoE, 2013c; Ford et al., 2005), and have been recorded off all states of Australia (Bannister et al., 1996a). Killer whales appear to be more common in cold, deep waters; however, they have been observed along the continental slope and shelf, particularly near seal colonies, as well as in shallow coastal areas of WA (Bannister et al., 1996b; Thiele and Gill, 1999). Killer whales were observed in waters offshore of the Dampier Peninsula on two occasions in 2009 and one occasion in 2010 (over 750 km north east of Area A) (Woodside, 2014), but have not been observed during surveys in deeper offshore waters (Jenner et al., 2010; Woodside, 2014). There are no recognised key localities or important habitats for killer whales within Areas A, B or C. Given the wide distribution of killer whales and their preference for colder waters, Areas A, B or C are unlikely to represent an important habitat for this species. Their presence is likely to be a rare occurrence and limited to a few individuals infrequently transiting the surrounding waters.

Indo-Pacific Humpback Dolphin

The Indo-Pacific humpback dolphin was identified as potentially occurring within Area A, but not within Areas B or C. The Indo-Pacific humpback dolphin is now recognised as two distinct species: the Indo-Pacific humpback dolphin (*Sousa chinensis*) and the Australian humpback dolphin (*S. sahulensis*) (Jefferson and Rosenbaum, 2014). This EP will herein refer to the Australian humpback dolphin (*S. sahulensis*) that is known to occur in waters of the Sahul Shelf from northern Australia to New Guinea. Distribution of the humpback dolphin in Australia is linked to the warm eastern boundary current, with resident groups within Ningaloo Reef (Bannister et al., 1996a). Humpback dolphins inhabit shallow coastal, estuarine habitats in tropical and subtropical regions generally in depths of less than 20 m (Corkeron et al., 1997; Jefferson, 2000; Jefferson and Rosenbaum, 2014). Given their preference for shallow coastal habitats, the species may occur in coastal waters but is unlikely to occur within any of the Areas.

Spotted Bottlenose Dolphin (Arafura/Timor Sea populations)

The spotted bottlenose dolphin was identified as potentially occurring within Areas A and C, but not within Area B. The spotted bottlenose dolphin is generally considered to be a warm water subspecies of the common bottlenose dolphin. Their distribution is primarily within inshore waters, often in depths of less than 10 m (Bannister et al., 1996a). They are known to occur from Shark Bay, north to the western edge of the Gulf of Carpentaria. Given the distribution of spotted bottlenose dolphins and their preference for shallow coastal waters, they may be present within the coastal regions of Areas A and C; however, due to water depths they are expected to be uncommon.

Dugong

Dugong are large herbivorous marine mammals. Although dugongs were not identified as occurring within Areas A, B or C, they may be present in inshore and coastal waters near Areas A and C. The species is distributed along the WA coast throughout the Gascoyne, Pilbara and Kimberley regions, with notable populations in (DSEWPaC, 2012a; Marsh et al., 2002; Preen et al., 1997):

- Ningaloo Marine Park (State waters) (about 9 km south east of Area C)
- Exmouth Gulf (about 21 km south-east of Area C), which forms a listed foraging/breeding/ nursing/calving BIA with the Ningaloo Marine Park (BIA is about 8 km from Area C)
- Shark Bay (about 429 km south of Area C), hosting the largest resident population in Australia.

Dugong distribution is correlated with seagrass habitats that dugong feed on, although water temperature has also been correlated with dugong movements and distribution (Preen et al., 1997; Preen, 2004). Dugong are known to migrate (up to hundreds of kilometres) between seagrass habitats (Sheppard et al., 2006). Given the distribution of dugong and their preference for shallow coastal waters, their presence is highly unlikely within Areas A, B or C due to the lack of suitable habitat (seagrass and macroalgae beds). However, they may be present in the nearby coastal waters where their habitat occurs.

4.5.2.6 Marine Reptiles

Marine Turtles

Five of the six marine turtle species recorded for the NWMR have the potential to occur within Areas A, B and C (**Appendix C**): the loggerhead, green, leatherback, hawksbill and flatback turtles.

The Recovery Plan for Marine Turtles in Australia (DoEE, 2017) identifies areas 'habitat critical to the survival of a species' ('habitat critical') for marine turtle stocks under the EPBC Act. 'Habitat critical' is defined by the EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance as areas necessary:

- for activities such as foraging, breeding or dispersal
- for the long-term maintenance of the species (including the maintenance of species essential to the survival of the species)
- to maintain genetic diversity and long term evolutionary development
- for the reintroduction of populations or recovery of the species.

Nesting and internesting habitats have been identified, described and mapped for the green turtle, loggerhead turtle, flatback turtle, hawksbill turtle, Olive Ridley turtle and the leatherback turtle (DoEE, 2017).

The areas of 'habitat critical' that overlap with the Areas and nearby waters are described in **Table 4-6**. It is noted that 'habitat critical' differs from 'Critical Habitat' as defined under Section 207A of the EPBC Act (Register of Critical Habitat). No 'Critical Habitat' has been identified and listed for marine turtles.

There is no emergent habitat within any of the Areas; therefore, nesting aggregations of marine turtles would not be expected. Area A partially overlaps a flatback turtle internesting BIA surrounding Montebello and Barrow islands. Area C partially overlaps with a flatback turtle internesting BIA surrounding the Muiron Islands. Nesting occurs from October to March each year (DoEE, 2017), with a peak period occurring from December to January. The BIA is considered very conservative as it is based on the maximum range of the internesting females. However, many turtles are likely to remain near their nesting beaches, and as they leave beaches they typically spread out. Consequently, density decreases rapidly with increasing distance from a nesting beach (Waayers et al., 2011; Whittock et al., 2014). It is also possible that marine turtles forage in shallow waters along the mainland coastline, as well as around offshore islands and shoals.

The 60 km internesting buffer for flatback turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) is based primarily on the movements of tagged internesting flatback turtles along the North West Shelf reported by Whittock et al. (2014), which found that flatback turtles may demonstrate internesting displacement distances up to 62 km from nesting beaches. However, these movements were confined to longshore movements in nearshore coastal waters or travel between island rookeries and the adjacent mainland (Whittock et al., 2014). There is no evidence to date to indicate flatback turtles swim out into deep offshore waters during the internesting period.

A more recent paper by the same authors (Whittock et al., 2016) has more precisely defined flatback turtle internesting habitat along the North West Shelf. The Whittock et al. (2016) study developed a habitat suitability map to identify areas where internesting flatback turtles may be present along the North West Shelf, based on data compiled for a suite of environmental variables and satellite tracks of 47 internesting flatback turtles from five different mainland and island rookeries tracked over 1289 days. Whittock et al. (2016) defined suitable interesting habitat as water 0–16 m deep and within 5–10 km of the coastline, while unsuitable internesting flatback habitat was defined as waters > 25 m deep and > 27 km from the coastline.

This interpretation of the suitability of deep, offshore waters adjacent to the Montebello Islands as internesting habitat for flatback turtles has been confirmed by the lead author of the Whittock et al. (2014, 2016) papers:

> *"…the location of the six proposed 4D seismic surveys are highly unlikely to host inter-nesting flatback turtles from the Montebellos and do not represent important inter-nesting habitat. Flatback turtles are known to spend their inter-nesting time resting on the seabed, the areas you describe are simply too deep to support this behaviour (>73 m)." (Paul Whittock, Pendoley Environmental Pty Ltd, personal communication, October 2019).*

The evidence that suitable internesting habitat for flatback turtles is likely to be limited to relatively shallow waters within close proximity of the coastline is further supported by data from satellite telemetry of 11 flatback turtles after nesting on the Lacepede Islands (Thums et al., 2017). This study found that "*During the inter-nesting phase, flatback turtles remained at an average distance of 15.75 ± 12.25 km from West Lacepede Island, in water depths of 16 ± 3 m…*" (Thums et al., 2017).

Additional nearby BIAs for green, loggerhead, flatback and hawksbill turtles include significant nesting rookeries on beaches along the mainland coast and islands, including the Montebello/Barrow/Lowendal islands, Muiron Islands, North West Cape, Ningaloo Reef and the Dampier Archipelago (DoEE, 2017; Limpus, 2007, 2008a, 2008b, 2009). Leatherback turtles are not confirmed as a nesting species within WA (Limpus, 2009), nor have any other BIAs been identified for them in the region. Additional BIAs adjacent to the Areas are detailed in **Section 4.5.2**. **Table 4-6** provides additional details of the marine turtle species identified, including breeding and nesting seasons, diet and key habitats.

Table 4-6: Key information about marine turtles in the NWMR

Turtle species	Key seasons within the NWMR	Diet	Key Habitats within the NWMR
Loggerhead Turtle	**Breeding:** Approximately September to April. **Nesting**: November to late May. Peak period from late	Carnivorous – feeding mainly on molluscs and crustaceans	**Preferred habitat**: Nearshore and island coral reefs, bays and estuaries in tropical and warm temperate latitudes. **Distribution**: Shark Bay to North West Cape and as far north as Muiron Islands and Dampier Archipelago. **Major nesting sites**: principally from Dirk Hartog Island, along the Gnarloo and Ningaloo coast to North West Cape and the Muiron Islands. There have been occasional records from

Turtle species	Key seasons within the NWMR	Diet	Key Habitats within the NWMR
	December to early January.		Varanus and Rosemary islands in the Pilbara. Late summer nesting recorded for Barrow Island, Lowendal Islands and Dampier Archipelago. **Internesting habitat**: Limited data on Australian loggerhead turtles; however, literature indicates internesting habitat for this species is generally within 20 km of nesting beaches (DSEWPaC, 2012a; DoEE, 2017). **Nearest BIA**: Internesting BIA at Muiron Islands and the Ningaloo Coast partially overlaps Area C. Internesting BIA at Montebello Islands is located about 14 km from Area A. **Nearest 'habitat critical' (DoEE, 2017)**: Area C partially overlaps the 20 km nesting buffer around Exmouth Gulf and the Ningaloo Coast.
Hawksbill Turtle	**Breeding**: Approximately October to January. **Nesting**: October to February.	Mainly sponges – also seagrasses, algae, soft corals and shellfish	**Preferred Habitat**: Nearshore and offshore reef habitats. **Distribution**: Shark Bay north to Dampier Archipelago. **Major nesting sites**: The most significant rookery in WA is at Rosemary Island. Other rookeries include Delambre Island, also in the Dampier Archipelago, Lowendal Islands, some islands in the Montebello group, Sholl Island, and along the Ningaloo Coast (DoEE, 2017; Limpus, 2009b). **Internesting habitat**: Limited data on Australian hawksbill turtles; however, literature indicates internesting habitat for this species is generally within 20 km of nesting beaches (DSEWPaC, 2012a). **Nearest BIA**: Internesting BIA at the Muiron Islands and Jurabi coast (peak October to February) partially overlaps Area C. Nesting on the Montebello Islands during summer, with a 20 km internesting buffer. **Nearest 'habitat critical' (DoEE, 2017)**: 20 km nesting buffer around Montebello Islands lies about 8 km from Area A.
Green Turtle	**Breeding:** Approximately September to March. **Nesting**: November to March. Peak period from January to February. *Note: green turtles are likely to occur year-round within inshore and coastal waters.*	Mostly herbivorous – feeding mainly on seagrass and algae	**Preferred habitat**: Nearshore reef habitats in the photic zone. **Distribution**: Ningaloo Coast to Lacepede Islands. **Major nesting sites**: Montebello Islands, Barrow Island, Muiron Islands, some islands of the Dampier Archipelago, and North West Cape, Ningaloo Coast, Scott, Ashmore and Cartier Reefs, and Browse Island (DoEE, 2017). **Internesting habitat**: Generally within 10 km of nesting beaches (Waayers et al., 2011). **Nearest BIA**: Internesting BIA at the Muiron Islands and North West Cape (peak November to March) partially overlaps Area C. Nesting on the Montebello Islands during summer, with a 20 km internesting buffer. **Nearest 'habitat critical' (DoEE, 2017)**: Area C partially overlaps the 20 km nesting buffer around Exmouth Gulf and the Ningaloo Coast. Area A lies approximately 8 km from the 20 km from nesting buffer around Montebello Islands.

Turtle species	Key seasons within the NWMR	Diet	Key Habitats within the NWMR
Leatherback Turtle	No confirmed nesting activity in Western Australia.	Carnivorous – feeding mainly in the open ocean on jellyfish and other soft-bodied invertebrates	**Preferred Habitat**: Nearshore, coastal tropical and temperate waters. **Distribution**: May be encountered within the NWMR, but are more commonly found in Australian east coast waters. **Major nesting sites**: N/A within NWMR. Closest nesting site is on the Cobourg Peninsula; however, nesting only occurs in small numbers (DoEE, 2017). **Internesting habitat**: N/A. **Nearest BIA**: N/A. **Nearest 'habitat critical' (DoEE, 2017)**: N/A.
Flatback Turtle	**Breeding**: Peak between December and February. **Nesting**: October to March with peak period in December and January.	Carnivorous – feeding mainly on soft bodied prey such as sea cucumbers, soft corals and jellyfish	**Preferred Habitat**: Nearshore and offshore sub-tidal and soft bottomed habitats of offshore islands. **Distribution**: Shark Bay north to Dampier Archipelago. **Major nesting sites**: The largest nesting sites of the Pilbara region are Barrow Island and the mainland coast (Mundabullangana Station near Cape Thouin and smaller nesting sites at Cemetery Beach in Port Hedland and Bell's Beach near Wickham). Other significant rookeries include the Montebello island in the Dampier Archipelago, coastal islands from Cape Preston to Locker Island, and various islands as well as coastal areas throughout the Kimberley (Eighty Mile Beach, Eco Beach, Lacepede Islands) (DoEE, 2017). **Internesting habitat**: Up to 70 km from nesting beaches (Waayers et al., 2011; Whittock et al., 2014). Satellite tracking of flatback turtle nesting populations at Barrow Island indicates this species travels to the east of Barrow Island, towards WA mainland coastal waters, between nesting events (Chevron, 2015). Whittock et al. (2016) defined suitable interesting habitat as water 0–16 m deep and within 5–10 km of the coastline, while unsuitable internesting flatback habitat was defined as waters > 25 m deep and > 27 km from the coastline. **Nearest BIA**: Internesting BIA at the Montebello Islands (peak late December to January) partially overlaps Area A. Internesting BIA buffering the Pilbara Southern Island Group peak late December to January partially overlaps Area C. **Nearest 'habitat critical' (DoEE, 2017):** A 60 km internesting buffer surrounding nesting locations at Barrow Island and Montebello Islands overlaps with Area A. The 60 km internesting buffer surrounding the coastal islands from Cape Preston to Locker Island is adjacent to Area C.

Post-nesting migratory routes for green, hawksbill and flatback turtles recorded for the NWMR (Barrow Island and mainland sites) (Chevron, 2015) and green turtle tracking for post-nesting individuals from Scott Reef (Guinea, 2009), indicated no overlap with Areas A, B or C. Green and flatback turtles travelling from nesting sites to foraging grounds generally travelled east or south of Barrow Island and around or through the Dampier Archipelago, and along the coast towards foraging grounds to the north (north of Broome). Hawksbill turtles tend to travel south to the coastal island chain south of Barrow Island (Chevron, 2015). Tracking data indicates that three of the marine turtle species recorded for the NWMR travel and forage in coastal waters that are relatively shallow (Chevron, 2015):

- hawksbill turtles – less than 10 m deep
- green turtles – less than 25 m deep
- flatback turtles – less than 70 m deep.

Leatherback turtles foraging off WA are thought to have come from nesting areas in the Andaman Sea and/or Java (DoEE, 2017). General migration pathways identified for this species do not overlap Areas A, B or C. These pathways are based on tag recovery data and satellite telemetry (DoEE, 2017), but do not represent a defined track used by most of the population.

In summary, all five marine turtle species identified will occur within Areas A, B and C, However, due to water depths, absence of known foraging habitat and lack of emergent land (nesting), occurrence within Areas A and C is likely to be uncommon and restricted to transitory individuals. Occurrence of any of these five turtle species within Area B is likely to be rare.

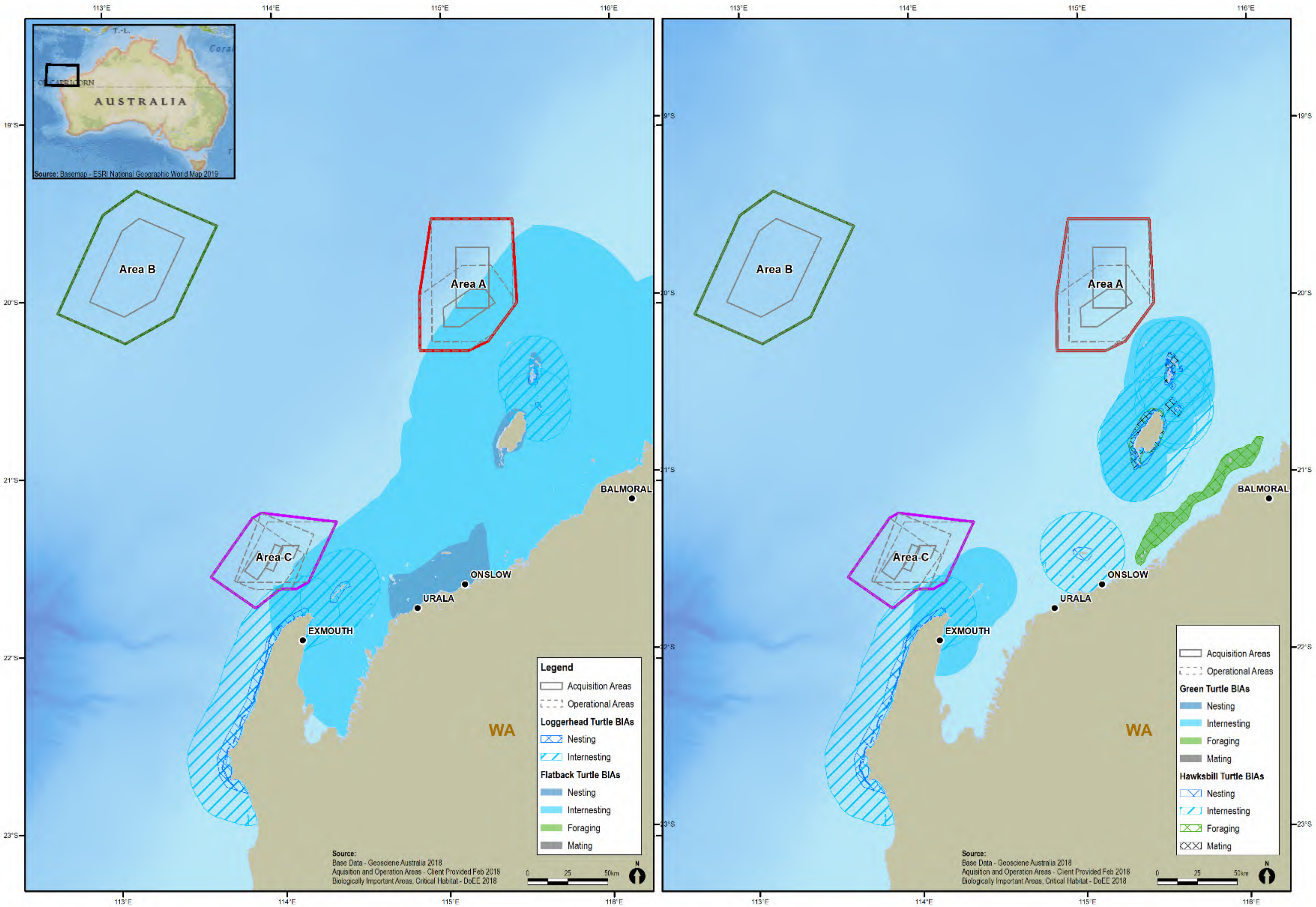

Figure 4-13: Marine turtle BIAs

Sea snakes

Sea snakes occur in the NWMR and are reported to occur in offshore and nearshore waters. They occupy diverse habitats including coral reefs, turbid water habitats and deeper water (Guinea et al., 2004). Species exhibit habitat preferences depending on water depth, benthic habitat, turbidity and season (Heatwole and Cogger, 1993).

The short-nosed sea snake, listed as Critically Endangered under the EPBC Act, was identified as occurring within Areas A and C. It was the only threatened sea snake species to be identified within the Protected Matters Search reports. Twelve other species, not currently listed as Migratory or Threatened, were identified as potentially occurring within Area A (the horned, Dubois', spine-tailed, olive, Stokes', spectacled, olive-headed, turtle-headed, fine-spined, elegant, spotted and yellow-bellied sea snakes) (**Appendix C**). Eleven sea snake species were identified as potentially occurring within Area C (the horned, Dubois', spine-tailed, olive, Stokes', spectacled, olive-headed, north-western mangrove, elegant, spotted and yellow-bellied sea snakes). In alignment with greater water depths, only three sea snake species were identified as potentially occurring within Area B (olive, spectacled and yellow-bellied sea snakes).

4.5.2.7 Fishes and Elasmobranchs

Seahorses and Pipefish

The EPBC Protected Matters Search identified 29 pipefish and six seahorse species within Area A, and 26 pipefish and five seahorse species within Area C. These species are not considered Threatened or Migratory under the EPBC Act. No pipefish or seahorses were identified as potentially occurring within Area B, largely due to the water depths in Area B (>900 m). By-catch data indicates seahorses and pipefish are uncommon in deeper continental shelf waters (>50 m) (DoF, 2010). Recent data collected using Baited Remote Underwater Video Stations (BRUVS) at offshore areas near Area A, including Rankin Bank and Glomar Shoals (16 and 120 km from Area A, respectively) did not record any seahorses or pipefish (AIMS, 2014). Seahorses and pipefish occur in nearshore and coastal waters comprising suitable habitat, such as seagrass, mangrove, coral reef and sandy habitats around coastal islands and shallow reef areas. Due to water depths and absence of known habitat, seahorses and pipefish are unlikely to occur within Areas A, B or C.

Sharks and Rays

<u>Great White Shark</u>

The great white shark is listed as Vulnerable and Migratory under the EPBC Act and typically occurs in temperate coastal waters between the shore and the 100 m depth contour; however, adults and juveniles have been recorded diving to depths of 1000 m (Bruce et al., 2006; Bruce, 2008). They are also known to make open ocean excursions of several hundred kilometres and can cross ocean basins (Weng et al., 2007a, 2007b). Along the WA coastline, white sharks move up the coast as far as North West Cape during spring and appear to return during summer. Although white sharks are not known to form and defend territories, they are known to return to (on a seasonal/regular basis) regions with high prey density, such as pinniped colonies (Bruce, 2008).

A recovery plan for the great white shark has been developed (DSEWPaC, 2013), which describes mortality from fishing (both commercial and recreational) and shark mitigation devices (nets and baited lines) as the key threats, with illegal trade of white shark products, ecosystem effects from habitat modification and climate change, and ecotourism as potential threats.

Great white sharks were identified by the EPBC Protected Matters Search as occurring within Areas A, B and C. However, given the migratory nature of the species, its low abundance, broad distribution in temperate waters across southern Australia and absence of preferred prey (pinnipeds), great white sharks are likely to be uncommon within the Areas.

Shortfin Mako

The shortfin mako shark is a pelagic species with a circumglobal, wide-ranging oceanic distribution in tropical and temperate seas (Mollet et al., 2000). It is listed as Migratory under the EPBC Act. Probably the fastest of all shark species, the shortfin mako is commonly found in water with temperatures greater than 16 °C and can grow to almost 4 m. Females mature later (19 to 21 years) than males (seven to nine years) and adults have moderate longevity estimates of 28 to 29 years (Bishop et al., 2006).

The shortfin mako shark is an apex and generalist predator that feeds on a variety of prey, such as teleost fish, other sharks, marine mammals and marine turtles (Campana et al., 2005). Tagging studies indicate shortfin makos spend most of their time in the top 50 m of the water column, with occasional dives up to 880 m (Abascal et al., 2011; Stevens et al., 2010). Little is known about the population size and distribution of shortfin mako sharks in WA; however, they were identified as occurring within Area A, B and C. It is possible they may infrequently transit the Areas.

Longfin Mako

The longfin mako is a widely distributed, but rarely encountered, oceanic shark species. The species can grow to just over 4 m long and is found in northern Australian waters, from Geraldton in WA to at least Port Stephens in New South Wales, and is uncommon in Australian waters relative to the shortfin mako (Bruce, 2013; DEWHA, 2010). There is very little information about these sharks in Australia, with no available population estimates or distribution trends. A study from southern California documented juvenile longfin mako sharks remaining near surface waters, while larger adults were frequently observed at greater maximum depths of about 200 m (Sepulveda et al., 2004). Longfin mako sharks may occur in Areas A, B and C, but given their widespread and highly dispersed distribution they are likely to be uncommon.

Giant Manta Ray

The giant manta ray is listed as Migratory under the EPBC Act and is broadly distributed in tropical waters of Australia. The species primarily inhabits near-shore environments along productive coastlines with regular upwelling, but they appear to be seasonal visitors to coastal or offshore sites including offshore island groups, offshore pinnacles and seamounts (Marshall et al., 2011). Areas A and B are not located in or adjacent to any known key aggregation areas for the species (e.g. feeding or breeding). However, Ningaloo Reef (adjacent to Area C) is an important area for giant manta rays between March and August (Environment Australia, 2002; Preen et al., 1997). Occurrence of giant manta rays within Area C is likely, particularly during this aggregation period as individuals transit the area. In Area A giant manta rays will potentially occur as transitory individuals within the upper slope portion of Area A. Due to the lack of suitable feeding opportunities, the giant manta ray is unlikely to occur within Area B.

Reef Manta Ray

The reef manta ray was redescribed relatively recently (Marshall et al., 2009), and is listed as Migratory under the EPBC Act. The species is commonly sighted inshore, but is also found around offshore coral reefs, rocky reefs and seamounts (Marshall et al., 2009). In contrast to the giant manta ray, long-term sighting records of the reef manta ray at established aggregation sites suggest this species is more resident in tropical waters and may exhibit smaller home ranges, philopatric movement patterns and shorter seasonal migrations than the giant manta ray (Deakos et al., 2011; Marshall et al., 2009). A resident population of reef manta rays has been recorded at Ningaloo Reef, and the species has been shown to have both resident and migratory tendencies in eastern Australia (Couturier et al., 2011). The reef manta ray was identified as occurring within Areas A and C, but was not identified as occurring within Area B. The reef manta ray is likely to occur within the upper slope portion of Area A and the southern portion of Area C, particularly near suitable habitat such as Ningaloo Reef.

Narrow Sawfish

The narrow sawfish occurs from the northern Arabian Gulf to Australia and north to Japan. The species inhabits inshore and estuarine waters and offshore waters up to depths of 100 m (D'Anastasi, 2015), and are most commonly found in sheltered bays with sandy bottoms. They are not currently listed as threatened but are commonly caught as bycatch, and constituted over half of sawfish by-catch in the Northern Prawn Fishery in 2013 (Morgan et al., 2010a). The species was identified as potentially occurring within Areas A and C; but not Area B. Due to the species' habitat preference for nearshore estuarine environments within the northern regions of WA, the narrow sawfish is likely to be uncommon within Areas A and C.

Dwarf Sawfish

Dwarf sawfish are found in Australian coastal waters extending north from Cairns around the Cape York Peninsula in Queensland to the Pilbara coast (DoE, 2013d). Dwarf sawfish typically inhabit shallow (2 to 3 m) silty coastal waters and estuarine habitats, occupying relatively restricted areas and moving only small distances (Stevens et al., 2008). Juvenile dwarf sawfish use estuarine habitats in north-western WA as nursery areas (Thorburn et al., 2008; Threatened Species Scientific Committee, 2009), and migrate to deeper waters as adults. Most capture locations for the species in WA waters have occurred within King Sound and the lower reaches of the major rivers that enter the sound, including the Fitzroy, Mary and Robinson rivers (Morgan et al., 2010). King Sound lies in the Kimberley region, about 930 km north-east of Area A. Individuals have also been recorded from Eighty Mile Beach, and occasionally have also been taken as by-catch from considerably deeper water from trawl fishing (Morgan et al., 2010). Dwarf sawfish were identified as potentially occurring within Areas A and C; however, were not identified as occurring in Area B. Due to depths within the Areas and known habitat preference, the dwarf sawfish is unlikely to occur within any of the Areas, but may occur in nearby coastal waters.

Green Sawfish

Green sawfish were identified as occurring within Areas A and C, but not within Area B. Green sawfish were once widely distributed in coastal waters along the northern Indian Ocean, although it is believed that northern Australia may be the last region where significant populations exist (Stevens et al., 2005). Within Australia, green sawfish are currently distributed from about the Whitsundays in Queensland across northern Australian waters to Shark Bay in WA (Commonwealth of Australia, 2015b). Green sawfish are present in coastal waters, tidal creeks, the north-eastern parts of the Ashburton Lagoon (Chevron, 2014). Despite records of the species in deeper offshore waters, green sawfish typically occur in the inshore fringe strongly associated with mangroves and adjacent mudflat habitats (Commonwealth of Australia, 2015b; Stevens et al., 2005). Movements within these preferred habitats are correlated with tidal movements (Stevens et al., 2008).

The Multi-species Recovery Plan for Sawfish and River Sharks indicates 'known to occur' distribution includes offshore waters of the NWS, with 'known' pupping areas in coastal waters north of Port Hedland to Roebuck Bay and pupping 'likely to occur' south of Port Hedland, Exmouth Gulf and North West Cape (Commonwealth of Australia, 2015b). The species is unlikely to occur within Areas A, B or C; however, may be found within nearby coastal waters, particularly mangroves and tidal creeks.

Whale Shark

Whale sharks aggregate annually to feed in the waters around Ningaloo Reef (this feeding BIA lies about 8 km south of Area C) from March to November. The largest numbers are recorded in April and May (CALM, 2005; DSEWPaC, 2012a; Environment Australia, 2002; Sleeman et al., 2010). However, seasonal aggregation can be variable, with individual whale sharks recorded at other times of the year. The super-population (comprising individuals that visit the reef at some point during their lifetime) has been estimated to range between 300 and 500 individuals and it is expected that the number visiting Ningaloo Reef in any given year will be somewhat smaller (Meekan et al., 2006). Timing of the whale shark migration to and from Ningaloo coincides with the coral mass spawning period when there is an abundance of food (krill, planktonic larvae and schools of small fish) in the waters adjacent to Ningaloo Reef. At Ningaloo Reef, whale sharks stay within a few kilometres of the shore and in waters about 30–50 m deep (Wilson et al., 2006).

The DoEE has defined an additional BIA for foraging whale sharks (post aggregation at Ningaloo) centred on the 200 m isobath from July to November. This area extends northward from the Ningaloo aggregation area to near Troughton Island in the east Kimberley. The foraging BIA originates in the eastern portion of Area C and transects the south-eastern side of Area A (note Area B does not overlap this BIA). Anecdotal evidence from sightings data collected from the Woodside offshore facilities in this area support the temporal limits of this BIA, and correspond with the whale shark's seasonal migration to and from Ningaloo Reef. Though the post aggregation BIA has been defined as foraging for whale sharks, based on the literature, it is more likely to be a migration pathway with whale sharks foraging opportunistically.

Aside from these aggregation periods, the distribution of the whale sharks is largely unknown. Tagging, aerial and vessel surveys suggest that the group disperses widely, up to 1800 km away into Indonesian waters, Christmas Island and the Coral Sea. Satellite tracking data indicates that the population has levels of behavioural polymorphism and may follow three migration routes from Ningaloo (Meekan and Radford 2010; Wilson et al., 2006):

- north-west, into the Indian Ocean
- directly north, towards Sumatra and Java
- north-east, travelling along the shelf break and continental slope (**Figure 4-15**).

While whale sharks were not identified as occurring within Area B in the Protected Matters Search, satellite tracks of whale sharks moving in a north-east direction show individuals do transit Areas A, B and C. It is possible that whale sharks may occur in all three Areas, particularly before and during these aggregation periods and within known foraging areas or migration pathways (**Figure 4-15**). Due to proximity to Ningaloo Reef and overlap with the whale shark foraging BIA, Area C is expected to be more frequently visited by whale sharks relative to Areas A and B.

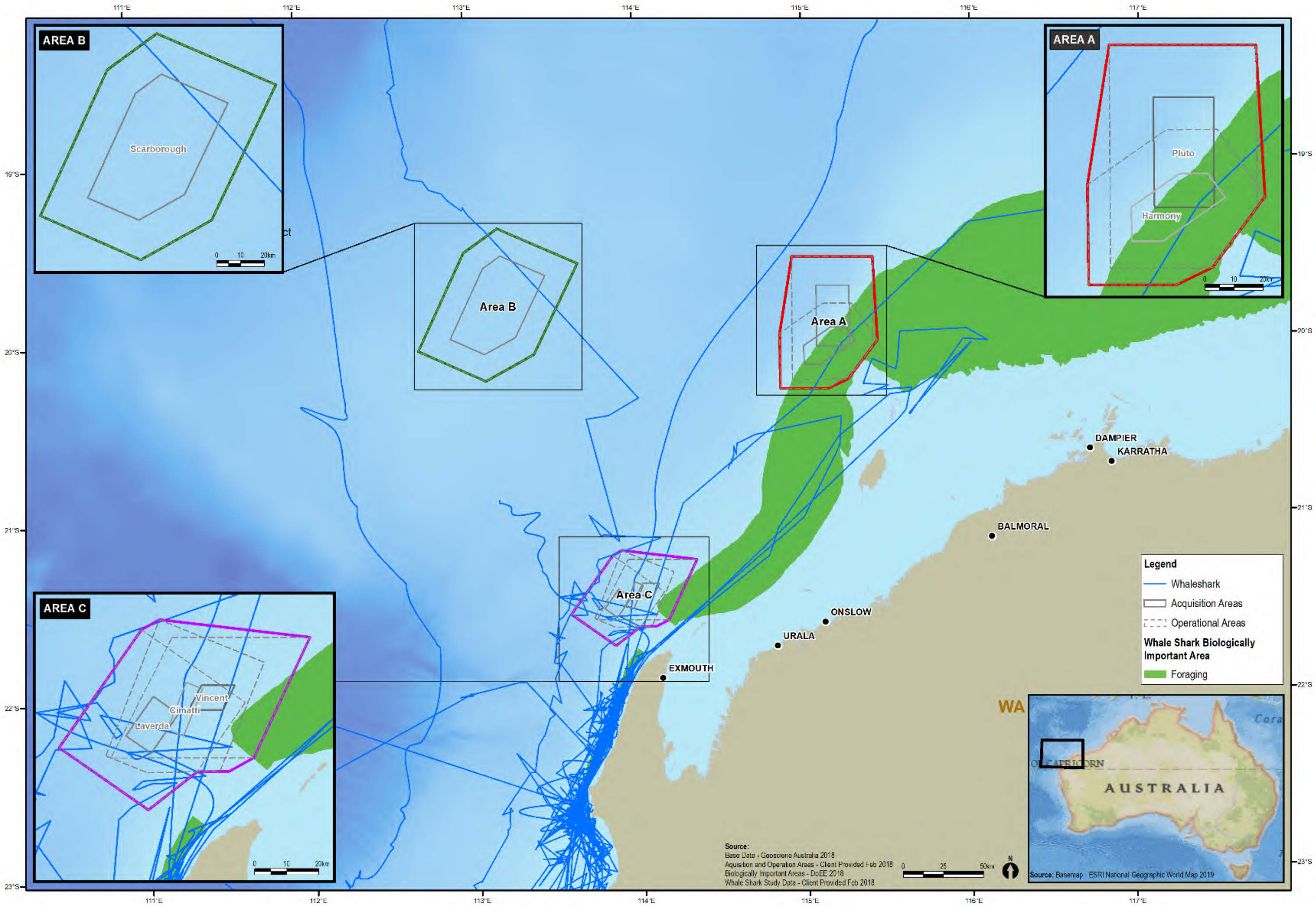

Figure 4-14: Satellite tracks of whale sharks tagged between 2005 and 2008 (after Meekan and Radford, 2010)

Grey Nurse Shark

The grey nurse shark is listed as Vulnerable under the EPBC Act and has a broad distribution in inner continental shelf waters, primarily in sub-tropical to cool temperate waters. The species occurs primarily in south-west coastal waters between 20 and 140 m depth off WA (Chidlow et al., 2006). Grey nurse sharks have been documented as aggregating in specific areas (typically reefs); however, no clear aggregation sites have been identified off Western Australia (Chidlow et al., 2006). A species recovery plan has been developed for the grey nurse shark, which describes mortality from fishing (both commercial and recreational) and shark mitigation devices (nets and baited lines) as the key threats, with ecotourism, collection for aquaria, pollution, disease and ecosystem effects of habitat modification and climate change as potential threats (DoE, 2014a).

Grey nurse sharks were identified as potentially occurring within Area A and C, but not occurring within Area B. Due to the grey nurse shark habitat preference and wide distribution, is likely to be uncommon within Area A and C.

4.5.2.8 Birds

Oceanic Seabirds and/or Migratory Shorebirds

Areas A, B and C may be occasionally visited by migratory and oceanic birds but do not contain any emergent land that could be used as roosting or nesting habitat and contain no known critical habitats (including feeding) for any species. Fifteen species of listed birds were identified by the EPBC Act Protected Matters Search (**Appendix C**) as potentially occurring within Areas A, B or C, of which six are listed as Threatened (**Table 4-3**). Thirteen of these were identified within Area A (five listed as Threatened), seven within Area B (two listed as Threatened), and fourteen within Area C (six listed as Threatened). Seven species were identified as occurring within all three Areas, including the:

- red knot, listed as Endangered and Migratory
- common sandpiper, listed as Migratory
- common noddy, listed as Migratory
- sharp-tailed sandpiper, listed as Migratory
- pectoral sandpiper, listed as Migratory
- lesser frigatebird, listed as Migratory
- southern giant petrel, listed as Endangered and Migratory.

There are several important habitats for seabirds and migratory shorebirds within inshore and coastal waters of the Pilbara coast, including key breeding/nesting areas, roosting areas and surrounding waters with important foraging and resting areas. These include:

- Muiron Islands
- Montebello Islands
- Barrow Island
- Pilbara Islands – Southern Island Group.

These habitats are discussed further in **Section 4.7** as key environmental sensitivities.

Seabird surveys over the Northwest Shelf Province have noted that seabird distributions in tropical waters were generally patchy, except near islands (Dunlop et al., 1988). Given the nearest landfall occurs 27 km from Area A and 16 km from Area C, seabirds are likely to occur in the southern portion of these two Areas. Migratory shorebirds may also be present in or fly through the region between July and December and again between March and April as they complete migrations between

Australia and offshore locations (Commonwealth of Australia. 2015c). Seabirds are unlikely to occur within Area B due to a lack of nearby emergent habitat but may transit the area during seasonal migrations.

4.6 Socio-economic and Cultural

4.6.1 Cultural Heritage

4.6.1.1 European and/or Indigenous Sites of Significance

There are no known sites of Indigenous or European cultural heritage significance within Areas A, B or C. Exmouth and the adjacent foreshores along North West Cape (about 16 km from Area C) have a long history of occupancy by Aboriginal communities. Indigenous heritage places are protected under the *Aboriginal Heritage Act 1972* (WA) or EPBC Act.

4.6.1.2 Historic shipwrecks

A search of the National Shipwreck Database (DoEE n.d.) identified four known historic shipwrecks within Area A (**Table 4-7**). There are no known historic shipwrecks within Area B or Area C.

Table 4-7: Recorded historical shipwrecks in the vicinity of the Areas (DoEE n.d.)

Vessel name	Year wrecked	Wreck location*	Latitude (°D.DD)	Longitude (°D.DD)
Curlew	1911	WA – North West (Montebello Area)	20°S	115.17°E
Marietta	1905	WA – North West (Montebello Area)	20°S	115.17°E
Vianen	1628	WA – North West (Montebello Area)	20°S	115.17°E
Wild Wave (China)	1873	WA – North West (Montebello Area)	20°S	115.17°E

*** Considered an unreliable generic location – refer to stated wreck location.*

4.6.1.3 National and Commonwealth Heritage Listed Places[5]

There are no heritage listed sites within Areas A, B or C. However, there are a number of gazetted and proposed National and Commonwealth heritage places surrounding Areas A, B and C, including:

- National Heritage places:

the proposed Barrow Island and the Montebello-Barrow Islands Marine Conservation Reserves National Heritage Place (about 20 km south-east of Area A)

the Ningaloo Coast National Heritage Area (2 km south-east of Area C).

- Commonwealth Heritage places:

Ningaloo Marine Area (Commonwealth Waters) Commonwealth Heritage Place (2 km from Area C).

4.6.2 Ramsar Wetlands

No Ramsar wetlands overlap Areas A, B or C. The nearest Ramsar wetland is Eighty Mile Beach, located over 500 km east of Area A.

[5] World Heritage designations are addressed in **Section** 4.7.

4.6.3 Fisheries – Commercial

4.6.3.1 Commonwealth and State Fisheries

A number of Commonwealth and State fisheries are located within, adjacent to or in the region of the Areas. **Table 4-8** provides further detail on the fisheries that have been identified through desk-based assessment and stakeholder consultation (**Section 5**). **Figure 4-16** and **Figure 4-17** provide the designated fisheries management areas in relation to the location of Areas A, B and C.

Table 4-8: Commonwealth and State fisheries of relevance to the Petroleum Activities Program

Fishery	Fishing boundary overlap with Areas			Management boundaries	Fishing season	Description of the fishery	Catch and effort potentially occurring within the Areas			Description of catch and effort within respective Areas
	A	B	C				A	B	C	
Commonwealth Managed Fisheries										
North West Slope Trawl Fishery (NWSTF)	✓	×	✓	The NWSTF extends from 114°E to 125°E, from the 200 m isobath to the outer limit of the Australian Fishing Zone.	12 month season	The NWSTF targets scampi and deep water prawns using benthic trawl gear. Fishing occurs over soft, muddy sediments or sandy habitats, typically at depths of 350–600 m using demersal trawl gear on the continental slope (Patterson at al., 2018). Two vessels were active in the 2016–2017 season (Patterson at al., 2018). The most recent publicly available fisheries data indicates that fishing effort in 2016–17 was about 2869 hours, an increase from the 2241 hours in 2015–16 (Patterson at al. 2018). Total scampi catch in the fishery was slightly higher in the 2016–2017 than in the previous year, 54.8 t up to 57.8 t (Patterson at al., 2018).	✓	×	×	***Area A*** NWSTF effort is concentrated along the southern portion of the fishery boundary between the Montebello Islands and Scott Reef. Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) Fishery Status Reports (Patterson et al., 2018, 2017, 2016, 2015, Woodhams et al., 2014, 2012) indicate the NWSTF potentially trawl within or nearby Area A. ***Area B*** N/A (Area B is located outside of the NWSTF management boundary). ***Area C*** No fishing effort occurs within or nearby Area C (Patterson et al., 2018, 2017, 2016, 2015; Woodhams et al., 2014, 2012).
Southern Bluefin Tuna Fishery (SBTF)	✓	✓	✓	The SBTF spans the Australian Fishing Zone.	12 month season	The SBTF targets southern bluefin tuna (*Thunnus maccoyii*) using purse seine and some longline fishing. The majority of the fishing effort for the SBTF occurs in the Great Australian Bight and north-east of Eden in New South Wales (Patterson at al., 2018; Australian Fisheries Management Authority (AFMA), 2013; Georgeson et al., 2014).	×	×	×	No fishing effort occurs within or nearby Areas A, B or C (Patterson at al. 2018, 2017, 2016, 2015; Woodhams et al., 2014, 2012).
(Western) Skipjack Tuna Fishery (WSTF)	✓	✓	✓	The WSTF spans the Australian Fishing Zone.	The WSTF is not currently active and the management arrangements are under review	No fishing activity for the WSTF has been recorded since the 2008–2009 fishing season as a result of the natural variability of skipjack tuna stocks in Australian waters and low unit price for this species of tuna (Patterson et al., 2018; Georgeson et al., 2014).	×	×	×	N/A (no fishing activity).
Western Tuna and Billfish Fishery (WTBF)	✓	✓	✓	The WTBF spans the western majority of the Australian Fishing Zone from the SA/Victoria Border to the Cape York Peninsula.	12 month season	The WTBF targets bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*), striped marlin (*Kajikia audax*) and swordfish (*Xiphias gladius*) using pelagic longline and some minor-line fishing. Since 2005, fewer than five vessels have been active in the fishery each year (Patterson et al., 2018). Effort is concentrated off south-west Western Australia and South Australia.	×	×	×	No fishing effort occurs within or nearby Areas A, B or C (Patterson et al., 2018, 2017, 2016, 2015; Woodhams et al., 2014, 2012).
Western Deepwater Trawl Fishery (WDTF)	×	✓	✓	The WDTF is located in deep water off Western Australia, from the line approximating the 200 m isobath to the edge of the Australian Fishing Zone.	12 month season	Most of the fishing effort is south and offshore of North West Cape, with areas of medium and high density fishing activity located to the south of Ningaloo Reef and west of Shark Bay, beyond the 200 m isobath (Patterson et al., 2018; Georgeson et al., 2014).	×	×	×	No fishing effort occurs within or nearby Areas A, B or C (Patterson et al., 2018, 2017, 2016, 2015; Woodhams et al., 2014, 2012).

Fishery	Fishing boundary overlap with Areas			Management boundaries	Fishing season	Description of the fishery	Catch and effort potentially occurring within the Areas			Description of catch and effort within respective Areas
	A	B	C				A	B	C	
State Managed Fisheries										
Mackerel Managed Fishery (MMF)	✓	✓	✓	The commercial fishery extends from Geraldton to the Northern Territory border. There are three managed fishing areas: Kimberley (Area 1), Pilbara (Area 2), and Gascoyne and West Coast (Area 3).	Fishing takes place over about six months (May to November), when Spanish mackerel are abundant in coastal areas (Molony et al., 2014)	The fishery targets Spanish mackerel using near-surface trawling gear from small vessels in coastal areas around reefs, shoals and headlands. Jig fishing is also used to capture grey mackerel (*S. semifasciatus*), with other species from the genus *Scomberomorus* (Lewis and Jones, 2018). The majority of the catch is taken in the Kimberley region, reflecting the tropical distribution of mackerel species (Molony et al., 2014). The seasonal appearance of mackerel in shallower coastal waters is most likely associated with feeding and gonad development prior to spawning (Molony et al., 2014). In 2016 the MMF landed 267 t of Spanish mackerel (Lewis and Jones, 2018).	✓	×	✓	***Area A*** In 2017, three vessels from the MMF were active for 41 days in the waters surrounding Montebello Islands, catching 19 tonnes of fish. Current catch and effort data indicates less than three vessels regularly fish nearby, and potentially within, the south-east boundary of Area A (Department of Primary Industries and Regional Development (DPIRD), 2019a). ***Area B*** No fishing occurs in Area B due to water depths and distance from shore. Current catch and effort data confirms the MMF fishes at least 160 km from Area B (DPIRD, 2019a). ***Area C*** Current catch and effort data indicates no fishing from the MMF occurs within Area C. The closest fishing effort relative to Area C occurs east of the Muiron Islands in the waters surrounding Serrurier and Thevenard Islands, at least 25 km from Area C.
Pilbara Demersal Scalefish Managed Fisheries (PDSMF): Pilbara Fish Trawl (Interim) Managed Fishery	✓	×	✓	The Pilbara Fish Trawl Managed Fishery covers the area from Exmouth northwards and eastwards to the 120° line of longitude, and offshore as far as the 200 m isobath. The Pilbara Fish Trawl Managed Fishery is divided into two zones: Zone 1 is closed to trawling and Zone 2 comprises six management areas, with Areas 3 and 6 closed to trawling (DoF, 2010) (**Figure 4-18**).	Year-round, with the highest fishing effort occurring between September and May (Newman et al., 2014b)	The Pilbara Trawl Fishery targets both small, low value fish such as spangled emperor (*Lethrinus nebulosus*) flagfish and threadfin bream (family *Nemipteridae*) as well as larger and more valuable fish such as red emperor (*Lutjanus sebae*), jobfish (*Aprion virescens*) and Rankin cod (*Epinephelus multinotatus*). The fishery uses benthic trawl gear in waters between 50 and 200 m water depth. (Newman et al., 2014a). In 2016, two vessels in the Pilbara Trawl Fishery landed 1529 t of demersal scalefish (Newman et al., 2018a).	×	×	×	***Area A*** Area A is partially located within the PDSMF management boundary, however no trawl fishing is permitted within Area A. The closest zone whee trawl fishing is permitted occurs about 58 km east of Area C. Current catch and effort data (2013–2017) confirms no catch or effort within Area A (DPIRD, 2019b). ***Area B*** Area B is located over 150 km from the fishing management boundary, and about 245 km east of a zone where trawl fishing is permitted. Current catch and effort data (2013–2017) confirms no catch or effort within Area B (DPIRD, 2019b). ***Area C*** Area C is partially located within the PDSMF management boundary, however no trawl fishing is permitted within Area C. The closest zone where trawl fishing is permitted occurs about 245 km north-east of Area C. Current catch and effort data (2013–2017) confirms no catch or effort within Area C (DPIRD, 2019b).
Pilbara Demersal Scalefish Managed Fisheries (PDSMF): Pilbara Trap Managed Fishery	✓	×	✓	The Pilbara Trap Managed Fishery covers the area from Exmouth northwards and eastwards to the 120° line of longitude, and offshore as far as the 200 m isobath (**Figure 4-18**).	Year-round	This Pilbara Trap Managed Fishery targets high value species such as red emperor and goldband snapper using fish traps, generally in waters less than 50 m depth. In 2016, three vessels in the Pilbara Trap Managed Fishery landed 495 t of demersal scalefish (Newman et al., 2018a).	✓	×	✓	***Area A*** Area A is partially located within the PDSMF management boundary where trap fishing is permitted. Current catch and effort data indicates the Pilbara Trap Managed Fishery regularly fishes in the waters surrounding, and potentially within Area A (DPIRD, 2019b). ***Area B*** Area B is located over 150 km from the fishing management boundary. Current catch and effort data (2013–2017) confirms no catch or effort within Area B (DPIRD, 2019b). ***Area C*** Area C is partially located within the PDSMF management boundary where trap fishing is permitted. Current catch and effort data indicates the Pilbara Trap Managed Fishery regularly fishes in the waters surrounding, and potentially within Area C (DPIRD, 2019b).

Fishery	Fishing boundary overlap with Areas			Management boundaries	Fishing season	Description of the fishery	Catch and effort potentially occurring within the Areas			Description of catch and effort within respective Areas
	A	B	C				A	B	C	
Pilbara Line Managed Fishery	✓	×	✓	The Pilbara Line Managed Fishery covers the area from Exmouth northwards and eastwards to the 120° line of longitude, and offshore as far as the 200 m isobath (**Figure 4-18**).	Year-round (fishers nominate a five month period to fish).	The Pilbara Line Managed Fishery targets similar demersal species to the Pilbara Trap and Trawl fisheries, as well as some deeper offshore species such as ruby snapper (*Eteliscarbunculus*) and eightbar grouper (*Hyporthodus octofasciatus*). The Pilbara Line Managed Fishery operates on an exemption basis and is comprised of operators with a fishing boat licence entitling them to unrestricted access to the fishery. In 2016, five vessels in the Pilbara Line Managed Fishery landed 126 t of demersal scalefish (Newman et al., 2018a).	✓	×	✓	***Area A*** Current catch and effort data indicates the Pilbara Line Managed Fishery regularly fishes in the waters surrounding, and potentially within Area A (DPIRD, 2019b). ***Area B*** No fishing occurs in Area B due to water depths and distance from shore. Current catch and effort data confirmed the Pilbara Line Managed Fishery does not fish within Area B (DPIRD, 2019b). ***Area C*** Current FishCube data indicates the Pilbara Line Managed Fishery regularly fishes in the waters surrounding, and potentially within Area C.
West Coast Deep Sea Crustacean Managed Fishery (WCDSCMF)	×	×	✓	The WCDSCMF extends north from Cape Leeuwin to the WA/NT border in water depths greater than 150 m within the Australian Fishing Zone.	Year-round	The WCDSCMF targets crystal (snow) crabs, giant (king) crabs and champagne (spiny) crabs using baited pots operated in a longline formation in the shelf edge waters, mostly in depths between 500 and 800 m. In 2016, two vessels in the WCDSCMF landed 153.3 t of crabs (How and Yerman, 2018).	×	×	×	Fishing effort is concentrated between Fremantle and Carnarvon, over 350 km south of Area C. Current catch and effort data (2013–2017) confirms no catch or effort within Areas A, B or C for the WCDSCMF (DPIRD, 2019b).
Pearl Oyster Managed Fishery	✓	×	✓	The fishery is separated into four zones. Area A and part of Area C overlap with the Pearl Oyster Zone 1, which extends from North West Cape (including Exmouth Gulf) (119°30´E) to Cape Thouin (118°20´E).	Year-round	The Pearl Oyster Managed Fishery collects Indo-Pacific silver-lipped pearl oysters (*Pinctada maxima*) which are harvested in shallow coastal waters along the NWS using divers, and are mainly used to culture pearls. In 2016, six vessels in the Pearl Oyster Managed Fishery collected 541,260 shells (Hart et al., 2018a). Within the Gascoyne region, hatchery production of oysters is conducted. Hatcheries in Carnarvon and Exmouth supply significant quantities of *P. maxima* spat to pearl farms in Exmouth Gulf and the Montebello Islands, while several hatcheries supply juveniles of the blacklip pearl oyster (*P. margaritifera*) to the region's developing black pearl farms.	×	×	×	Due to water depth, fishing method limitations, distance offshore, and distance from popular fishing spots, the Pearl Oyster Managed Fishery is not expected to fish within Areas A, B or C. Current catch and effort data (2013–2017) confirms no catch or effort within, or nearby Areas A, B or C (DPIRD, 2019b).
Abalone Managed Fishery	✓	✓	✓	The WA Abalone Managed Fishery includes all coastal waters from the WA and SA border to the WA and NT border.	Year-round (commercial fishery only)	The Abalone Managed Fishery targets the greenlip abalone (*Haliotis laevigata*), brownlip abalone (*H. conicopora*) and Roe's abalone (*H. roei*) (Strain et al., 2018). The fishers in the north coast bioregion target Roe's abalone. Abalone is harvested by hand using an abalone iron from reefs and rock shelves within Western Australian waters, limiting the fishery to shallow waters. Shark Bay is considered the northern range limit for the commercial abalone species (DoF, 2004). In 2016, 22 vessels operating in the Abalone Managed Fishery landed 49 t of Roe's abalone (Strain et al., 2018).	×	×	×	Due to water depth, fishing method limitations and distance offshore, the Abalone Managed Fishery is not expected to fish within Areas A, B or C.
Marine Aquarium Managed Fishery (MAMF)	✓	×	✓	The MAMF licence area extends into Commonwealth waters, spanning the coastline from the Northern Territory border to the South Australian border (Smith et al., 2010).	Year-round	The MAMF is primarily a dive-based fishery that uses hand-held nets to capture target species operating from boats up to 8 m in length. The fishery is typically active from Esperance to Broome, with popular areas including the coastal waters of the Capes region, Dampier and Exmouth. Licencees are not permitted to operate within the Ningaloo Marine Park, however, are permitted to operate in the general purpose zone of Montebello Islands Marine Park. In 2016, eleven licences operated in the MAMF, predominantly collecting ornamental fish but also included hermit crabs, seahorses, invertebrates, corals and live rock (Newman et al., 2018b).	×	×	×	Due to water depth, distance offshore, and distance from popular fishing spots, the MAMF is not expected to fish within Areas A, B or C. Current catch and effort data (2013–2017) confirms no catch or effort within, or nearby Areas A, B or C (DPIRD, 2019c).

Fishery	Fishing boundary overlap with Areas			Management boundaries	Fishing season	Description of the fishery	Catch and effort potentially occurring within the Areas			Description of catch and effort within respective Areas
	A	B	C				A	B	C	
Specimen Shell Managed Fishery (SSMF)	✓	×	✓	The SSMF fishing area includes all Western Australian waters between the high water mark and the 200 m isobath.	Year-round	The SSMF targets the collection of specimen shells for display, collection, cataloguing and sale. Collection is predominantly by hand when diving or wading in shallow coastal waters. deeper water collection has recently commenced with the employment of ROVs at water depths up to 300 m. In 2016, seven licence holders recorded consistent activity (and 17 occasional operators) to collect a total of 8531 shells (Hart et al., 2018b).	×	×	×	Current catch and effort data (2013–2017) indicates the SSMF is active in waters near Montebello Islands, Muiron Island and Pilbara Southern Island Group (DPIRD, 2019c). However, due to water depth, distance offshore, and distance from popular fishing spots, the SSMF is not expected to fish within Areas A, B or C.
West Coast Rock Lobster Managed Fishery (WCRLF)	×	×	✓	The WCRLF fishing area stretches between Shark Bay and Cape Leeuwin. The WCRLF is divided into three zones: (A) Abrolhos Islands; (B) north of latitude 30°S; and (C) south of latitude 30°S.	Year-round	The WCRLF targets the western rock lobster (*Panulirus cygnus*) from Shark Bay south to Cape Leeuwin using baited traps (pots) (DPIRD, 2017). In 2008, it was determined that the allocated shares of the West Coast Rock Lobster resource would be 95% for the commercial sector, 5% to the recreational sector, and one tonne to customary fishers. In 2016, 226 commercial vessels landed 6095 t of rock lobster (de Lestang et al., 2018).	×	×	×	The WCRLF targets rock lobster from south of Shark Bay, over 400 km from Area C. Therefore the WCRLF is not expected to fish within Areas A, B or C.
Beche-de-Mer Fishery	✓	✓	✓	The sea cucumber or 'trepang' fishery can operate within all WA waters.	Year-round	The sea cucumber or 'trepang' fishery is a hand-harvested fishery (methods principally by diving or wading), primarily targeting a single species with 99% of the catch being sandfish (*Holothuria scabra*). In 2016, the Beche-de-Mer fishery landed 93 t of sea cucumber (Hart et al., 2018c).	×	×	×	Current catch and effort data (2013–2017) indicates the fishery is active in waters near Montebello Islands, Muiron Island and Pilbara Southern Island Group (DPIRD, 2019a). However, due to water depth, distance offshore, and distance from popular fishing spots, fishers do not collect sea cucumber within Areas A, B or C.
Onslow Prawn Managed Fishery (OPMF)	✓	×	×	The OPMF management boundary extends east from the Dampier Archipelago to the southern extent of Eighty Mile Beach, and offshore as far as the 200 m isobath.	The season extends from March to November, with several specific areas restricted to May to September to protect nursery areas (Sporer et al., 2014)	The OPMF targets western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*) and endeavour prawns (*Metapenaeus* spp.) using low opening otter prawn trawl systems. In 2016, the OPMF landed a total of 3 t of prawns (Kangas *el al*., 2018a).	×	×	×	Although the OBPMF management boundary overlaps with Area A, effort is concentrated in coastal waters, about 10 km south-east of Area A (Sporer et al., 2014).
Exmouth Gulf Prawn Managed Fishery (EGPMF)	×	×	×	The EGPMF management boundary includes the waters of the Exmouth Gulf. Muiron and Serrurier islands comprise the northern extent of the management boundary.	Year-round, with the highest effort occurring from September to mid-May. Monthly moon closures of at least four days around each full moon.	The EGPMF primarily targets western king, brown, endeavour and banana prawns using low opening, otter prawn trawl systems within the Exmouth Gulf. In 2016, the EGPMF landed a total of 822 t of prawns (Kangas el al., 2018b).	×	×	×	The EGPMF managemenent boundary does not overlap with Areas A, B or C. The closest catch and effort for the EGPMF occurs at least 19 km east of Area C.

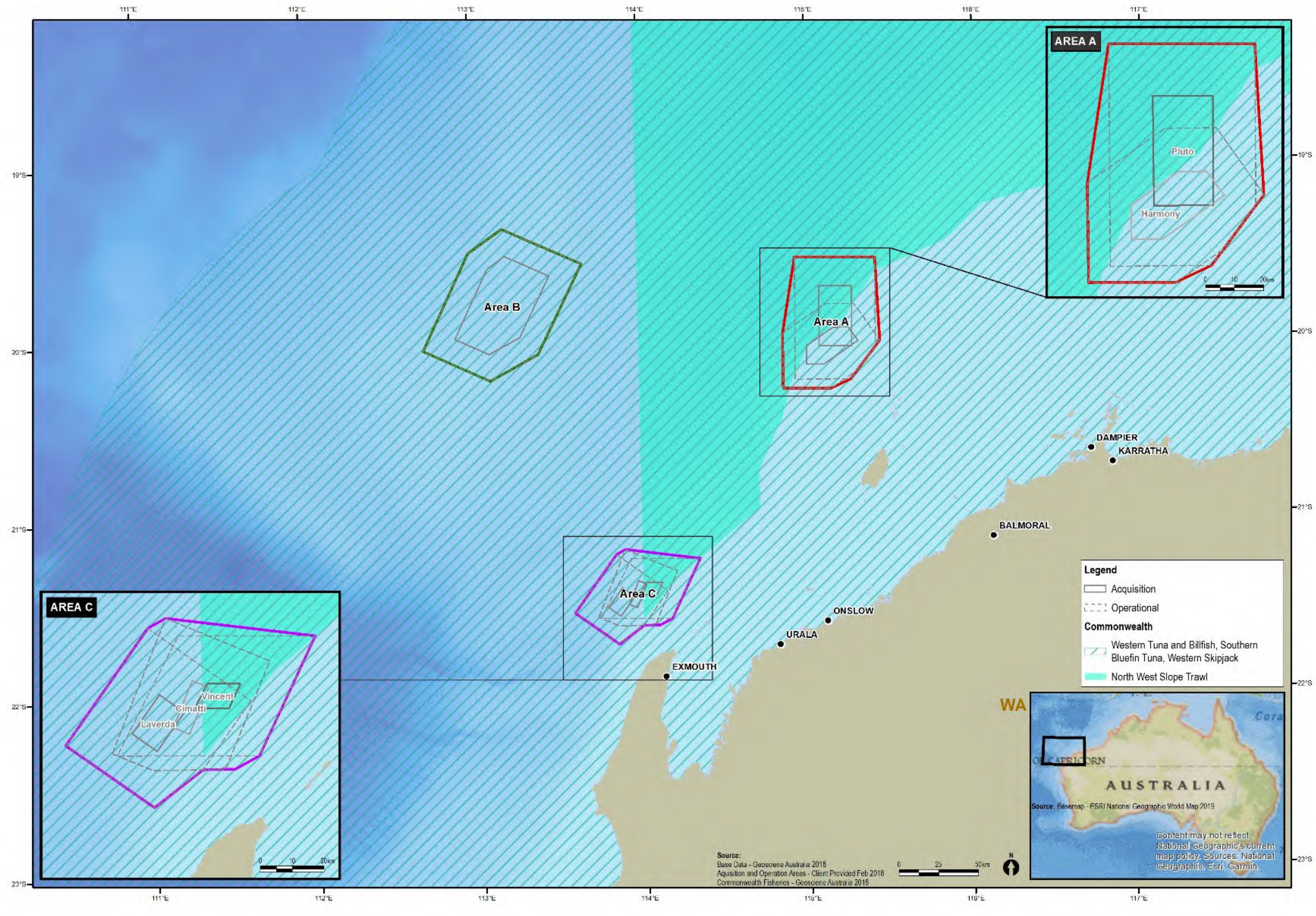

Figure 4-15: Location of Commonwealth fisheries in relation to the Areas (Geoscience Australia, 2018)

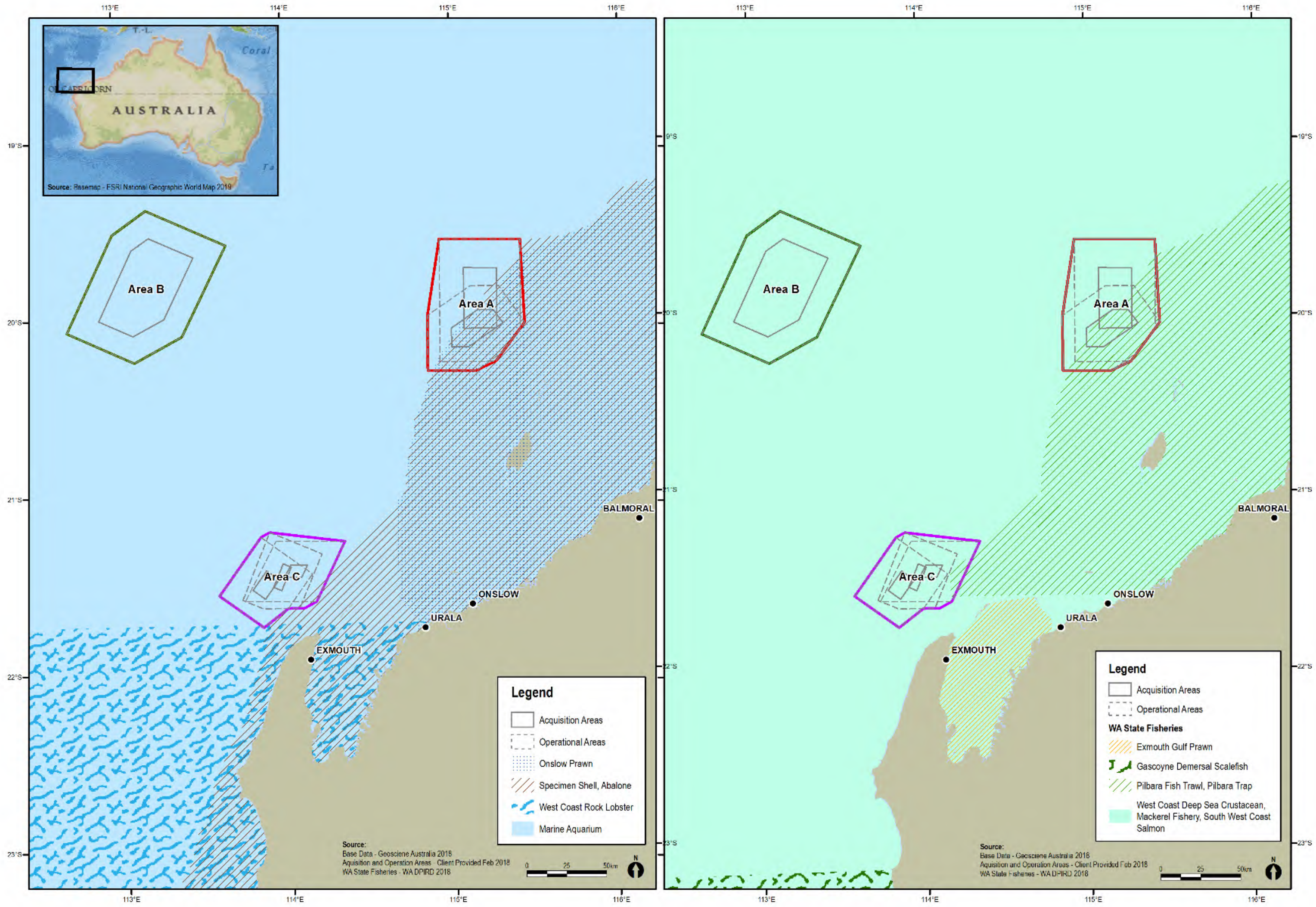

Figure 4-16: Location of State fisheries in relation to the Areas (Geoscience Australia, 2018)

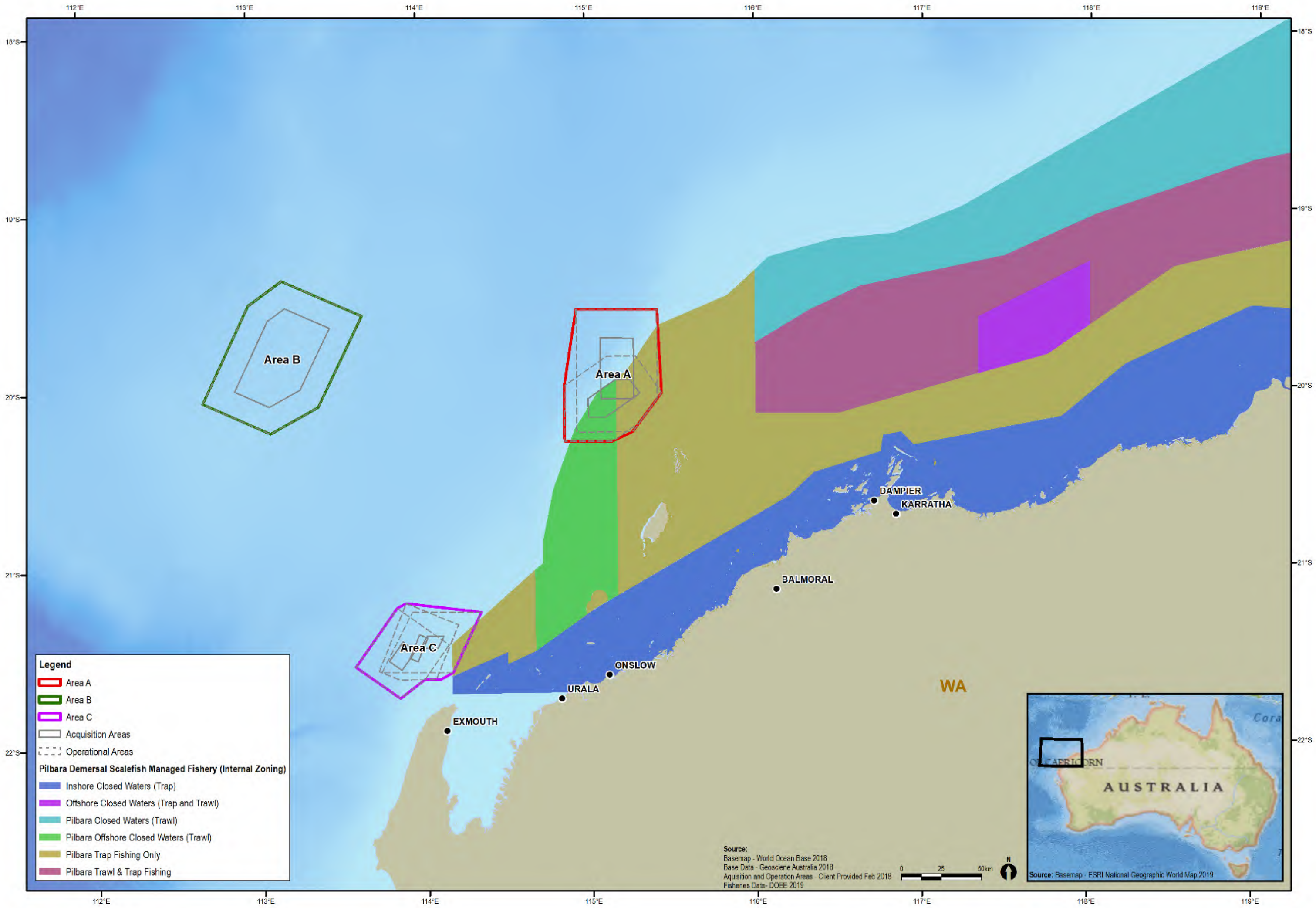

Figure 4-17: Pilbara Demersal Scalefish Managed Fishery zoning (Geoscience Australia, 2018)

4.6.3.2 Aquaculture

There are no aquaculture leases within or adjacent to Area A, B or C. Aquaculture in the NWMR is typically restricted to shallow coastal waters and consists primarily of culturing hatchery, reared and wild caught oysters (*Pinctada maxima*) for pearl production (Note: the Pearl Oyster Managed Fishery, which targets *P. maxima* for aquaculture farming is included in **Table 4-8**). Leases typically occur in shallow coastal waters at depths of less than 20 m (Fletcher and Santoro, 2011). Currently, there are three aquaculture leases and 404 licences, contributing to a total production volume of 20,814 tonnes in the 2015/2016 season (DoF, 2016a).

A large number of pearl oysters for seeding is obtained from wild stocks and supplemented by hatchery-produced oysters, with major hatcheries operating at Broome and the Dampier Peninsula. Pearl farm sites are located mainly along the Kimberley coast, particularly in the Buccaneer Archipelago, in Roebuck Bay and at the Montebello Islands (which is located about 20 km from Area A) (Gaughan and Santoro, 2018).

Along the Gascoyne Coast, aquaculture focuses on the blacklip oyster *P. margitifera*. The local aquaculture sector is also focusing on producing aquarium species, including coral and live rock (Gaughan and Santoro, 2018).

4.6.4 Fisheries – Traditional

There are no traditional, or customary, fisheries within Areas A, B or C, as these are typically restricted to shallow coastal waters and/or areas with structures such as reefs. However, it is recognised that Barrow Island (approximately 50 km from Area A), the Montebello Islands (about 30 km from Area A) and Ningaloo Reef (2 km from Area C) have a known history of fishing from when areas were occupied (as from historical records).

4.6.5 Tourism and Recreation

No tourism activities take place specifically within Areas A, B or C, but it is acknowledged that there are growing tourism and recreational sectors in WA and these sectors have expanded in area over the last couple of decades. Potential for growth and further expansion in tourism and recreational activities in the Pilbara and Gascoyne regions is recognised, particularly with the development of regional centres and a workforce associated with the resources sector (Gascoyne Development Commission, 2012).

Due to water depths (greater than 40 m) and distance offshore, recreational fishing is unlikely to occur in Areas A, B or C. However, an estimated third of the WA population participate in recreational fishing each year (about 640,000 fishers) (DPIRD, 2018). Recreational fishing in the Northwest Shelf Province is mainly concentrated around the coastal waters and islands (including Dampier Archipelago, Ningaloo Marine Park, North West Cape area, the Montebello Islands, and other islands and reefs in the region) (DEWHA, 2008) and has grown exponentially with the expanding regional centres and increasing residential and fly in/fly out work force, particularly in the Pilbara region.

4.6.5.1 Area A

Occasional recreational fishing occurs at Rankin Bank, located about 15 km east of Area A. The Montebello Islands (about 30 km from Area A) are the next closest location for tourism, with some charter boat operators taking visitors to these remote islands (Australia's Northwest, 2018). Along the Pilbara Coast, the Dampier Archipelago (about 145 km from Area A) is a popular location for tourist activities including recreational fishing, diving, surface water-sports and wildlife viewing (Karratha Visitor Centre, 2019). In particular, the waters of the Archipelago are extensively used by local people from surrounding towns (Department of Environment and Conservation (DEC), 2002).

DPIRD uses a spatial grid known as Catch and Effort System (CAES) blocks to record catch and effort for fishing activity in WA waters (DPIRD, 2019). Each block measures 60 nm². The south-east portion of Area A is located within a block that has high effort from tour operators relative to adjacent blocks, with ten licenced vessels making 298 fishing trips to the block in 2017. The block contains the Montebello Islands, Browse Island and some nearshore islands off the Pilbara coast, which are popular locations visited by charter boats (DEC, 2013). It is unlikely that tour operators will make trips within Area A, but will operate in the coastal waters around the Montebello/Barrow islands.

4.6.5.2 Area B

Current FishCube data (2013–2017) indicates no tour operators use the waters within or surrounding Area B (DPIRD, 2019). Area B is considered too far offshore for recreational fishing or tourism activities to occur.

4.6.5.3 Area C

Tourism is one of the major industries of the Gascoyne region and contributes significantly to the local economy in terms of both income and employment. The main marine nature-based tourist activities are concentrated around and within the Ningaloo Marine Park, 2 km from Area C.

Recreational use of the Ningaloo Marine Park varies in intensity throughout the year, depending on school holidays and seasonal peaks of marine fauna being observed. Coral Bay is documented as one of the most heavily used areas (Marine Parks and Reserves Authority (MPRA), 2005). Marine nature-based tourism attracts about 102,000 annual visitors to the Exmouth region, with an estimated $151 million spent per year by visitors (Tourism Research Australia, 2017).

Area C is located within two CAES blocks that contain the North West Cape and Pilbara Southern Island Group. These two blocks report consistent moderate intensity recreational fishing in the region, with 11–12 licence holders making an average of 123 fishing trips within the waters directly west of North West Cape between 2014 and 2017 (DPIRD, 2019). Tour operators have also been active in the waters surrounding the Pilbara Southern Island Group, with four to seven licence holders making an average of 147 fishing trips in the region between 2013 and 2017.

In addition to these activities, the Exmouth Game Fishing Club runs annual fishing competitions that may overlap with Area C. In 2020, these events are scheduled as follows:

- Heavy Tackle Tournament – 25 to 27 January (three days of fishing)
- Billfish Bash – held just prior to GAMEX (three days of fishing)
- GAMEX 2020 – 13 to 21 March (six days of fishing).

4.6.6 Shipping

The region supports significant commercial shipping activity, mostly associated with the mining, oil and gas industries (**Figure 4-19**). Major shipping routes in the area are associated with entering the ports of Dampier and Barrow Island. Shipping activities in the region include:

- international bulk freighters/tankers arriving and departing from Dampier, including mineral ore, hydrocarbons (LNG, liquefied petroleum gas, condensate) and salt carriers
- domestic support/supply vessels servicing offshore facilities and Barrow Island development
- construction vessels/barges/dredges
- offshore survey vessels.

AMSA has introduced a network of marine fairways on the NWS of WA to reduce the risk of vessels colliding with offshore infrastructure. The fairways are not mandatory but AMSA strongly recommends commercial vessels remain within the fairways when transiting the region. It is noted that Area A partially overlaps the fairway in the north (**Figure 4-19**). Areas B and C do not overlap any of the fairways.

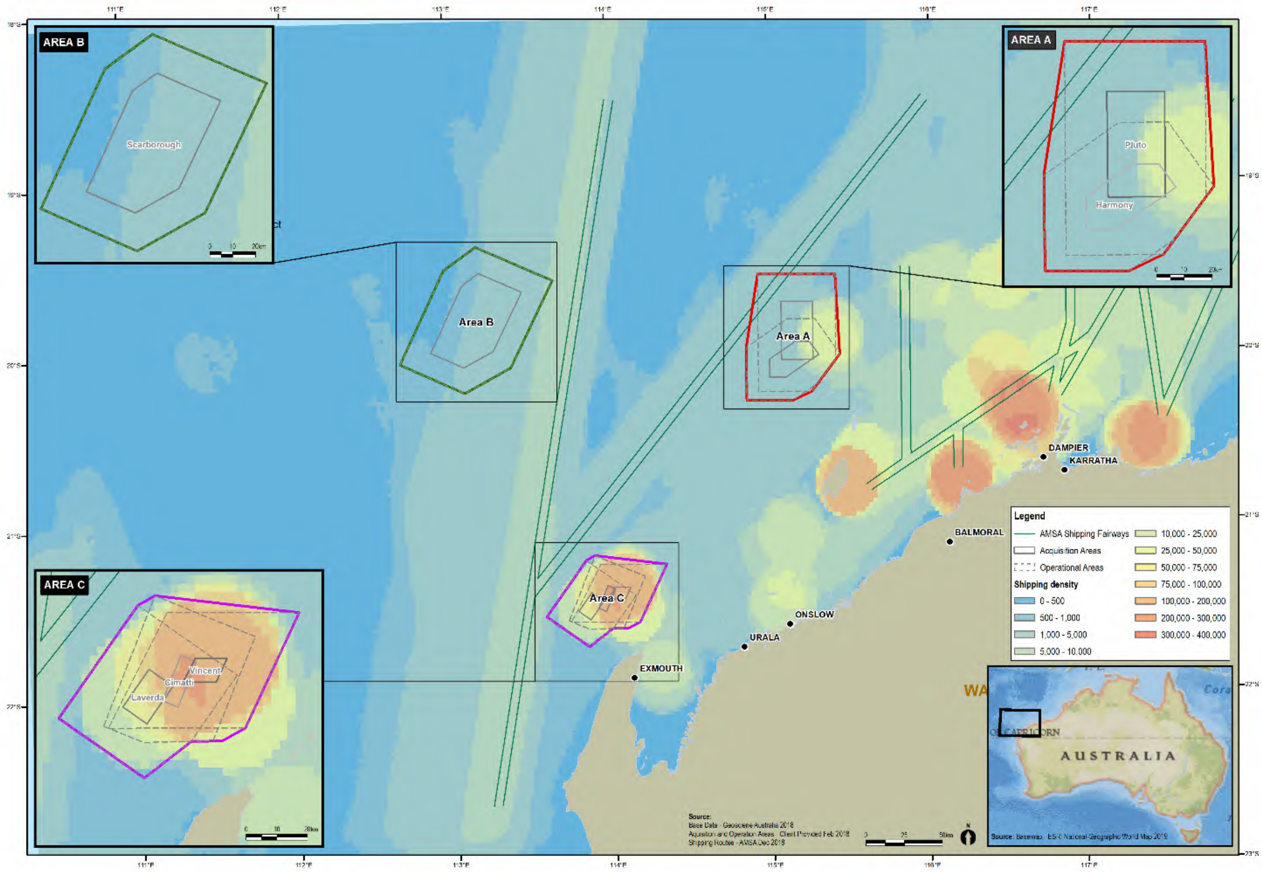

Figure 4-18: Vessel density map for Areas A, B and C from 2019, derived from AMSA satellite tracking system data

4.6.7 Oil and Gas Activities

4.6.7.1 Existing Oil and Gas Infrastructure

The Petroleum Activities Program is located within an area of established oil and gas operations in the broader NWMR. **Table 4-9** provides further detail on the oil and gas activities that have been identified.

Table 4-9: Other oil and gas facilities in the vicinity of Areas A, B and C

Facility name and operator	Area	Approximate distance from Area	Direction
Pluto Platform (Woodside)	Area A	Within	N/A
Wheatstone Platform (Chevron)	Area A	Within	N/A
Ngujima-Yin FPSO (Woodside)	Area C	Within	N/A
Ningaloo Vision FPSO (Quadrant Energy, now Santos)	Area C	Within	N/A
John Brookes Platform (Santos)	Area A	14 km	South
East Spar (Quadrant, now Santos)	Area A	45 km	South
Goodwyn Platform (Woodside)	Area A	53 km	East
North Rankin Platform (Woodside)	Area A	75 km	East

4.6.7.2 Seismic Survey Activities

To inform the consideration of the cumulative impacts from concurrent activities, Woodside engaged with other proponents to identify marine seismic surveys that have the potential to occur concurrently within about 100 km of the Petroleum Activities Program (**Table 4-10**). Previous activities have also been identified (**Table 4-10**).

The locations of the potential concurrent surveys, relative to Areas A, B and C, are shown in **Figure 4-20**. As outlined in **Section 6.6.1** only four surveys have the potential to be concurrent with the Petroleum Activities Program.

Table 4-10: Potential concurrent and past marine seismic surveys within 100 km of Areas A, B and C

Survey Name	Proponent	Status
Concurrent Activities		
Davros Extension Multi-client 3D MSS	CGG Services (Australia) Pty Ltd	The EP was accepted by NOPSEMA on 21/02/2018. The survey could occur at any time between November 2018 and end of June 2020, with avoidance of the period from beginning of July to end of September, in both years.
Rollo Multi-client MSSs	PGS Australia Pty Ltd	The EP was accepted by NOPSEMA on 04/10/2018. Surveys could occur within a period of five years, from the date of acceptance of the EP.
TGS North West Shelf Renaissance North Multi-Client MSSs	TGS-NOPEC Geophysical Company Pty Ltd	The EP was accepted by NOPSEMA on 13/06/2018. Surveys could occur within two years. No start or end date was stated in the EP Summary.
Outer Exmouth Multi-client 3D MSS	Petroleum Geo-Services	The EP was accepted by NOPSEMA on 08/08/2014. Surveys could occur within five years. No start date or end date was stated in the EP Summary.
Past Activities		
Hockey and Bianchi 3D MSS	Quadrant Northwest Pty Ltd	The EP was accepted by NOPSEMA on 22/12/2016. The earliest date for starting the MSS was December 2016, with all activity completed on or before 31 December 2018. The survey did not occur between 1 May and 31 December.
Capreolus Phase II 3D MSS	Polarcus Seismic Ltd	The EP was accepted by NOPSEMA on 26/07/2016. The survey started in the second half of 2016 and was completed by 30 June 2018.

Survey Name	Proponent	Status
Exmouth SLB15 Multi-client 3D MSS	Schlumberger Australia Pty Ltd (SLB)	The EP was accepted by NOPSEMA on 09/08/2016. The survey period was between September 2016 and September 2018.
Davros MC3D MSS	CGG Multiclient and New Ventures	The EP was accepted by NOPSEMA on 27/06/2014. The survey started in the second quarter of 2014 and lasted for nine months.
Bianchi Seismic Survey Environment	Apache Northwest Pty Ltd	The EP was accepted by NOPSEMA on 21/10/2014. The survey started in 2015 and lasted for about 30 days.
Pluto 4D MSS	Woodside Energy Ltd	The EP was accepted by NOPSEMA on 08/01/2016. The survey period was between November 2015 and February 2016 and was expected to be completed in about 55 days.
Capreolus 3D Multi-client MSS, 2014–2015 Revision No. 3	Polarcus Seismic Limited	The EP was accepted by NOPSEMA on 22/06/2015. The survey period was between January and November 2015.
Dunnart 2D MSS	Searcher Seismic Pty Ltd	The EP was accepted by NOPSEMA on 22/04/2015. The survey period was between April and May 2015 and expected to last five days.
Canning-Northern Carnarvon Multi-client MSS	TGS-NOPEC Geophysical Company Pty Ltd	The EP was accepted by NOPSEMA on 09/02/2015 and was expected to last 18 months. No start or end date was stated in the EP Summary.
Bilby 2D Multi-client MSS 2015	Searcher Seismic Pty Ltd	The EP was accepted by NOPSEMA on 05/03/2015. The survey period was between March and June 2015.
Titan Multi-client 3D MSS Environment Plan	PGS Australia Pty Ltd	The EP was accepted by NOPSEMA on 21/11/2014. The survey started in December 2014 and lasted 24 months.
Rosemary 3D Multi-client MSS 2014	Polarcus Seismic Limited	The EP was accepted by NOPSEMA on 20/10/2014. The survey period was between October 2014 and March 2015.
CGG Dirk Multi-client 3D MSS	CGG Multi-client and New Ventures	The EP was accepted by NOPSEMA on 14/11/2013. The survey lasted nine months. No start date or end date was stated in the EP Summary.

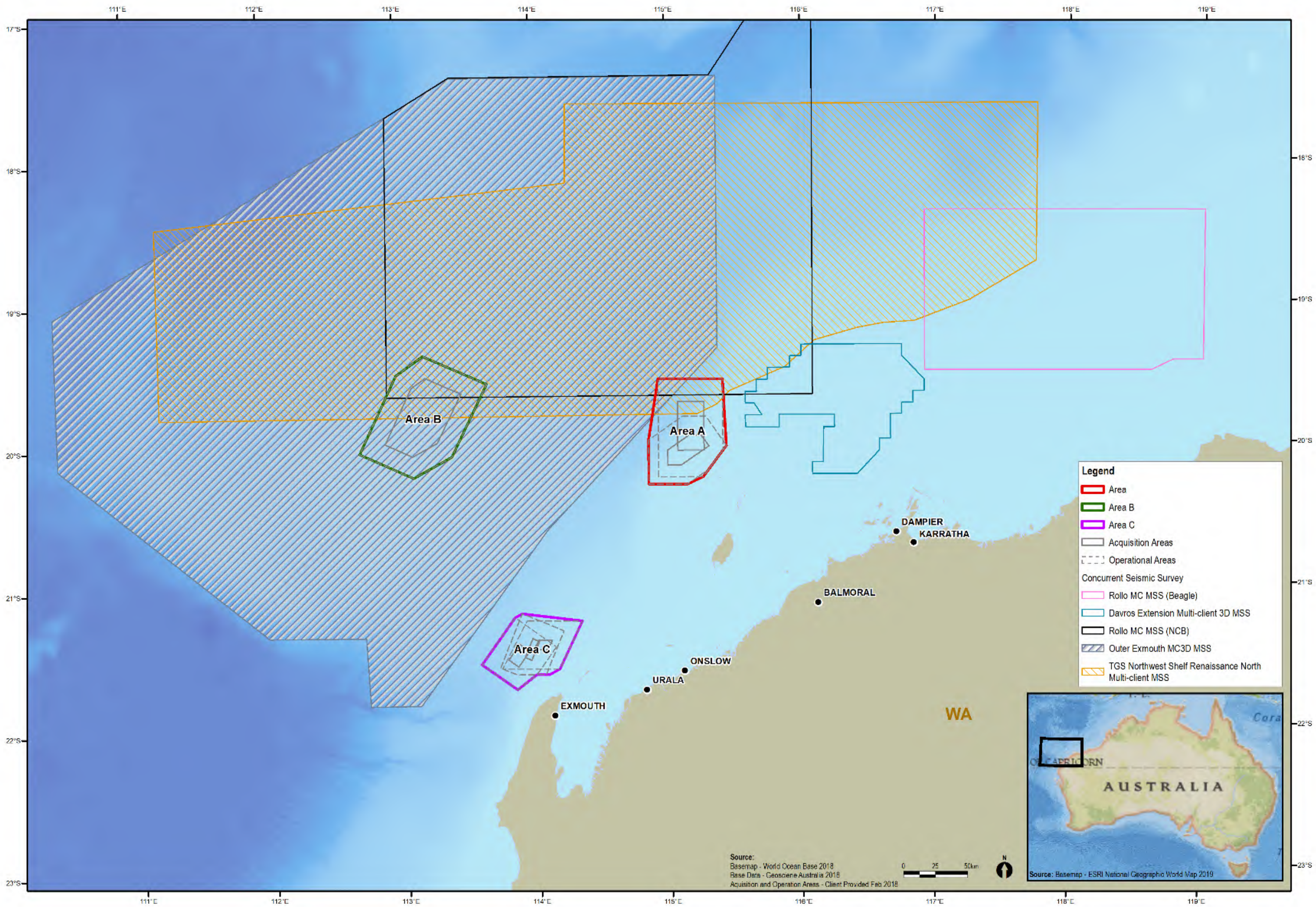

Figure 4-19: Location of potential concurrent seismic surveys in proximity to Areas A, B and C

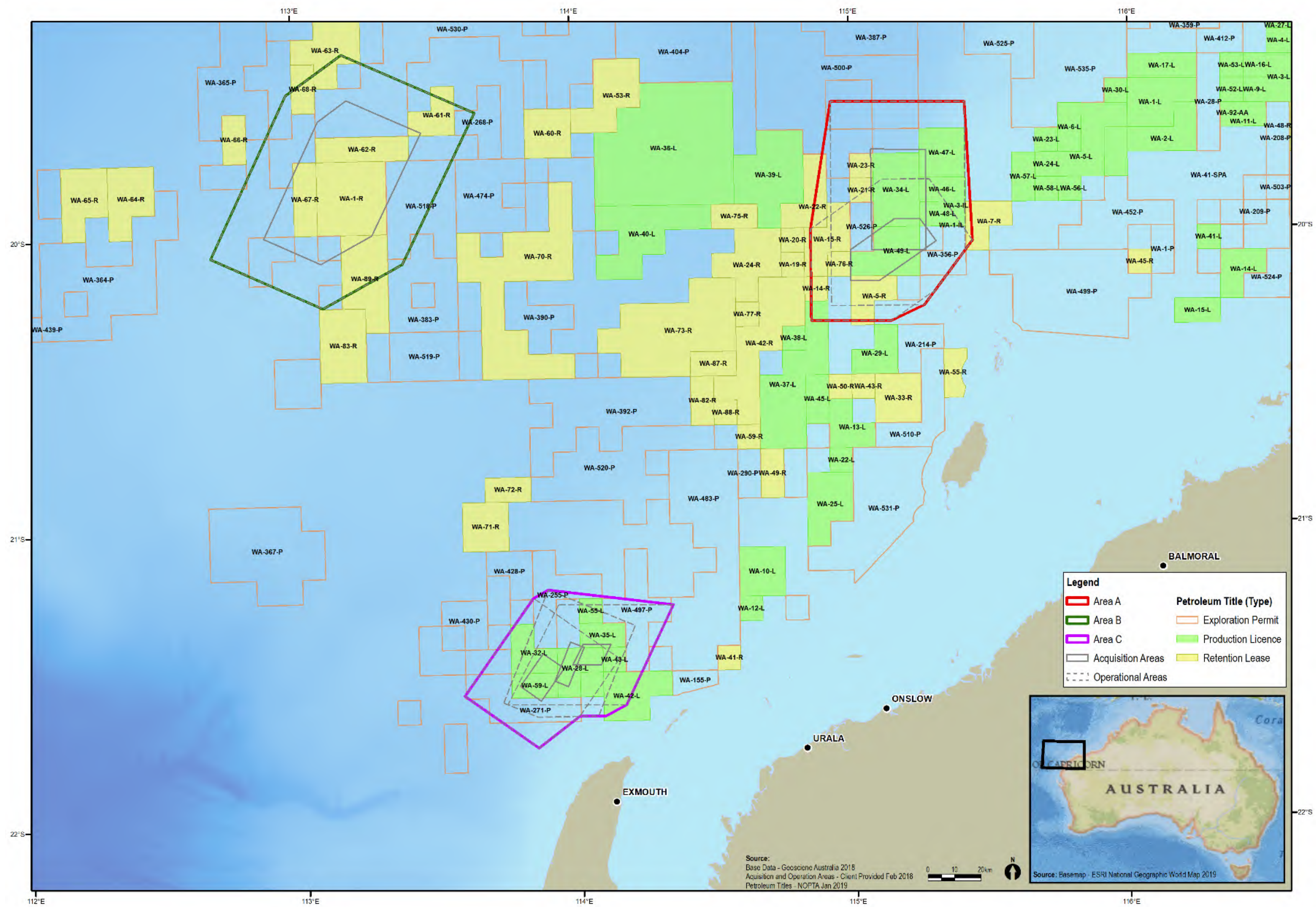

Figure 4-20: Petroleum titles and type within and adjacent to the Areas

4.6.8 Defence

There are designated defence practice areas in the offshore marine waters off Ningaloo Reef and the North West Cape.

Area C and some of Area A overlap designated defence practice areas. Consultation with Department of Defence confirmed there is no objection to the proposed seismic survey activities (**Section 7**). Area B does not overlap any designated defence practice areas.

A search for unexploded ordnance (UXO) was conducted using the Department of Defence's UXO database. The search did not identify any known occurring UXO areas within any of the Areas. Substantial occurrence of UXO occurs 18 km east of Trimouille Island, about 41 km south-east of Area A. Substantial occurrence of UXO also occurs in two areas just north of Serrurier Island, the closest of which is 33 km east of Area C. Slight occurrence of UXO is recorded around the North West Cape, 6 km south of Area C.

4.7 Values and Sensitivities

The values and sensitivities within the Areas and wider regional perspective are presented in this sub-section. The offshore environment of the NWMR contains environmental assets (such as habitat and species) of high value or sensitivity, including Commonwealth offshore waters, as well as the wider regional context including coastal waters and habitats such as the Montebello Islands, Barrow Island, and the Ningaloo Coast World Heritage Area, and the associated resident, temporary or migratory marine life including species such as marine mammals, turtles and birds (**Section 4.5.2**).

Many sensitive receptor locations are protected as part of Commonwealth and State managed areas and have been allocated conservation objectives (International Union for Conservation of Nature (IUCN) Protected Area Category), based on the Australian IUCN reserve management principles in Schedule 8 of the EPBC Regulations 2000. These principles determine what activities are acceptable within a protected area under the EPBC Act. Activities associated with the Petroleum Activities Program will be conducted consistent with the Australian IUCN reserve management principles for the IUCN categories which have been identified in **Table 4-11**.

The following section outlines the values and sensitivities of the established and proposed Marine Protected Areas (MPAs) and other sensitive areas (listed in **Table 4-11**, shown in **Figure 4-22**) that occur in waters that may be impacted by the Petroleum Activities Program (planned and unplanned).

Table 4-11: Summary of established and proposed MPAs and other sensitive locations within and nearby Areas A, B and C

	Distance from Area (km)			IUCN Protected Area Category
	Area A	Area B	Area C	
Australian Marine Parks				
Montebello	Overlaps	175	107	VI
Gascoyne	122	51	Overlaps	VI
Ningaloo	163	183	2	IV
State Marine Parks and Reserves				
Marine Parks				
Montebello Islands	18	206	148	IA, II and IV
Barrow Island	211	46	114	IA and VI
Ningaloo	148	183	10	IA, II and IV
Marine Management Areas				
Muiron Islands	148	195	12	1A and VI
Barrow Island	26	208	102	1A and VI
World Heritage Properties				
Ningaloo Coast	148	183	2	N/A
Key Ecological Features				
Continental Slope Demersal Fish Communities	Overlaps	103	Overlaps	N/A
Ancient Coastline at 125 m Depth Contour	Overlaps	162	Adjacent	N/A
Canyons Linking the Cuvier Abyssal Plain and the Cape Range Peninsula	123	106	Overlaps	N/A
Commonwealth Waters Adjacent to Ningaloo Reef	164	183	2	N/A
Exmouth Plateau	56	Overlaps	44	N/A
Other Sensitive Areas				
Rankin Bank	16	205	212	N/A

Conservation objectives for IUCN categories in **Table 4-11 include:*

- *IA: Strict nature reserve – Area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.*
- *II: National park – Natural area of land and/or sea, designated to: (a) protect the ecological integrity of one or more ecosystems for this and future generations; (b) exclude exploitation or occupation inimical to the purposes of designation of the area; and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.*
- *IV: Habitat/species management area – Area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.*
- *VI: Protected area with sustainable use of natural resources – Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing a sustainable flow of natural products and services to meet community needs.*

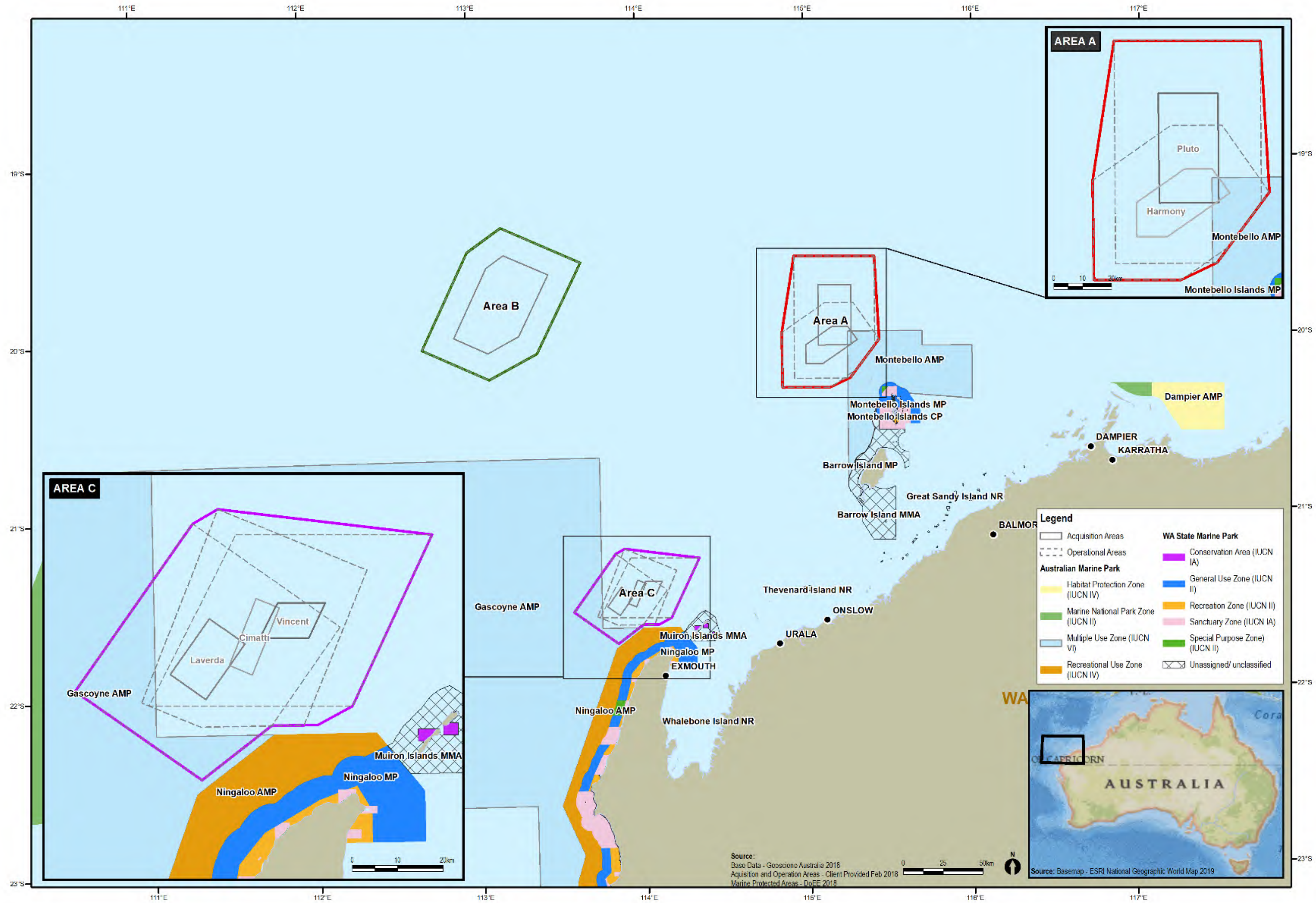

Figure 4-21: Established Australian and State Marine parks in relation to Areas A, B and C

4.7.1 Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island Marine Management Area

The marine and coastal environments of the Montebello/Barrow Islands region represent a unique combination of offshore islands, intertidal and subtidal coral reefs, mangroves, macroalgal communities and sheltered lagoons, and are considered a distinct coastal type with very significant conservation values (DEC, 2007).

The Montebello Islands Marine Park, Barrow Island Marine Park and Barrow Island Marine Management Area (MMA) are jointly managed and cover a combined area of 1770 km², located about 19 km south-east of Area A at the closest point. A sanctuary zone covers the entire 4100 ha Barrow Island Marine Park. The Barrow Island MMA covers 114,500 ha and includes most of the waters surrounding Barrow Island and Lowendal Islands, except for the port areas around Barrow and Varanus islands. Key conservation and environmental values within the reserves include (DEC, 2007):

- a complex seabed and island topography consisting of subtidal and intertidal reefs, sheltered lagoons, channels, beaches, cliffs and rocky shores
- pristine sediment and water quality, supporting a healthy marine ecosystem
- undisturbed intertidal and subtidal coral reefs and bommies with a high diversity of hard corals
- important mangrove communities, particularly along the Montebello Islands, which are considered globally unique as they occur in offshore lagoons
- extensive subtidal macroalgal and seagrass communities
- important habitat for cetaceans and dugongs
- nesting habitat for marine turtles
- important feeding, staging and nesting areas for seabirds and migratory shorebirds
- rich finfish fauna with at least 456 species
- culture of the pearl oyster (*Pinctada maxima*) in the reserves, producing some of the highest quality pearls in the world.

These islands support significant colonies of wedge-tailed shearwaters and bridled terns. The Montebello Islands support the biggest breeding population of roseate terns in WA. Ospreys, white-bellied sea-eagles, eastern reef egrets, Caspian terns, and lesser crested terns also breed in this area. Barrow, Lowendal and Montebello islands are internationally significant sites for six species of migratory shorebirds, supporting more than 1% of the East Asian-Australasian Flyway population of these species (DSEWPaC, 2012a).

The Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island MMA are contiguous with the Montebello AMP. The intertidal habitats of the Montebello/Barrow/Lowendal Islands region are influenced by the passage of tropical cyclones that shape sandy beaches (RPS Bowman Bishaw Gorham, 2007). The dominant habitats on the exposed west coasts of islands in the area are sandy beaches, rocky shores and cliffs. The predominant physical habitats of the sheltered east coasts of islands are sand flats, mud flats, rocky pavements and platforms (RPS Bowman Bishaw Gorham, 2007).

4.7.1.1 Barrow Island Nature Reserve

The Barrow Island Nature Reserve is a Class A Nature Reserve covering about 235 km² and extends to the low water mark adjacent to the Montebello Islands/Barrow Island Marine Parks. It is about 154 km from Area A at the closest point. The islands surrounding Barrow Island including Boodie, Double, and Middle islands make up the Boodie, Double and Middle Islands Nature Reserve, covering 587 ha (Department of Parks and Wildlife (DPaW), 2015). Together, these two nature reserves are commonly referred to as the Barrow Group Nature Reserves (DPaW, 2015).

The Barrow Island coastline consists of dry creek beds, beaches, clay and salt flats, mangroves, intertidal flats and reefs and is bordered by high cliffs on the western side. Key conservation values within the reserves include (DPaW, 2015):

- the second largest island off the WA coast
- important biological refuge site because of isolation from certain threatening processes on the mainland
- flora that are restricted in distribution and at or near the limit of their range
- high number of fauna species with high conservation value
- extensive hydrogeological karst system that supports a subterranean community of high conservation significance
- regionally and nationally significant rookeries for green and flatback turtles
- important habitat for migratory shorebirds and also used by these species as a staging and destination terminus
- significant habitat values, such as intertidal mudflats, rock platforms, mangroves, rock piles and cliffs, clay pans and caves
- a significant fossil record that indicates local historical biodiversity and evolution
- a history of Aboriginal and other Australian use including 13 registered Aboriginal cultural heritage sites.

4.7.1.2 Montebello Australian Marine Park

The Montebello AMP covers an area of 3413 km² adjacent to the Montebello Islands Marine Park/Barrow Island Marine Park/Barrow Island MMA, providing a contiguous marine reserve covering both State and Commonwealth waters. The Montebello AMP is managed under the North West Marine Park Management Plan (2018). Area A partially overlaps about 350 km², or 10%, of the Marine Park. The entire Montebello AMP is designated a multiple use zone (IUCN Category IV), allowing for long-term protection and maintenance of the AMP in conjunction with sustainable use, including oil and gas exploration activities.

The Montebello AMP contains habitats, species and ecological communities associated with the Northwest Shelf Province, including species listed as threatened, migratory, marine or cetacean under the EPBC Act 1999. The AMP is thought to provide connectivity between the coastal waters of Barrow and Montebello islands and the deeper waters of the shelf and slope (Director of National Parks, 2018):

Major conservation values within the Montebello AMP include (Director of National Parks, 2018):

- foraging areas adjacent to important breeding areas for migratory seabirds
- foraging areas for vulnerable and migratory whale sharks
- foraging areas adjacent to important nesting sites for marine turtles
- part of the migratory pathway of the protected humpback whale
- shallow shelf environments with depths ranging from 15 to 150 m providing protection for shelf and slope habitats, as well as pinnacle and terrace seafloor features
- one KEF for the region, the Ancient Coastline at 125 m Depth Contour (**Section 4.7.4**).

The Ancient Coastline at 125 m Depth Contour KEF is thought to contain rocky escarpments that provide biologically important habitat in areas otherwise dominated by soft sediments (Director of National Parks, 2018). Recent ROV transect surveys have been conducted within the Montebello AMP, including over the Ancient Coastline KEF occurring within the AMP (Advisian, 2019). The survey transect was fully comprised of soft sediment habitat and did not identify hard substrate or other values commonly associated with the KEF. The survey identified a flat fine sandy seabed, with small isolated sand waves and sparse benthic sand-dwelling habitat. Ripples containing organic/algae covering were observed, particularly in the troughs; however, no macroalgae or seagrass was present. Benthic epifauna were uncommon and generally occurred as individuals. Benthic epifauna included echinoderms (e.g. brittle stars and feather stars), and cnidarians (whip corals and quill corals (seapens). Isolated corals also occurred on the sand. The percentage cover of benthic organisms ranged from 0% to ~5%. The survey found no significant high relief habitat features in the KEF.

The Montebello AMP is not included on any national, Commonwealth or international Heritage lists. The adjacent Western Australia Barrow Island and the Montebello–Barrow Island Marine Conservation Reserves which have been nominated for national heritage listing (Director of National Parks, 2018). Two shipwrecks listed under the *Historic Shipwrecks Act 1976* occur within the Montebello AMP (but not within Area A). These are the *Trial,* the earliest known shipwreck in Australian waters (wrecked in 1622), and *Tanami* (unknown date).

Important socioeconomic activities within the marine park include tourism and recreation (**Section 4.6.5**), commercial fishing (**Section 4.6.3**) and mining (Director of National Parks, 2018). There is limited information about the cultural significance of the Montebello Marine Park to Aboriginal communities. It is acknowledged that sea country is valued for Aboriginal cultural identity, health and wellbeing.

4.7.2 Ningaloo Coast and Gascoyne

4.7.2.1 Ningaloo Coast World Heritage Property

The Ningaloo Coast WHA is 2 km from the south-east border of Area C. The WHA includes North West Cape and the Muiron Islands, and was inscribed under criteria (vii) and criteria (x) by the World Heritage Committee onto the World Heritage Register in June 2011. The statement of Outstanding Universal Value for the Ningaloo Coast was based on the natural criteria and recognised the following (United Nations Educational, Scientific and Cultural Organization, 2011):

- **Criterion (vii)**: The landscapes and seascapes of the property are comprised of mostly intact and large-scale marine, coastal and terrestrial environments. The lush and colourful underwater scenery provides a stark and spectacular contrast with the arid and rugged land. The property supports rare and large aggregations of whale sharks (*Rhincodon typus*) along with important aggregations of other fish species and marine mammals. The aggregations in Ningaloo following the mass coral spawning and seasonal nutrient upwelling cause a peak in productivity that leads about 300–500 whale sharks to gather, making this the largest documented aggregation in the world.
- **Criterion (x)**: In addition to the remarkable aggregations of whale sharks, the Ningaloo Reef harbours a high marine diversity of more than 300 documented coral species, over 700 reef fish species, roughly 650 mollusc species, as well as around 600 crustacean species and more than 1000 species of marine algae. The high numbers of 155 sponge species and 25 new species of echinoderms add to the significance of the area. On the ecotone, between tropical and temperate waters, the Ningaloo coast hosts an unusual diversity of marine turtle species with an estimated 10,000 nests deposited along the coast annually.

The Ningaloo Coast WHA is recognised as being of outstanding conservation value, supporting a rich array of habitats and a diverse and abundant marine life (DoEE n.d.). The region has a high diversity of marine habitats including coastal mangrove systems, lagoons, coral reef, open ocean, continental slope and the continental shelf (CALM, 2005). The dominant feature of the Ningaloo Coast WHA is Ningaloo Reef, the largest fringing reef in Australia. Ningaloo Reef supports both tropical and temperate species of marine fauna and flora and more than 300 species of coral (CALM, 2005).

The Ningaloo Coast WHA provides important nesting habitat for four species of marine turtle found in WA. The North West Cape and Muiron Islands are major nesting sites for loggerhead turtles, with about 400 to 600 females nesting annually on the Ningaloo coast (particularly, North West Cape area) and Muiron Islands, respectively (Department of Environmental Protection, 2001). The North West Cape is also a major nesting habitat for hawksbill and green turtles, with an estimated 1000–1500 green turtles nesting in the area annually (DEC, 2008). The Muiron Islands are minor nesting sites for flatback and hawksbill turtles (DEC, 2008).

Each year, the largest congregation of whale sharks anywhere in the world takes place off the coast of the Ningaloo WHA. It is estimated that between 300 and 500 whale sharks visit each year between March and July, coinciding with the annual mass coral spawning events.

It is these natural heritage values, iconic wilderness, seascapes, wildlife and biodiversity which are major attractions of the WHA and therefore the main driver for tourism on the North West Cape. All properties inscribed on the World Heritage List must have adequate management to ensure their protection, thus the Ningaloo Coast WHA is managed via the Australian Marine Park and State marine park (see subsections below).

4.7.2.2 Ningaloo Australian Marine Park

The Ningaloo AMP covers 2326 km². It is contiguous with the WA Ningaloo Marine Park and is 2 km from the south-east border of Area C. The Ningaloo Reef, which lies in State waters within the State managed Marine Park, is further protected by the Ningaloo AMP. Water depths range from shallow water of 30 m depth to oceanic waters at 1000 m depth. Major conservation values of the AMP include (Director of National Parks, 2018):

- foraging areas adjacent to important breeding areas for migratory seabirds, whale sharks and marine turtles
- important nesting sites for marine turtles
- part of the migratory pathway of the humpback whale
- shallow shelf environments with depths ranging from 15 to 150 m, providing protection for the shelf and slope habitats, as well as pinnacle and terrace sea-floor features
- examples of the seafloor habitats and communities of the Central Western Shelf Transition.

The AMP has international and national significance due to its diverse range of marine species and unique geomorphic features. The AMP provides essential biological and ecological links that sustain the biodiversity and ecological processes, including the supply of nutrients to reef communities from deeper waters further offshore, to the Ningaloo Reef ecosystem.

The Ningaloo Marine Park (Commonwealth Waters) Management Plan outlines objectives for retaining the values of this protected area and any potential or confirmed threats that could impact these values. Values which could be impacted from the Petroleum Activities Program include high water quality, marine mammals and fish, marine reptiles, seabirds, recreational fishing and boating, and nature-based tourism. Relevant management strategies in the Management Plan include preventing petroleum and mineral exploration and production from Commonwealth waters. Note each management objective in the plan relates only to a source of risk, rather than the value potentially impacted, and are, therefore, generic for all Petroleum Activities.

4.7.2.3 Ningaloo Marine Park and Muiron Islands Marine Management Area

The Ningaloo Marine Park (State waters) was established in 1987 and stretches 300 km from the North West Cape to Red Bluff. It encompasses the State waters covering the Ningaloo Reef system and a 40 m strip along the upper shore. At its closest point (near the North West Cape) the Marine Park lies about 9 km from Area C. The Muiron Islands MMA is managed under the same management plan as the Ningaloo State Marine Park (CALM, 2005). The Ningaloo Marine Park is part of the Ningaloo Coast WHA.

Ecological and conservation values of the Ningaloo Marine Park and Muiron Islands are summarised below. Generally, all ecological values are presumed to be in an undisturbed condition except for some localised high use areas (CALM, 2005). The ecological and conservation values include:

- The unique geomorphology has resulted in a high habitat and species diversity.
- There is high sediment and water quality.
- Subtidal and intertidal coral reef communities provide food, settlement substrate and shelter for marine flora and fauna.
- Filter feeding communities (sponge gardens) are in the northern part of the North West Cape and the Muiron and Sunday islands.
- Shoreline intertidal reef communities provide feeding habitat for larger fish and other marine animals during high tide.
- Soft sediment communities are found in deeper waters, characterised by a surface film of microorganisms that provide a rich source of food for invertebrates.
- Macroalgae and seagrass communities are an important primary producer providing habitat for vertebrate and invertebrate fauna.
- Mangrove communities occur only in the northern part of the Ningaloo Marine Park and are important for reef fish communities (Cassata and Collins, 2008) and support a high diversity of infauna, particularly, molluscs (600 mollusc species).
- There is diverse fish fauna (about 460 species).
- Foreshores and nearshore reefs of the Ningaloo coast and Muiron/Sunday islands provide internesting, nesting and hatchling habitat for several species of marine turtles including the loggerhead, green, flatback and hawksbill turtles.
- Whale sharks aggregate annually to feed in the waters around Ningaloo Reef, from March to July, with the largest numbers being recorded around April and May (Sleeman et al., 2010). The season can be variable, with individual whale sharks being recorded at other times of the year. Timing of the whale sharks’ migration to and from Ningaloo coincides with the mass coral spawning period when there is an abundance of food (krill, planktonic larvae and schools of small fish) in the waters adjacent to Ningaloo Reef.
- Seasonal shark aggregations and manta rays are commonly found in the area with a permanent population of manta rays (*Manta alfredi*) inhabiting the Ningaloo Reef. Numbers are boosted periodically by roaming and seasonal animals. Small aggregations coincide with small pulses of target prey and the spawning events of many reef inhabitants, while larger aggregations coincide with major seasonal spawning events. The number of species in the Ningaloo Reef area peaks during autumn, which corresponds to coral spawning, and during spring which corresponds with the crab spawning event (McGregor n.d.).

- There is annual mass coral spawning on Ningaloo Reef. Synchronous, multi-specific spawning of tropical reef corals occurs during a brief predictable period in late summer/early autumn generally seven to nine nights after a full moon on neap, nocturnal ebb tides March/April each year (Rosser and Gilmour, 2008; Taylor and Pearce, 1999).
- Large coral slicks generally form over shallow reef areas in calm conditions. It is noted that there are minor spawning activities on the same nights after the February and April full moons. In some years the mass spawning event occurs after the April full moon (Simpson et al., 1993).
- Marine mammals such as dugong and small cetacean populations frequent or reside in nearshore waters. Dugong numbers in Ningaloo Marine Park are considered to be in the order of around 1000 individuals, with a similar number in Exmouth Gulf (CALM, 2005). The Ningaloo/Exmouth Gulf region supports a significant population of dugongs which is interconnected with the Shark Bay resident population (which represents less than 10% of the world's dugongs).
- Nesting and foraging habitat for seabirds and shorebirds. About 33 species of seabirds are recorded in the Ningaloo Marine Park (13 resident and 20 migratory) and there are five known rookeries as well as isolated rookeries on the Muiron and Sunday islands.

In addition to the ecological and conservation values, the Ningaloo Marine Park has a number of social values including culture heritage (both Indigenous and maritime; **Section 4.6.1**) and marine based tourism and recreation (water-sports and fishing) (**Section 4.6.5**). The Ningaloo Marine Park (State waters) is contiguous with the Ningaloo Commonwealth Marine Reserve (**Figure 4-22**).

The Management Plan for the Ningaloo Marine Park and Muiron Islands MMA outlines objectives for retaining the values of this protected area and any potential or existing threats which could impact these values.

4.7.2.4 Ningaloo Shoreline, Shallow Subtidal Reef and Intertidal Habitats

The Ningaloo Marine Park reef and lagoonal systems comprise a variety of shallow subtidal and intertidal communities that comprise shallow outer reef slope (spur and groove habitat), reef crest (emergent at low tide), reef flat (coralline algae and high cover tabular *Acropora* spp. coral communities), back reef lagoon (coral, soft sediment and macro-algal communities), sublittoral limestone platform (turf algae/molluscs/echinoderm community), and intertidal mangrove, mud flat and salt marsh communities (Cassata and Collins, 2008).

The area seaward of the reef crest is characterised by a coralline algae/coral community (spur and groove reef slope). The area has a series of perpendicular spurs and grooves from 5 to 40 m depth range consisting of narrow, deep channels filled with sand and coral rubble, and rock spurs with diverse hard coral communities (with dominant tabular *Acropora* spp. growing in small, compact colonies), together with soft corals, *Millepora* (fire coral), sponges and macroalgae. Coralline algae encrusts dead corals, rocks and coral rubble. Coral growth is most prolific between 5 and 10 m depth.

On the landward side of the reef crest is a reef flat habitat and back reef lagoon with a number of subtidal and intertidal habitats (Cassata and Collins, 2008) as follows:

- Outer reef flat (very shallow, <1 m depth) at the back of the reef crest: Coralline algae/coral community (spur and groove). Similar morphology to the reef slope.
- Rocky middle/inner reef flat (about 1 m depth): Tabular *Acropora* spp. Community.
- Back reef lagoon (>2 m depth): Patchy staghorn, massive and sub-massive coral community.

- Lagoonal sand flat (1–2 m depth): Sparse corals and algae community. This habitat is characterised by sheltered areas of limestone pavement with a veneer of sand and small outcrops of corals (*Porites* spp., *Acropora* spp.) with scattered patches of macroalgae (*Sargassum* spp., *Halimeda* spp., *Caulerpa* spp.) or seagrass (*Halophila* spp.).
- Lagoonal and inter-reef sandy depressions (3–15 m depth): Coral 'bommies' and algal patch community. A distinctive habitat type composed of sandy depressions either found as large deep regions within the lagoon or small depressions/channels inside the reef flat.
- Lagoon, shoreward reef channels (shallow): Macroalgal community. Fleshy algae colonising subtidal limestone pavement that is covered in sand with *Sargassum* spp. up to 0.5 m high and other red and green algal species. There are also small patches of hard and soft corals, sponges and ascidians.
- Sublittoral limestone platform: Turf algae/mollusc/echinoderm community. This habitat is composed of a flat limestone pavement often contiguous with the rocky shoreline, and supports intertidal and subtidal fauna comprising molluscs (limpets, chitons, small mussels, cowries and giant clams) and echinoderms (sea cucumbers, starfish and sea urchins) with isolated hard and soft coral colonies. The limestone pavement also has a ubiquitous coverage of turf algae.
- Mangrove coastal swamps: Although not a common habitat type within Ningaloo Marine Park, there are mangrove stands in the upper intertidal zone on a muddy substrate of carbonate silt and lay. The mangrove communities are located within the Mangrove Sanctuary Zone (where they occupy a large section of coast between Low Point and Mangrove Bay) and sporadically within the Osprey Sanctuary Zone on the Yardie Creek banks. There are three species of mangrove: *Avicennia marina*, *Rhizophora stylosa* and *Bruguiera exaristata*. *Avicennia marina* is most common and widespread. This habitat supports a diverse community of invertebrate fauna including gastropods, crabs and burrowing worms and is also a nursery area for the juveniles of many species of reef fish.
- Intertidal mud flats: Mud flats occur in the lower intertidal zone of the lagoon, formed by mud being deposited in the sheltered tidal waters.
- Salt marshes: The salt marsh habitat is seaward of the mangroves and is represented by salt tolerant vegetation and sandy patches.

Muiron Islands: Shallow Subtidal, Intertidal and Shoreline Habitats

The Muiron Islands lie about 17 km east of Area C. Coastal sensitivity mapping identified the onshore sensitivities to be turtle rookeries and turtle nesting occurring from October to April (Joint Carnarvon Basin Operators, 2012). Most of the western coast consists of limestone coastal cliffs interspersed with sandy beaches and intertidal rock platforms. The nearshore sensitivities include the intertidal/nearshore reef (Joint Carnarvon Basin Operators, 2012). Soft coral communities dominate the reefs on the western side of the Muiron Islands. Habitats on the eastern side of the Muiron Islands are more sheltered, consisting of sandy beaches and shallow lagoons with diverse soft and hard coral communities (Cassata and Collins, 2008; Kobryn et al., 2013).

4.7.2.5 Gascoyne Australian Marine Park

The Gascoyne AMP covers about 81,766 km² and includes waters from less than 15 m depth to 6000 m depth. The south and south-west margins of Area C partially overlap with the Gascoyne

AMP (Category VI Multiple Use Zone). The conservation values identified within the reserve include (Director of National Parks, 2018):

- foraging areas for migratory seabirds (including the wedge-tailed shearwater), hawksbill and flatback turtles and whale sharks
- a continuous connectivity corridor from 15 to over 5000 m
- seafloor features including canyon, terrace, ridge, knolls, deep hole/valley and continental rise
- sponge gardens in the south of the reserve adjacent to Western Australian coastal waters
- examples of the ecosystems of the Central Western Shelf Transition, the Central Western Transition and the North West province provincial bioregions as well as the Ningaloo mesoscale bioregion.

The AMP contains three key conservation values for the region:

- canyons on the slope between the Cuvier Abyssal Plain and the Cape Range Peninsula (associated enhanced productivity, aggregations of marine life and unique sea-floor feature)
- Exmouth Plateau (unique seafloor feature associated with internal wave generation)
- continental slope demersal fish communities (high species diversity and endemism which is the most diverse slope bioregion in Australia with over 500 species recorded, of which 76 are endemic to the area).

The reserve boundary is adjacent to the existing Commonwealth portion of the Ningaloo AMP.

4.7.3 Pilbara

4.7.3.1 Pilbara Islands (Southern Island Group)

Within the nearshore waters between the Muiron Islands and the Dampier Archipelago are a series of islands collectively termed the Northern, Middle and Southern Island Groups. This area has been defined as the Pilbara offshore region (greater than 10 m water depth) and includes islands, shoals and rocky outcrops.

The Southern Island Group includes Serrurier, Bessieres and Thevenard Islands Nature Reserves, the closest of which, Serrurier Island, is located 45 km east of Area C. The nearshore habitats of these islands generally consist of fringing reefs on the seaward side and wide intertidal sand flats on the leeward side. Despite generally high turbidity in the area and relatively low abundance, hard coral biodiversity is high (Chevron, 2010). The coral community structure within this area, and others within the region, is highly temporally variable due to cyclonic activity.

The large islands of the groups provide important nesting habitat for seabirds and marine turtles (Chevron, 2010). In the Southern Island Group, a number of seabirds, including Caspian terns, little terns, wedge-tailed shearwaters and ospreys, breed on Serrurier Island and nearby Airlie Island. Serrurier Island also is a major nesting area for green turtles and may also be a foraging area for this species. Thevenard Island supports a significant flatback turtle rookery, along with small numbers of green turtles, and is a known feeding area for green turtles.

Chevron (2010) documented the key subtidal habitats of the Pilbara offshore region as:

- limestone pavement supporting dense macroalgae
- biogenic fringing coral reefs
- coral communities associated with hard substrate (shoals and rocky outcrops)

- filter feeding communities (sponges and ascidians) on sand veneered pavement
- sand/gravel plains and shoals supporting sparse foliose macroalgae.

4.7.4 Key Ecological Features

KEFs are the parts of the marine ecosystem that are considered to be important for a marine region's biodiversity or ecosystem function and integrity. KEFs have been identified by the Australian Government based on advice from scientists about the ecological processes and characteristics of the area.

KEFs meet one or more of the following criteria:

- a species, group of species, or a community with a regionally important ecological role (e.g. a predator, prey that affects a large biomass or number of other marine species)
- a species, group of species or a community that is nationally or regionally important for biodiversity
- an area or habitat that is nationally or regionally important for:
  - enhanced or high productivity (such as predictable upwellings – an upwelling occurs when cold nutrient-rich waters from the bottom of the ocean rise to the surface)
  - aggregations of marine life (such as feeding, resting, breeding or nursery areas)
  - biodiversity and endemism (species which only occur in a specific area).
- a unique seafloor feature, with known or presumed ecological properties of regional significance.

Five KEFs have been identified as occurring within or adjacent to the Areas (**Table 4-11**, **Figure 4-23**), and are described in relation to relevant Areas below.

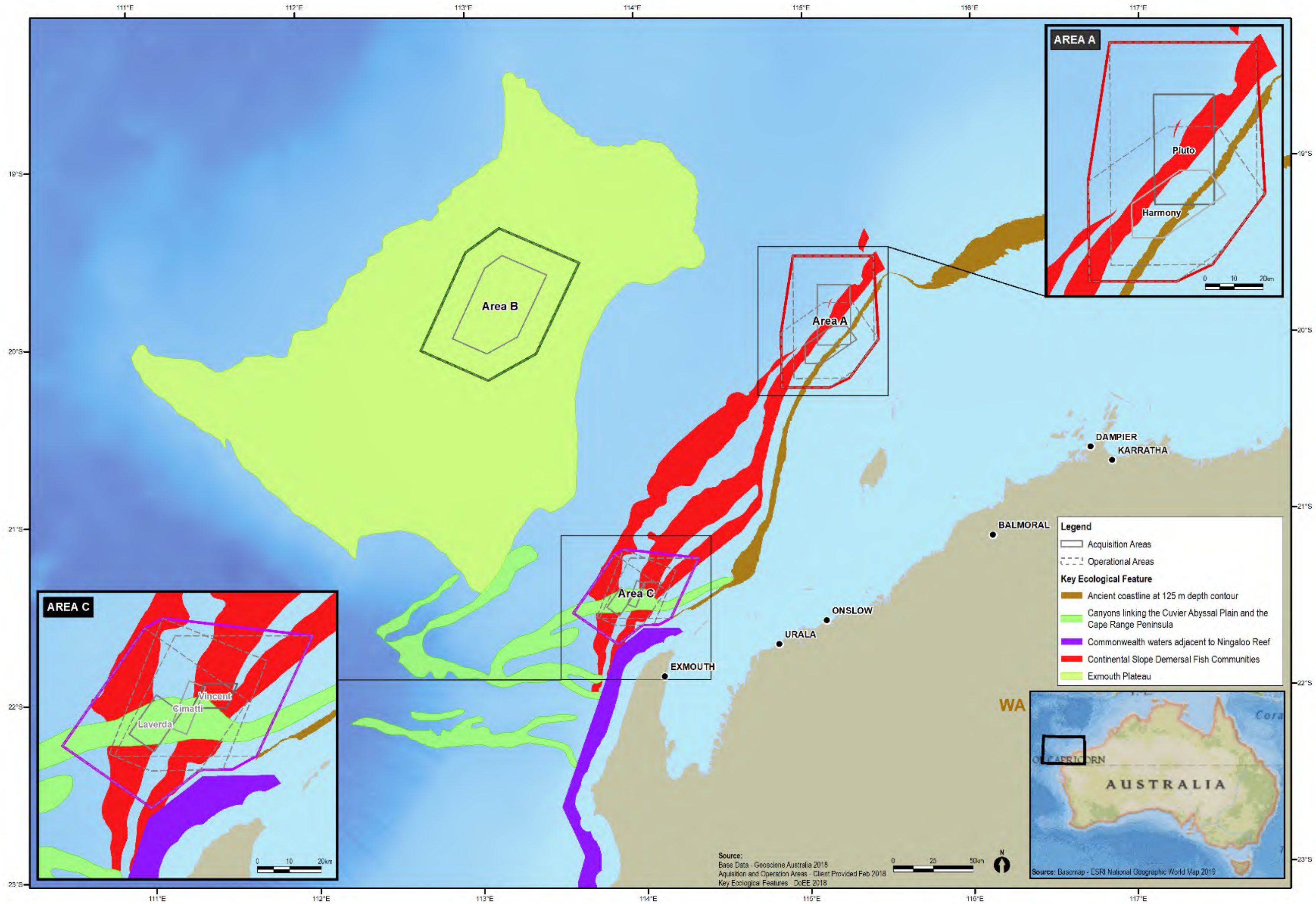

Figure 4-22: Key ecological features in relation to Areas A, B and C

4.7.4.1 Area A

Two KEFs spatially overlap with Area A: the Continental Slope Demersal Fish Communities and the Ancient Coastline at 125 m Depth Contour (**Figure 4-23**). Both KEFs overlap Area A as a relatively narrow strip running in a south-west to north-east direction.

Continental Slope Demersal Fish Communities

The Continental Slope Demersal Fish Communities in the region have been identified as a KEF of the NWMR (DSEWPaC, 2012a). The continental slope between North West Cape and the Montebello Trough has been identified as one of the most diverse slope assemblages in Australian waters, with over 508 fish species and the highest number of endemic species (76) of any Australian slope habitat (DEWHA, 2008). Additional features relating to the fish populations of this area are as follows:

- Continental slope demersal fish communities have been identified as a KEF of the NWMR due to the notable diversity of the demersal fish assemblages and high levels of endemism (DSEWPaC, 2012a).
- The North West Cape region is a transition area for demersal shelf and slope fish communities between the tropical dominated communities to the north and temperate communities to the south (Last et al., 2005). The benthic shelf and slope communities offshore of the North West Cape comprise both tropical and temperate fish species with a north–south gradient (DEWHA, 2008).
- The fish fauna of the North West Cape region, like the ichthyofauna of many regions, exhibits decreasing species richness as depth increases (Last et al., 2005). Fish species diversity has been shown to be positively correlated with habitat complexity, with more complex habitats (e.g. coral reefs) typically hosting higher species richness than simpler habitats such as bare, unconsolidated muddy sediments (Gratwicke and Speight, 2005). A total of 500 finfish species from 234 genera and 86 families have been recorded within the Ningaloo Marine Park, and 393 species were identified at study sites of the Muiron Islands (CALM, 2005). The offshore sediment habitats of Area A are expected to support lower fish species richness than other shallower, more complex habitats in the coastal areas of the region.

Ancient Coastline at 125 m Depth Contour

Several steps and terraces as a result of Holocene sea level changes occur in the region. The most prominent of these features occurs as an escarpment along the NWS and Sahul Shelf at a water depth of 125 m, which forms the Ancient Coastline at 125 m Depth Contour KEF (the ancient coastline). The ancient coastline is not continuous throughout the NWS, and coincides with a well-documented eustatic stillstand at about 130 m worldwide (Falkner et al., 2009).

Where the ancient coastline provides areas of hard substrate, it may contribute to higher diversity and enhanced species richness relative to soft sediment habitat (DSEWPaC, 2012a). Parts of the ancient coastline, represented as rocky escarpment, are considered to provide biologically important habitat in an area predominantly made up of soft sediment. As described in **Section 4.7.1**, recent ROV transect surveys conducted over the Ancient Coastline KEF did not identify hard substrate or other values commonly associated with the KEF, and found the transect was fully comprised of soft sediment habitat (Advisian, 2019).

The escarpment type features may also potentially facilitate mixing within the water column due to upwelling, providing a nutrient-rich environment. Although the ancient coastline adds additional habitat types to a representative system, the habitat types are not unique to the coastline as they are widespread on the upper shelf (Falkner et al., 2009).

4.7.4.2 Area B

Area B is located entirely within the Exmouth Plateau KEF and spatially overlaps about 5580 km², or 11%, of the KEF (**Figure 4-23**).

Exmouth Plateau

The Exmouth Plateau is a large, mid-slope, continental margin plateau that lies off the north-west coast of Australia. The full Exmouth Plateau ranges in depth from about 900 to 3500 m and is a major structural element of the Carnarvon Basin (Miyazaki and Stagg, 2013). The plateau is bordered by the Rankin Platform and the Exmouth sub-basin of the Northern Carnarvon Basin to the east, the Argo Abyssal Plain to the north, and the Gascoyne and Cuvier Abyssal Plains to the north-west and south-west.

The Exmouth Plateau is overlaid by an interface between the ITF and the Indian Ocean Central Water. This interface constitutes a potential shear zone (with associated mixing) and may display substantial temporal variability both seasonally and in response to longer term changes, such as ITF variability (Brewer et al., 2007). Internal tides are strongest during January–March (Brewer et al., 2007). Satellite observations suggest productivity is enhanced along the northern and southern boundaries of the plateau and along the shelf edge, which in turn suggests that the plateau is a significant contributor to the productivity of the region (Brewer et al., 2007). The seascape of the Exmouth Plateau is not considered to be unique by Falkner et al. (2009) in their review of KEFs in the NWMR; however, the geological origin (Exon and Willcox, 1980) and potential enhanced upwelling due to the Exmouth Plateau (Brewer et al., 2007) may constitute unique environmental values (DSEWPaC, 2012a). Fauna in the pelagic waters above the plateau are likely to include small pelagic species and nekton (Brewer et al., 2007). Protected and migratory species are also known to pass through the region, including whale sharks and cetaceans.

Only a portion of the full Exmouth Plateau geological feature is considered a KEF under Australian legislation. The listed Exmouth Plateau KEF covers mainly the shallower region of the plateau (i.e. the plateau's surface). Most actions in or adjacent to the NWMR are considered unlikely to adversely impact the integrity or ecosystem function of the Exmouth Plateau; ocean acidification resulting from climate change is the only potential pressure identified in the relevant bioregional plan (DSEWPaC, 2012a). Further explanation on the bathymetry and expected habitat of the Exmouth KEF is included in **Section 4.4**.

4.7.4.3 Area C

Area C overlaps with three KEFs: the Continental Slope Demersal Fish Communities, Ancient Coastline at 125 m Depth Contour (both described above in Area A), and the Canyons Linking the Cuvier Abyssal Plain and the Cape Range Peninsula (described below) (**Figure 4-23**). Area C also abuts the Commonwealth Waters Adjacent to Ningaloo Reef KEF, which is contiguous with the Ningaloo AMP.

Canyons Linking the Cuvier Abyssal Plain and the Cape Range Peninsula

The canyons that link the Cuvier Abyssal Plain with the Cape Range Peninsula (the Canyons KEF) is located off the north-west coast of Australia and partially overlaps Area C. The canyons are believed to support the productivity and species richness of Ningaloo Reef (DSEWPaC, 2012a). Interactions with the Leeuwin Current and strong internal tides are thought to result in upwelling at the canyon heads, thus creating conditions for enhanced productivity in the region (Brewer et al., 2007). As a result, aggregations of whale sharks, manta rays, humpback whales, sea snakes, sharks, predatory fish and seabirds are known to occur in the area due to the enhanced productivity (Sleeman et al., 2007).

The eastern extent of the Canyons KEF comprises 'blind canyons' (i.e. confined to the continental slope with heads that terminate below the continental shelf). Such canyons are thought to have formed during slumping of deposited sediments downwards along the continental slope, rather than as the result of drowned river valleys during Holocene sea level changes (BMT Oceanica, 2016).

Woodside commissioned a literature review of the Cape Range Canyon, supported by an environmental survey of the Enfield Canyon (BMT Oceanica, 2016). This survey examined several sections of the canyons (about 365–870 m water depth) and sampled a range of physical and biological parameters, including water, sediments, epifauna and mobile invertebrates, infauna and fish assemblages. Benthic habitats within and surrounding the canyons surveyed were similar in nature to those observed elsewhere in the NWMR and were characterised by flat unconsolidated sediments composed of sand- and mud-sized particles (BMT Oceanica, 2016; Falkner et al., 2009). Epifauna and mobile invertebrate communities associated with these habitats were considered to be similar to those observed elsewhere in the region, as well as other continental slopes in the Indo-Pacific region (BMT Oceanica, 2016; Heyward et al., 2001). The fish assemblages associated with the canyon observed during the survey were considered to be high, and consistent with data recorded during other investigations (Last et al., 2005; Williams et al., 2001). The fish assemblage at the foot of the canyon (the deepest area surveyed) was more diverse than those observed in higher sections of the canyon, with Angulliform (eels) and Scorpaeniform (*Paraliparis* spp.) species present that were not observed in the body of the canyon.

In reviewing KEFs in the NWMR, Falkner et al. (2009) concluded that the canyons examined in the region exhibited habitat heterogeneity (although noted that such habitat was not restricted to canyon features) and were representative of the region. These conclusions were based on a review of existing physical and biological data from a range of sources. The observations made during the survey of the Canyons KEF were not consistent with these conclusions, finding that the habitat at different locations within the canyon comprised flat unconsolidated sediments composed of sand- and mud-sized particles (BMT Oceanica, 2016).

Commonwealth Waters Adjacent to Ningaloo Reef

The Commonwealth Waters Adjacent to Ningaloo Reef KEF lies adjacent to the three nautical mile State waters limit along Ningaloo Reef and includes the Ningaloo AMP. See **Section 4.7.2** for further information about the values and sensitivities associated with this KEF.

4.7.5 Other Sensitive Areas

4.7.5.1 Rankin Bank

Rankin Bank is on the continental shelf, about 16 km east of Area A. While Rankin Bank is not protected and is not a KEF, it is the only large, complex bathymetrical feature on the outer western shelf of the West Pilbara and represents habitats that are likely to play an important role in the productivity of the Pilbara region (AIMS, 2014). Rankin Bank consists of three submerged shoals delineated by the 50 m depth contour with water depths of about 18–30.5 m (AIMS, 2014).

Rankin Bank was surveyed by AIMS in 2013 as part of a co-investment project between Woodside and AIMS to better understand the habitats and complexity of the submerged shoal ecosystems. Rankin Bank represents a diverse marine environment, predominantly composed of consolidated reef and algae habitat (~55% cover), followed by hard corals (~25% cover), unconsolidated sand/silt habitat (~16% cover), and benthic communities composed of macroalgae, soft corals, sponges and other invertebrates (~3% cover) (AIMS, 2014). Hard corals are a significant component of the benthic community of some parts of the bank, with abundance in the upper end of the range observed elsewhere on the submerged shoals and banks of north-west Australia (Heyward et al., 2012).

Rankin Bank has been shown to support a diverse fish assemblage (AIMS, 2014). This is consistent with studies showing a strong correlation between habitat diversity and fish assemblage species richness (Gratwicke and Speight, 2005; Last et al., 2005).

5. STAKEHOLDER CONSULTATION

5.1 Summary

Woodside consults relevant stakeholders to ensure their interests or comments inform our decision-making and planning for proposed petroleum activities.

Consultation for the proposed activity builds upon Woodside's extensive and ongoing stakeholder consultation for its offshore petroleum activities in the region.

This includes consultation for activities to support exploration, development and operation activities from the Enfield and Vincent oil fields, which commenced production in 2006 and 2008 respectively. Woodside has also undertaken consultation in the region to support decommissioning activities for the Nganhurra production facilities and infrastructure at Enfield.

Woodside has also performed extensive consultation over many years for its Pluto LNG activities that are nearby to the proposed Julimar development and more recently for the proposed Scarborough LNG project.

5.2 Stakeholder Consultation Guidance

Woodside has followed the requirements of Subregulation 11A(1) of the Environment Regulations to identify relevant stakeholders, these being:

- each Department or agency of the Commonwealth Government to which the activities to be performed under the EP, or the revision of the EP, may be relevant
- each Department or agency of a State or the Northern Territory Government to which the activities to be performed under the EP, or the revision of the EP, may be relevant
- the Department of the responsible State Minister, or the responsible Northern Territory Minister
- a person or organisation whose functions, interests or activities may be affected by the activities to be performed under the EP, or the revision of the EP
- any other person or organisation that the Titleholder considers relevant.

Woodside's assessment of stakeholder relevance is outlined in **Table 5-1**.

5.3 Stakeholder Consultation Objectives

In support of this Environment Plan, Woodside has sought to:

- ensure all relevant stakeholders are identified and engaged in a timely and effective manner
- develop, and make available to stakeholders, communications material that is relevant to their interests and information needs
- incorporate stakeholder feedback into managing the proposed activity where practicable
- provide feedback to stakeholders on Woodside's assessment of their feedback and record all engagements
- make available opportunities to provide feedback during the life of this EP.

5.4 Stakeholder Expectations for Consultation

Stakeholder consultation for this activity has also been guided by stakeholder organisation expectations for consultation on planned activities. This guidance includes:

NOPSEMA

- *GL1721 – Environment plan decision making – Rev 5 – June 2018*
- *GN1847 – Responding to public comment on environment plans – Rev 0 – April 2019*
- *GN1344 – Environment plan content requirements – Rev 4 – April 2019*
- *GN1488 – Oil pollution risk management – Rev 2 – February 2018*.

Australian Government

- *Offshore Petroleum and Greenhouse Gas Activities: Consultation with Australian Government agencies with responsibilities in the Commonwealth Marine Area*.

Australian Fisheries Management Authority

- *Petroleum industry consultation with the commercial fishing industry*.

Department of Agriculture and Water Resources

- *Fisheries and the Environment – Offshore Petroleum and Greenhouse Gas Act 2006*.

Department of Primary Industries and Regional Development

- *Guidance statement for oil and gas industry consultation with the Department of Fisheries*.

WA Department of Transport

- *Offshore Petroleum Industry Guidance Note*.

Woodside acknowledges that additional relevant stakeholders may be identified before or during the proposed activity. These stakeholders will be contacted, provided information relevant to their interests and invited to provide feedback about the proposed activity. Woodside will assess their feedback, respond to the stakeholder and incorporate feedback into the management of the proposed activity where practicable.

Woodside consultation arrangements typically provide stakeholders up to 30 days (unless otherwise agreed) to review and respond to proposed activities where stakeholders are potentially affected. Woodside considers this consultation period an adequate timeframe in which stakeholders can assess potential impacts of the proposed activity and provide feedback.

Table 5-1: Assessment of relevant stakeholders for the proposed activity

Stakeholder	Relevant to activity			Reasoning
	Area A	Area B	Area C	
Australian Government department or agency				
Australian Customs Service – Border Protection Command	Yes	Yes	Yes	Responsible for coordinating maritime security.
Australian Fisheries Management Authority	Yes	Yes	Yes	Responsible for managing Commonwealth fisheries. There has been recent effort by Commonwealth fishery licence holders in Areas A and C.
Australian Hydrographic Office (AHO)	Yes	Yes	Yes	Maritime safety and responsible for Notice to Mariners (NTM).
Australian Maritime Safety Authority	Yes	Yes	Yes	Statutory agency for vessel safety and navigation and legislated responsibility for oil pollution response in Commonwealth waters.
Department of Agriculture and Water Resources (DAWR)	Yes	Yes	Yes	Responsible for implementing Commonwealth policies and programmes to support the agriculture, fisheries, food and forestry industries. The proposed activity has potential to impact Commonwealth fishers in Areas A and C and, as a result, triggers the DAWR's functions and interests.
Department of Defence	Yes	Yes	Yes	Proposed Operational Areas overlap defence activity areas.
Department of the Environment and Energy	No	No	No	Responsible for designing and implementing Australian Government policy and programs to protect and conserve the environment, water and heritage, promote climate action, and provide adequate, reliable and affordable energy.
Director of National Parks (DNP)	Yes	No	Yes	Responsible for managing Australian Marine Parks. Planned activities in Areas A and C affect the functions, interests or activities of the DNP, with seismic acquisition in or adjacent to Australian Marine Parks.
Department of Industry, Innovation and Science	Yes	Yes	Yes	Department of relevant Commonwealth Minister and is required to be consulted under the Regulations.
Western Australian Government department or agency or advisory body				
Department of Biodiversity, Conservation and Attractions (DBCA), Parks and Wildlife Service	No	No	Yes	Responsible for managing Western Australia's parks, forests and reserves. Planned activities in Area C affect the functions, interests or activities of the DBCA, with seismic data to be acquired adjacent to DBCA-managed areas.
Department of Mines, Industry Regulation and Safety (DMIRS)	Yes	Yes	Yes	Department of relevant State Minister and is required to be consulted under the Regulations.

Stakeholder	Relevant to activity			Reasoning
	Area A	Area B	Area C	
Department of Primary Industries and Regional Development (DPIRD)	Yes	Yes	Yes	Responsible for managing State fisheries.
Department of Transport (DoT)	No	No	Yes	Legislated responsibility for oil pollution response in State waters.
Ningaloo Coast World Heritage Advisory Committee	No	No	Yes	Independent advisory Committee to Government on Ningaloo World Heritage matters.
Commonwealth fisheries*				
North-West Slope Trawl Fishery	Yes	No	Yes	The fishery overlaps Areas A and C. There has been recent fishing effort near Area A.
Southern Bluefin Tuna Fishery	No	No	No	While the fishery overlaps Areas A, B and C, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Areas.
Western Tuna and Billfish Fishery	No	No	No	While the fishery overlaps Areas A, B and C, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Areas.
Western Deepwater Trawl Fishery	No	Yes	Yes	While the fishery overlaps Areas B and C, fishing typically occurs south and offshore of North West Cape with medium and high density fishing activity located to the south of Ningaloo Reef and west of Shark Bay.
State fisheries*				
Abalone Managed Fishery	No	No	No	While the fishery overlaps Areas A, B and C, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Areas.
Beche-de-Mer Fishery	No	No	No	While the fishery overlaps Areas A, B and C, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Areas.
Exmouth Gulf Prawn Managed Fishery	No	No	No	While the fishery overlaps Areas A, B and C, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Areas.
Marine Aquarium Managed Fishery	No	No	No	While the fishery overlaps Areas A and C, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Areas.
Nickol Bay Prawn Managed Fishery	No	No	No	While the fishery overlaps Areas A, B and C, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Areas.
Onslow Prawn Managed Fishery	No	No	No	While the fishery overlaps Area A, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Area.

Stakeholder	Relevant to activity			Reasoning
	Area A	Area B	Area C	
Pearl Oyster Managed Fishery	Yes	No	Yes	Zone 1 of the fishery overlaps Areas A and C. There has been recent fishing effort in this Zone.
Pilbara Demersal Scalefish Managed Fisheries:				
Pilbara Trawl	No	No	No	Fishing Area Zone 1 of the Pilbara Trawl Fishery overlaps Area A. The Zone is closed to trawl fishing.
Pilbara Trap	Yes	No	Yes	Fishery overlaps Areas A, B and C. There has been recent fishing effort in Areas A and C.
Pilbara Line	Yes	No	Yes	Fishery overlaps Areas A, B and C. There has been recent fishing effort in Areas A and C.
Specimen Shell Managed Fishery	No	No	No	While the fishery overlaps Areas A and C, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Areas.
West Coast Deep Sea Crustacean Managed Fishery	No	No	No	While the fishery overlaps Areas A, B and C, interactions with participants in the fishery are not expected as fishing effort occurs outside of the Operational Areas.
West Coast Rock Lobster Fishery	No	No	No	While the fishery overlaps Area C, interactions with participants in the fishery are not expected as fishing effort occurs of the Operational Area.
West Australian Mackerel Managed Fishery	Yes	No	Yes	The Pilbara (Area 2) and Gascoyne and West Coast (Area 3) areas of the fishery overlap Areas A, B and C. There has been fishing effort in Areas A and C.
Industry				
AWE	No	No	Yes	Adjacent titleholder.
BHP Billiton Petroleum	No	No	Yes	Adjacent titleholder.
Chevron	Yes	Yes	No	Adjacent titleholder.
Santos	No	No	Yes	Adjacent titleholder.
Western Gas	No	Yes	No	Adjacent titleholder.
Industry representative organisation				
Australian Petroleum Production and Exploration Association (APPEA)	Yes	Yes	Yes	Represents the interests of oil and gas explorers and producers in Australia.
Commonwealth Fisheries Association (CFA)	Yes	Yes	Yes	Represents the interests of commercial fishers with licences in Commonwealth waters. Potential for interaction with Commonwealth fishery licence holders in Areas A, B and C.

Stakeholder	Relevant to activity			Reasoning
	Area A	Area B	Area C	
Pearl Producers Association (PPA)	Yes	No	Yes	Represents the interests of the Australian South Sea Pearling industry. Potential for interaction with pearl fishers in Areas A and C.
Recfishwest	Yes	No	Yes	Represents the interests of recreational fishers in Western Australia. Potential for interaction with recreational fishers in Areas A and C.
Western Australian Fishing Industry Council (WAFIC)	Yes	Yes	Yes	Represents the interests of commercial fishers with licences in State waters. Potential for interaction with commercial fishers in Areas A, B and C.
Other stakeholders				
Cape Conservation Group	No	No	Yes	Volunteer not-for-profit organisation that is involved in protecting the terrestrial and marine environment of the North West Cape.
Exmouth Community Reference Group	No	No	Yes	Group established in 2002 to provide a forum for local community, industry and government stakeholders to have a say about the development of the Enfield Oil Project. The group now embraces the petroleum activities of BHP and Santos for respective petroleum activities.
Exmouth Game Fishing Club	No	No	Yes	Exmouth based game fishing club, which hosts a number of fishing tournaments, including GAMEX (13 to 21 March 2020).
Fishing Charter Operators	No	No	Yes	Possible recreational fishing over Area C.
Wilderness Society	No	No	No	Broader environmental interests. Information provided as a courtesy.
WWF	No	No	No	Broader environmental interests. Information provided as a courtesy.
Australian Conservation Foundation	No	No	No	Broader environmental interests. Information provided as a courtesy.

** Fisheries have been identified as being relevant based on fishing licence overlap with the proposed Operational Areas as well as consideration of fishing effort data, fishing methods and water depth. Table 4-8 provides a detailed assessment of Commonwealth and State fisheries within or adjacent to the Operational Areas.*

5.5 Consultation Engagement Plan

Consultation activities conducted for the proposed activity are outlined in **Table 5-2**.

Table 5-2: Stakeholder consultation plan activities

Stakeholder	Timing	Information Provided
Australian Government department or agency		

Stakeholder	Timing	Information Provided
Australian Hydrographic Office	1 April 2019	• Email advising of proposed activity, consultation Information Sheet and shipping lane map relevant to proposed activity.
Department of Agriculture and Water Resources	10 May 2019	• Email advising of proposed activity, consultation Information Sheet and Commonwealth fisheries maps relevant to proposed activity.
Australian Maritime Safety Authority	1 April 2019	• Email advising of proposed activity, consultation Information Sheet and shipping lane map relevant to proposed activity.
	8 May 2019	• Email and a copy of the Oil Pollution First Strike Plan.
Australian Fisheries Management Authority	1 April 2019	• Email advising of proposed activity, consultation Information Sheet and Commonwealth fisheries maps relevant to proposed activity
	17 May 2019	• Phone call to AFMA following Small Pelagic Fishery Association advice it wasn't the correct representative organisation and seeking further guidance on consulting commercial fishers
	21 May 2019	• Email to AFMA following Small Pelagic Fishery Association advice it wasn't the correct representative organisation and seeking further guidance on consulting commercial fishers • Map of Commonwealth Fisheries and Information Sheet.
Department of Environment and Energy	15 May 2019	• Email advising of proposed activity, potential impacts to the Montebello and Gascoyne Marine Parks for noise emissions and in the unlikely event of a hydrocarbon release, and proposed control measures. • Woodside offer of a meeting to discuss in further details if required.
Department of Defence	1 April 2019	• Email advising of proposed activity, consultation Information Sheet and defence areas map relevant to proposed activity.
Australian Customs Service	1 April 2019	• Email advising of proposed activity and consultation Information Sheet. • Website publication of the consultation Information Sheet at www.woodside.com.au/sustainability/transparency/consultation-activities. • Provision of toll free 1800 phone number.
Department of Industry, Innovation and Science	1 April 2019	• Email advising of proposed activity and consultation Information Sheet. • Website publication of the consultation Information Sheet at www.woodside.com.au/sustainability/transparency/consultation-activities. • Provision of toll free 1800 phone number.
Director of National Parks	2 May 2019	• Email advising of proposed activity, potential impacts to the Montebello and Gascoyne Marine Parks for noise emissions and in the unlikely event of a hydrocarbon release, and proposed control measures.

Stakeholder	Timing	Information Provided
	6 May 2019	• Email advising of proposed activity, potential impacts to the Commonwealth Ningaloo Marine Park for noise emissions and in the unlikely event of a hydrocarbon release, and proposed control measures.
	22 May 2019	• Meeting with representatives of the DNP to discuss the proposed activity, potential impacts and proposed control measures.
Western Australian Government department or agency or advisory body		
Department of Biodiversity, Conservation and Attractions, Parks and Wildlife Service	3 May 2019	• Email advising of proposed activity, potential impacts to the Commonwealth Ningaloo Marine Park for noise emissions and in the unlikely event of a hydrocarbon release, and proposed control measures.
	9 May 2019	• Email providing additional information about potential impact of acoustic emissions on the ecological and social values of the Ningaloo Marine Park and Muiron Islands Management Area.
Department of Primary Industries and Regional Development	19 February 2019	• Email requesting meeting to discuss the proposed 4D seismic campaign and preliminary fishery considerations.
	13 March 2019	• Email confirming meeting and provision of pre-meeting presentation slides.
	20 March 2019	• Meeting to discuss the proposed 4D seismic campaign and preliminary fishery considerations.
	1 April 2019	• Email advising of proposed activity, consultation Information Sheet and State fisheries map relevant to proposed activity.
	2 April 2019	• Email with updated risk description for underwater noise emissions.
	4 April 2019	• Email seeking support to create a single point of reference for industry to understand habitat and life history information for key commercial species.
	18 May 2019	• Email providing EP extract on noise modelling and noise impact assessment on issues related to fishing.
	31 May 2019	• Phone call and voicemail left following up to see if there are further queries regarding the noise modelling and noise impact assessment.
	11 July 2019	• Email to DPIRD providing a response to comments received 19 June 2019.
Ningaloo Coast World Heritage Advisory Committee	21 May 2019	• Email advising of proposed activity, consultation Information sheet and information about potential impact of acoustic emissions on the ecological and social values of the Ningaloo Marine Park and Muiron Islands Management Area.
Department of Mines, Industry Regulation and Safety	1 April 2019	• Email advising of proposed activity and consultation Information Sheet. • Website publication of the consultation Information Sheet at www.woodside.com.au/sustainability/transparency/consultation-activities. • Provision of toll free 1800 phone number.

Stakeholder	Timing	Information Provided
Department of Transport	3 May 2019	• Email advising of consultation approach for the Oil Pollution First Strike Plan.
	8 May 2019	• Email and a copy of the Oil Pollution First Strike Plan.
Commonwealth fisheries		
North-West Slope Trawl Fishery	31 May 2019	• Email advising of proposed activity, consultation Information Sheet and Commonwealth fisheries maps relevant to proposed activity.
State fisheries		
Pilbara Demersal Scalefish Managed Fisheries – Pilbara Trap and Pilbara Line	1 April 2019	• Email/letter to licence holders providing information about potential impacts to fishers and Woodside's proposed management and mitigation measures.
	2 April 2019	• Email/letter with updated risk description for underwater noise emissions.
	4 April 2019	• Email to the Pilbara Line licence holders offering meeting on 15 April 2019 to discuss survey activities and potential impacts on fishers, as well as a commitment to provide presentation material before the meeting.
	18 April 2019	• Email/letter providing additional information about operational details, potential impacts and mitigation measures.
West Australian Mackerel Managed Fishery	1 April 2019	• Email/letter to licence holders providing information about potential impacts to fishers and Woodside's proposed management and mitigation measures.
	18 April 2019	• Email/letter providing additional information about operational details, potential impacts and mitigation measures.
Industry		
AWE, BHP Billiton Petroleum, Chevron, Santos, Western Gas	1 April 2019	• Email advising of proposed activity, consultation Information Sheet and titles map relevant to proposed activity.
Industry representation organisation		
APPEA	1 April 2019	• Email advising of proposed activity, provision of consultation information sheet, and opportunity to provide feedback.
Commonwealth Fisheries Association	1 April 2019	• Email advising of proposed activity, consultation Information Sheet and Commonwealth fisheries maps relevant to proposed activity.
	14 May 2019	• Follow-up phone call to CFA on consultation materials sent on 1 April 2019.
Small Pelagic Fishery Association	14 May 2019	• Email to Small Pelagic Fishery Association following CFA advice it wasn't the correct representative organisation

Stakeholder	Timing	Information Provided
Pearl Producers Association	1 April 2019	• Email and phone call advising of proposed activity including potential impacts to commercial fishers and proposed management/mitigation measures, consultation Information Sheet and State fisheries map relevant to proposed activity.
	2 April 2019	• Email with updated risk description for underwater noise emissions.
Western Australian Fishing Industry Council	1 April 2019	• Email and phone call advising of proposed activity including potential impacts to commercial fishers and proposed management/mitigation measures, consultation Information Sheet and State fisheries map relevant to proposed activity.
	2 April 2019	• Email with updated risk description for underwater noise emissions.
	4 April 2019	• Phone call and email offering meeting on 15 April 2019 to discuss survey activities and potential impacts on fishers, as well as a commitment to provide presentation material before the meeting.
	5 April 2019	• Phone call to discuss requirement for a meeting with WAFIC and relevant licence holders to provide more detailed information. Agreed that information should first be provided by email/letter, with a future meeting depending on feedback received.
	18 April 2019	• Email providing additional information about operational details, potential impacts and mitigation measures.
Recfishwest	10 July 2019	• Phone call and email advising of proposed activity, consultation information Sheet and list of charter operators in the Gascoyne and Pilbara Kimberley regions. Request to help identify possible relevant charter operators in Area C.
Other stakeholders		
Exmouth Community Reference Group	7 March 2019	• Face to face briefing on the proposed activity and map for Area C provided.
	2 April 2019	• Email advising of proposed activity, provision of consultation information sheet, and opportunity to provide feedback.
	8 August 2019	• Face to face update on the proposed activity.
	7 November 2019	• Face to face update on the proposed activity.
Exmouth Game Fishing Club	8 March 2019	• Face to face briefing on the proposed activity and discussion of possible implications for GAMEX. Map for Area C provided.
	28 August 2019	• Phone call to understand active fishing days for GAMEX and the Heavy Tackle Tournament and notification timeframes.
	18 September 2019	• Phone call to advise the fishing club there will be no seismic activity in Area C during the active fishing days of GAMEX.
Cape Conservation Group	7 March 2019	• Initial engagement with the Cape Conservation Group was carried out via the Exmouth Community Reference Group. Subsequent one-on-one consultation referenced in table 5.3.
Shire of Exmouth	8 March 2019	• Face to face briefing on the proposed activity.

Stakeholder	Timing	Information Provided
Exmouth Chamber of Commerce and Industry	8 March 2019	• Face to face briefing on the proposed activity
Broader Exmouth Community	6 September 2019	• Information sheet including map posted on the oil and gas noticeboard in town.
Fishing Charter Operators	17 July 2019	• Email advising of proposed activity, and consultation Information Sheet.

Copies of Woodside correspondence and consultation material outlined in **Table 1-2** are included in **Appendix F**.

5.6 Consultation Feedback

A summary of stakeholder feedback and Woodside's responses is outlined in **Table 5-3**.

Table 5-3: Stakeholder consultation feedback

Stakeholder	Stakeholder feedback	Woodside response
Australian Government department or agency		
Australian Maritime Safety Authority	On 3 April 2019 AMSA emailed Woodside asking for Esri ArcGIS shapefiles for the three survey areas.	On 16 April 2019 Woodside provided copies of the requested files to AMSA.
	On 12 April 2019 AMSA emailed Woodside providing information about marine vessel traffic in the three survey areas.	Woodside acknowledges AMSA's provision of marine vessel traffic to assist with activity planning.
	AMSA requested that its Joint Rescue Coordination Centre (JRCC) be notified 24–48 hours before operations commence for each survey and provided details of information required by the Centre in that communication.	Woodside will notify AMSA's JRCC 24–48 hours before operations commence for each survey (**Section 7.8).**
	AMSA requested that AHO be contacted through datacentre@hydro.gov.au no less than four working weeks before operations commence for the promulgation of related NTMs.	Woodside will notify AHO no less than four working weeks before operations commence (**Section 7.8**).
	AMSA requested Woodside access its AMSA's spatial data gateway and Spatial@AMSA portal for future activities, to download digital datasets and maps to obtain vessel traffic showing vessel Automatic Identification System (AIS) data for the area of interest.	On 16 April 2019 Woodside emailed AMSA noting AMSA's advice on spatial data for consideration for future activities.

Stakeholder	Stakeholder feedback	Woodside response
Australian Customs Service – Border Protection Command	No feedback received	Woodside has received no response from Customs. Woodside addressed customs related issues for this activity in **Section 6** based on previous offshore activities. Woodside considers the level of consultation to be adequate.
Australian Fisheries Management Authority	On 22 May 2019 AFMA provided advice that direct contact details for the rights holders in the North West Slope Trawl and Western Deepwater Trawl fisheries can be obtained by contacting AFMA licencing.	On 27 May 2019 Woodside emailed AFMA thanking them for outlining the process to source licence holder contact details. The email sought advice on whether catch and effort data is available to better determine relevant fisheries. On 31 May 2019 Woodside emailed fishing licence holders in the North West Slope Trawl and Western Deepwater Trawl fisheries.
Australian Hydrographic Office	No feedback received from AHO. AMSA requested that AHO be contacted through datacentre@hydro.gov.au no less than four working weeks before operations commence for the promulgation of related NTMs.	Woodside will notify AHO no less than four working weeks before operations commence. Woodside considers the level of consultation to be adequate.
Department of Agriculture and Water Resources	No feedback received	Woodside has received no response from the Department. Woodside engaged relevant fishers and representative bodies. Woodside addressed biosecurity for this activity in **Section 6** based on previous offshore activities. Woodside considers the level of consultation to be adequate.
Department of Defence	No feedback received	Woodside has received no response from the Department. Historically Woodside has received no response from the Department. Woodside considers the level of consultation to be adequate.
Department of Industry, Innovation and Science	No feedback received	Woodside has received no response from the Department. Woodside engaged the Department as required under the Regulations. Assessment of the EP will be conducted by NOPSEMA as the offshore regulator. Woodside considers the level on consultation to be adequate.
Director of National Parks	On 2 May 2019 DNP emailed Woodside requesting details of titles relevant to the three survey areas.	On 2 May 2019 Woodside emailed title maps of the three survey areas.

Stakeholder	Stakeholder feedback	Woodside response
	On 22 May 2019 Woodside met with representatives from the DNP. DNP advised they were preparing a response to the detailed consultation sent by Woodside. During the meeting DNP raised queries regarding definitions of Temporary Threshold Shift (TTS) and recovery timeframes. DNP also queried whole ecosystem assessment with specific reference to zooplankton and benthic invertebrates.	The meeting included representatives of Woodside's Scientific and Environment team and a bioacoustic subject matter expert (SME) who provided a detailed reply to the position of these matters within the EP.
	On 4 June 2019 DNP emailed Woodside, noting its advice that the proposed activity was located in the Gascoyne and Montebello Marine Parks. It also noted that the activity was located adjacent to Ningaloo Marine Park.	Woodside acknowledges DNP's understanding of the proposed activity.
	DNP requested Woodside observe approval obligations when undertaking activities in the Multiple Use Zones of the Gascoyne and Montebello Marine Parks.	Woodside will comply with its obligations under an accepted Environment Plan (**Section 1.10.1** and **Section 6**).
	DNP advised It had worked with NOPSEMA to prepare a guidance note for titleholders to consider in preparing an EP for petroleum activities that may affect an Australian Marine Park, ensuring that the management plan: • identifies and manages the impacts and risks on Australian Marine Park values to an acceptable level and has considered all options to avoid or reduce them to as low as reasonably practicable. • clearly demonstrates that the activity will not be inconsistent with the management plan.	Woodside acknowledges the feedback. The potential impacts and risks of seismic activity on the values of the marine parks are assessed in **Section 6** management controls to reduced impact levels to and acceptable level are also outlined.
	DNP provided advice on the categories of Marine Park values, noting some specific values for the Gascoyne, Montebello and Ningaloo Marine Parks, as well as the Ningaloo Marine Park's World Heritage Listing status.	The specific values of the Gascoyne, Montebello and Ningaloo Marine Parks are considered in **Section 6.**
	DNP directed Woodside to the Recovery Plan for Marine Turtles in Australia 2017-2027 to determine where operations intercept 'habitat critical' areas and overlap marine turtle nesting and hatchling emergence periods.	The Recovery Plan for Marine Turtles in Australia 2017-2027 including threats, 'habitat critical' areas and BIA locations is considered in **Section 4** and **Section 6.**
	DNP provided advice on emergency response arrangements, noting Woodside's commitment to inform DNP if an environmental incident occurs that may impact on the values of an Australian Marine Park. DNP provided contact details and expectations on content and timeliness of communications in the event of such an incident.	Woodside acknowledges the feedback DNP notification requirements are outlined in **Section 6**.
Western Australian Government department or agency or advisory body		

Stakeholder	Stakeholder feedback	Woodside response
Department of Mines, Industry Regulation and Safety	On 8 April 2019 DMIRS emailed Woodside thanking Woodside for keeping the Department informed about its activities in Commonwealth waters, acknowledging NOPSEMA jurisdiction for the proposed activity.	Woodside acknowledges DMIRS's feedback on being consulted for the proposed activity.
	DMIRS requested that the Operational Area for the Area C surveys (Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys) is set back from the boundary of the Ningaloo Marine Park as far as possible.	Woodside notes DMIRS's request, noting that the planned sail lines have been planned to replicate those of a previous 4D survey. Woodside has assessed potential impacts from planned activities to the Ningaloo Marine Park and Muiron Islands Management Area (**Section 4** and **Section 6)** and has adopted relevant management measures.
	DMIRS sought commencement and cessation notifications for the activities.	Woodside will provide DMIRS with commencement and cessation notifications.
Department of Biodiversity, Conservation and Attractions, Parks and Wildlife Service	On 10 May 2019 DBCA emailed Woodside advising it had no comments about its responsibilities under the *Biodiversity Conservation Act 2016* and the *Conservation and Land Management Act 1984* based on information provided by Woodside.	No further action required for this EP.
	On 5 June 2019 DBCA noting that Woodside's consultation information had not identified that the Quarter 2 activities will overlap humpback whale migration. DBCA asked for this to be considered,	On 6 June 2019 Woodside responded noting the northern migration between Jurien Bay to Montebello Islands occurs from May – November, and peaks in June and July, and the southern migration occurs from August – November. Woodside has controls in place to restrict the timing for Area A and C to November 2019 – May 2020 and further controls to manage interactions with whales outside of peak migration periods including not surveying Laverda during May-June (**Section 6**). Refer to **Table 4-5** for a summary of survey acquisition timings.
Ningaloo Coast World Heritage Advisory Committee (via DBCA)	On 21 May 2019 the DBCA emailed Woodside on behalf of the Ningaloo Coast World Heritage Advisory Committee asking if Woodside was seeking input from the Committee on the proposed activity.	Woodside advised it would be happy to receive comments from the Committee and provided information previously sent to DBCA on 3 May 2019. Woodside notes previous advice from DBCA on 10 May 2019 that it had no comments on the proposed activity.
	On 10 June 2019 DBCA emailed Woodside on behalf of the Ningaloo Coast World Heritage Advisory Committee advising it would like to provide comment and requested an extension to provide comment until late June.	Woodside advised it would be pleased to receive a response from the Committee and extended the deadline to 30 June 2019.
	On 9 August 2019, submission from the Advisory Committee recommending the survey do not enter the world heritage area.	On 10 September 2019 Woodside emailed the Committee responding to recommendations noting the survey will not enter the world heritage area.

Stakeholder	Stakeholder feedback	Woodside response
	Recommended the survey in Area C is completed in January – February 2020 to avoid impacts on pygmy blue whale, whale shark and coral recruitment.	Woodside is taking all efforts to ensure the activity is timed to avoid key sensitivities where possible. Varying the timing of the Petroleum Activities Program to commit to avoiding peak pygmy blue whale migration, whale shark aggregation and coral spawning has been considered and assessed in detail and required to be evaluated against other considerations including; the commitment to avoid the humpback migratory period, regulatory approval uncertainty, vessel availability and the critical business driver to ensure the data is acquired as soon as possible.
	Queried whether sources fired within the Operational Area, external to the Acquisition Area, would be restricted to 4 km from the edge of the Acquisition Area and recommended the modelling estimate for sound reaching and entering the world heritage area is based on the closest shot point to this area (i.e. worst case scenario).	The acoustic modelling and impact assessment are based on a worst-case scenario. There will be no full power discharge of the seismic source at any point closer to the NCWHA boundary within the Operational areas for any of the three surveys within Area C. The restriction on source discharge within 4 km of the Acquisition areas is a commitment, and this will only occur during line run-ins, run-outs and soft starts. Woodside will commit to doing any source testing within the Acquisition area.
	Recommended the modelling of impacts on species included in the OUV of the world heritage area include the worst-case minimum separation distance sought for approval and extend to include the KEF.	The acoustic modelling and impact assessment are based on a worst-case scenario. As described in Section 4.7.4.3 of the EP, and shown in Figure 4-23, the Acquisition Areas for the Laverda, Cimatti and Vincent surveys in Area C overlap with a portion of the "Canyons linking the Cuvier Abyssal Plain and the Cape Range Peninsula KEF". Hence, a "minimum separation distance" cannot be applied.
	Recommended a commitment to the Bureau of Ocean Energy Management recommended 40 km geographic separation distance, given the four existing approval marine seismic surveys within 100km of the proposed survey have the same requirement.	Woodside will commit to a recommended 40 km geographic separation distance if any new seismic is identified within 100 kms of the proposed North-west surveys during acquisition.
	Recommended impacts on whale sharks and blue pygmy whales uses the precautionary principle rather than estimated impacts based on fish responses.	Acoustic noise emissions from seismic sources has not been identified as a threat to whale sharks (or other shark species identified as possibly present in the region) in either the Approved Conservation Advice or previously in force Whale Shark Recovery Plan 2005–2010. Potential impacts to pygmy blue whales have not been assessed based on fish responses but rather on current sound exposure thresholds for low-frequency cetaceans, which are based on the best available science and technical guidance.

Stakeholder	Stakeholder feedback	Woodside response
	Recommended start ups are limited to times of good visibility given the request to conduct the survey during times known to overlap with key species presence in, and near, the proposed seismic survey operational area.	Commencement of discharge of the seismic source, via a ramp-up or soft-start procedure, cannot be limited to periods of good visibility only as this would significantly increase the time required to acquire each survey. The main control will be applied to minimise the potential for impacts from underwater noise to marine fauna (whales, turtles and whale sharks) during acquisition of the surveys will be application of EPBC Policy Statement 2.1 – Part A Standard Management Measures.
	Requests to be kept informed of the location and timing of seismic activities occurring within 100 km of the world heritage area.	Woodside confirms it will notify the NCWHC at least 10 days prior to any seismic activities occurring within 100 km of WHA (i.e. Area C).
	Recommends KPIs are set for each species included in the OUV to ensure they are not adversely affected by the survey. Requested the provision of an annual update on the performance of the KPIs.	The environmental performance outcomes (EPOs) are equivalent to KPIs. Under the Regulations, titleholders undertaking an activity must submit a report to the Regulator in relation to the titleholder's environmental performance for the activity. As described in Section 7.8.2.3 of the EP, Woodside is required to submit and Environmental Performance Report to NOPSEMA within three months of completing the activity. The report will address compliance with EPOs and achieving standards outlined in the EP.
	Requests Table 5.1 within the EP is updated to include the Committee as an individual stakeholder, and requests table 5.3 is updated to include the Committee as an individual stakeholder and revise notes under DBCA to clearly define the Department as the State management body for the world heritage area, and the Committee as the independent Ministerial advisory body.	Table 5.1 will be updated to show the Committee is an individual and relevant stakeholder to the activity. This table (table 5.3) includes the comments raised by the Committee and Woodside's response.
	Woodside called the Committee representative who advised the Committee are located across the State and the best form of engagement is in writing.	Follow up phone call on 11 September 2019 to note a response had be provided to the Committee on 10 September 2019. Woodside is open to meeting with the Committee to discuss its response. A map on operations within the area can also be provided and discussed.

Stakeholder	Stakeholder feedback	Woodside response
		On 4 November 2019, Woodside emailed the Committee advising it had implemented new controls in response to recommendations made by the Committee including (revised survey map also attached to the email): • Reducing the size of the operational area for Area C to allow for a minimum 2 km buffer between the operational area and World Heritage Area, and implementing an alarm system on the seismic vessel when it comes within 1 km of the operational area boundary. • Passive acoustic monitoring to avoid potential impacts to sperm and beaked whales. • Implementation of the revised safe dividing distance from the Diving Medical Advisory Committee from seismic operations. • Aim to ensure no overlap on the peak of the northbound migration of pygmy blue whales in the region (May-June), however adaptative management measures would be implemented should this need to occur. • Adaptative management procedures for marine turtles in Area A.
Department of Transport	On 7 May 2019 DoT emailed Woodside to coordinate a meeting to discuss oil pollution consultation for the proposed activity.	On 7 May 2019 Woodside emailed DoT, advising of timeframes for providing oil pollution consultation and the First Strike Response Plan for the proposed activity.
	On 10 May 2019 DoT emailed Woodside providing feedback on Woodside's proposed oil pollution arrangements for the proposed activity. DoT requested accepted versions of its oil pollution documentation as well as tactical plans for the activity.	Woodside notes DoT's feedback and will provide the Department accepted versions of its oil pollution documentation as well as tactical plans for the activity.
Department of Primary Industries and Regional Development	On 5 April DPIRD emailed Woodside, providing feedback on availability to create a single point of reference for industry to understand habitat and life history information for key commercial species.	On 8 April 2019 Woodside provided greater clarity on its request, seeking to focus consultation on depth range for specific species, location of each species in the Pilbara management area, spawning locations and seasons, and fisheries targeting specific species.
	On 9 April 2019 DPIRD emailed Woodside and provided data in response to a request from Woodside for information about key species in the survey areas on water depth, spawning and commercial fishing activities.	Woodside considered the information provided by DPIRD to inform planning for the proposed activity as well as undertaking additional consultation with commercial fishers.
	On 23 April DPIRD emailed Woodside requesting a summary of the acoustic propagation modelling relevant to fisheries. DPIRD advised it would formally respond about the proposed activity after receiving the summary report and clarification of data provided to the Department.	On 18 May 2019 Woodside emailed DPIRD providing an extract from the EP including a noise impact assessment on fishing related aspects and data sourced from the JASCO Applied Sciences noise modelling report.

Stakeholder	Stakeholder feedback	Woodside response
	On 19 June 2019 DPIRD emailed Woodside, requesting that Woodside consult the following representative bodies as appropriate to the proposed activities: • Western Australian Fishing Industry Council (WAFIC) • Pearl Producers Association of WA (PPA) • Recfishwest • Relevant Traditional Owner groups	On 11 July 2019 Woodside emailed DPIRD advising that on 1 April 2019 we had consulted WAFIC, the PPA and Recfishwest, providing advice about the activity, an Information Sheet and a State fishery map relevant to the proposed activity. Woodside noted that there was no known indigenous fishing at Areas A, B and C.
	DPIRD also requested that Woodside consult individual commercial fishers and charter operators who fish in the affected area, providing advice on Department resources to identify potentially affected fishers and understand fish stock. The Department noted that Woodside had already obtained Department data on fishing effort and to provide advice to relevant stakeholders if assumptions had been made about that data.	Woodside advised it had used WA government data outlining the spatial boundaries of each fishery to determine the commercial fisheries that overlap Areas A, B and C. The Department's FishCube data was used to determine fishing effort overlapping Areas A, B and C and consultation was undertaken with licence holders of these fisheries. Woodside advised it had requested and been provided with the contact details from DPIRD of charter operators for the Gascoyne and Pilbara/Kimberley areas. Woodside had sought advice on 10 July 2019 from Recfishwest to determine which operators were relevant to Areas A, B and C. Consultation will be undertaken with operators once relevant operators have been determined.
	DPIRD noted its expectation that Woodside in its EP had considered and incorporated the recommendations published by NOPSEMA on the Acoustic Impact evaluation and management guidance to ensure environmental impacts and detailing how those impacts will be managed to ensure they are. The Department also expected that Woodside had incorporated the outcomes of DPIRD's Risk Assessment of the potential impacts of seismic air gun surveys on marine finfish and invertebrates in Western Australia and developed the appropriate controls to reduce the risk.	Woodside advised that it had considered, and incorporated recommendations published by NOPSEMA on acoustic impact evaluation and management, as well as the outcomes of the DPIRD risk assessment of potential impacts of seismic air gun surveys on marine finfish and invertebrates in Western Australia. Woodside advised it had used additional information to inform its risk/impact assessment, including modelling DPIRD acoustic thresholds in a 3D propagation model to provide an accurate representation of the potential impacts of the proposed activity on the receiving environment. Based on the results of the impact assessment and limited interaction with spawning areas and fisheries, the proposed survey is considered as acceptable and ALARP.

Stakeholder	Stakeholder feedback	Woodside response
	DPIRD advised that it did not support any proposed seismic survey where the risk is severe or high, in particular for immobile and mobile invertebrates and demersal finfish, unless scientific peer reviewed literature (location and species specific) demonstrates there is no impact. DPIRD noted that fish stocks in the area were fully allocated from a sustainability perspective and any addition risk could potentially impact long term sustainability for fish stocks.	Woodside advised that none of the DPIRD scenarios that were considered severe or high risks were relevant to Areas B and C, given that water depths were greater than 250 m. Woodside also noted that 3% of Area C was in water depth of less than 100 m. As a result, only a small percentage of the Area C interacted with the DPIRD Risk Assessment shallow water scenarios identified for demersal finfish and immobile invertebrates as high risk or severe risk.
	DPIRD noted that spawning grounds and nursery areas for key fish species were particularly vulnerable to the impacts of seismic surveys or sudden changes to the marine environment. The Department requested that no seismic survey acquisition occur during spawning periods for key species. It requested that management controls to mitigate any risk to fish stock (if spawning time can't be avoided) should be undertaken and provided to relevant stakeholders for comment. DPIRD also requested greater clarity on the timing of the surveys than quarters and years.	Woodside advised that on current planning, the survey activity may take place in a period between November to May 2019 in Areas A and C, and January to July 2020 in Area B. Woodside provided a matrix showing possible temporal and spatial spawning impacts to key indicator fish species within the Pilbara Line, Pilbara Trap, and Mackerel fisheries during these times. Woodside confirmed that the overlap – 1.6% for Red Emperor and 5.3% for Ruby Snapper – had been conservatively calculated using the full extent of the proposed Operational Areas. Woodside advised that given the very short ranges to conservatively assigned thresholds, the small extent of spatial overlap with the identified depth ranges for the key indicator species and the short duration of any potential impacts, it considered it highly unlikely that the proposed activity would cause significant impacts to spawning and recruitment in any key commercial fish species.

Stakeholder	Stakeholder feedback	Woodside response
	DPIRD sought clarification on how Woodside determined in the impact assessment that, "None of the ranges for these key indicator species overlap Area B". DPIRD also sought clarification if cumulative impacts of recent or other planned seismic surveys had been undertaken.	Woodside advised that DPIRD information on the depth contours for key species was less than that for Area B, with had a depth range of 806 m – 1113 m. Woodside acknowledged that cumulative impacts from seismic could potentially occur if activities took place concurrently or when the timing between surveys was less that the recovery rate of potential impacts. Woodside noted that four other planned seismic surveys had the potential to occur concurrently. Woodside committed to engaging with survey proponents prior to commencing the Petroleum Activities Program to develop a concurrent operations plan for any concurrent surveys identified within 50 km of Areas A, B and C. Woodside also advised that the most recent survey undertaken over or near Areas A, B and C was undertaken in 2018 and overlapped most of Area C. Woodside noted that the recovery periods for any impacts to sensitive receptors for its Petroleum Activities Program were predicted to be: • Immediately after completing seismic acquisition for migratory or transient species that may avoid the area, e.g. whales, whale sharks, turtles and pelagic fishes. • Days or weeks after completing seismic acquisition for demersal fish species, including key indicator commercial fish species that may show avoidance or behavioural reactions during the surveys. Days to months after completing seismic acquisition for plankton, based on a CSIRO modelling study.
	DPIRD provided updated finfish spawning information, based on the most current science from relevant scientists, noting that the information was also sent to WAFIC and relevant fishers.	Woodside noted DPIRD's advice.
	The Department advised that it reserved the right to update its advice to ensure it reflects any significant management or environmental changes that occurs.	Woodside noted DPIRD's advice.
Commonwealth Fisheries		
North West Slope and Trawl and Western Deepwater Trawl Fisheries	No response received.	While the fisheries overlap the proposed Operational Areas no fishing effort occurs within or nearby Areas A, B or C (Patterson et al., 2018, 2017, 2016, 2015; Woodhams et al., 2014, 2012) Based on this, Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
State Fisheries		

Stakeholder	Stakeholder feedback	Woodside response
Pearl Oyster Managed Fishery	No response received.	Consultation information sheet, and map provided and bespoke information on potential fisheries impacts and mitigation and management strategies provided. Due to the water depth, fishing method limitations, distance offshore and distance from popular fishing sports the Pearl Oyster Managed Fishery is not expected to fish within Areas A, B and C. Current catch and effort data (2013-2017) confirms no catch or effort (DPIRD). Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Pilbara Demersal Scalefish Managed Fisheries	No response received.	Consultation information sheet, and map provided and bespoke information on potential fisheries impacts and mitigation and management strategies provided. Invitation sent for a face-to-face or phone meeting with Pilbara Line holders to discuss the activity and seek feedback, and further additional information including spawning impacts and previous seismic activity provided for feedback. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
West Australian Mackerel Managed Fishery	No response received.	Consultation information sheet, and map provided and bespoke information on potential fisheries impacts and mitigation and management strategies provided. Further additional information including spawning impacts and previous seismic activity provided for feedback. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Industry		
AWE, BHP Billiton, Chevron, Santos, Western Gas	No feedback received	Consultation information sheet and bespoke maps provided. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Industry representation organisations		
APPEA	No feedback received	Consultation information sheet including map provided. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
	On 15 May 2019 WAFIC emailed Woodside and provided the following feedback on a PowerPoint presentation emailed to WAFIC on 18 April 2019:	On 22 May Woodside emailed WAFIC providing responses to its feedback of 15 May 2019:

Stakeholder	Stakeholder feedback	Woodside response
Western Australian Fishing Industry Council	WAFIC drew Woodside's attention to a possible typographical error in its slide pack.	Woodside advised that the material presented was correct.
	WAFIC expected Woodside to liaise with affected commercial fishers and schedule seismic activities to ensure absolute minimal disruption to commercial fishing activities and consideration of fish spawning and aggregation.	Woodside confirmed that consultation with potentially affected fishers would continue during planning for the activity, noting that there had been no interactions with commercial fishers over the survey areas for previous surveys. Woodside also acknowledged that final timing of the survey would take account of stakeholder feedback, as well as other considerations including marine fauna movements, vessel availability, weather and community impacts. Woodside also advised that communication protocols will be in place, including a 24-hour look-ahead of seismic vessel location, to further minimise disruption to commercial fishing activities.
	WAFIC noted the total survey time for Areas A and C being 98 days of acquisition. WAFIC looked forward to seeing the schedule to ensure key fishing activities across multiple sites and key spawning areas were not impacted.	Woodside confirmed it would share details of the survey schedule with WAFIC and relevant commercial fishers as it firmed up. Woodside also referred WAFIC to Slide 10 of an attached presentation with reference to fish spawning.
	WAFIC raised the following expectations: • No recreational fishing from support or commercial vessels. • Support vessels to divert around active commercial fishing activity and remain clear of underwater fishing gear. • Support vessels to avoid close and or disruptive engagement with any commercial fishing activity. • Support vessels in the vicinity of a commercial fishing vessel to do their utmost not to create an ocean disturbance, risking disruption to schooling fish. Woodside has a clear communication policy and process with all staff and vessel crew, contractors and subcontractors to ensure all points raised and agreed to in the EP are communicated down the line.	Woodside confirmed all of these policies for its seismic operations.
	WAFIC indicated that most of the Mackerel Area 2, Pilbara Trap and Pilbara Line fishers identified by Woodside as potentially affected were not Perth based and suggested that personal meetings such as at the Whaleshark Festival in Exmouth may be an opportunity to meet with local fishers. WAFIC also indicated it offered a fee-for-service to facilitate direct fisher contact.	Woodside confirmed it would contact relevant Pilbara Trap and Pilbara Line licence holders to see if they would like a personal meeting. For Mackerel Area 2 licence holders, Woodside sought from WAFIC advice on how best to obtain contact information (other than postal addresses) for relevant licence holders. In the interest of avoiding stakeholder fatigue, Woodside sought advice from WAFIC on which particular licence holders should be prioritised.

Stakeholder	Stakeholder feedback	Woodside response
	WAFIC sought more information from Woodside on survey scheduling, noting that planned survey timing of November to April overlapped with peak spawning for Red Emperor and Ruby Snapper. WAFIC supported Woodside conducting the deep water Area B survey during this period. WAFIC also sought clarity on Woodside's calculation for spatial spawning overlap for red emperor and ruby snapper.	Woodside advised that based on current planning the survey activity may occur in a period between November to May in Areas A and C, and January to July in Area B. This will be reflected in the EP to be submitted for public comment. Woodside provided maps to demonstrate how it calculated the spatial spawning overlap for red emperor and ruby snapper within the Pilbara component of the North Coast Bioregion. Woodside advised that the overlap was conservatively calculated using the full extent of the proposed Operational Areas. It also advised that the currently accepted published thresholds for potential injury to fish eggs and larvae (207 dB re 1 µPa (PK) and 210 dB re 1 µPa2·s (SEL24h)) (Popper et al., 2014) were derived from a study that demonstrated no damage to fish eggs and larvae at these received levels. Woodside noted that modelling conducted for this activity adopted these precautionary no effect thresholds for potential injury to fish eggs and larvae which extend out to 110–130 m from the seismic source. Therefore, any potential impacts to fish eggs and larvae would be much more localised around the seismic source. In addition, Woodside advised there would only be a relatively short survey duration within these areas of spatial overlap. Given the very short ranges to conservatively assigned thresholds, the small extent of spatial overlap with the identified depth ranges for the key indicator species and the short duration of any potential impacts, Woodside considered it highly unlikely that the proposed activity will cause any significant impacts to spawning and recruitment in any key commercial fish species.
	WAFIC stated that scheduling around fishing activity needed to be considered in addition to start and end of survey notifications, to reduce vessel interaction risks.	Woodside acknowledged WAFIC's feedback and confirmed its commitment to consult potentially affected fishers while planning and conducting the activity.
	WAFIC commented that it had experienced a surge in consultation activities by industry over the past six to 12 months for proposed seismic activities, with Woodside and NOPSEMA unaware of these activities until EPs were lodged for acceptance. These surveys overlapped Mackerel, Pilbara Trap and Pilbara Line fisheries, with WAFIC expressing concern for cumulative impacts on fisheries, not just the survey site. WAFIC claimed this was a major flaw in the EP approval system.	Woodside advised that cumulative impacts on potential concurrent and past marine seismic surveys had been detailed in the EP.
	WAFIC expressed its requirement for a 'make good' process, where proponents cannot address potential impacts to commercial fishing activities and the commercial fishing resource to ALARP levels.	Woodside confirmed the EP for this activity demonstrated an acceptable level of potential impacts to commercial fishing activities and resource, and that these potential impacts would be managed to ALARP levels. Accordingly, Woodside is not proposing for the EP to include a formal 'make good' process.

Stakeholder	Stakeholder feedback	Woodside response
	WAFIC confirmed that its responses in relation to the 4D surveys can be included in full in the EP, with no areas of communication needing to be redacted.	Woodside noted WAFIC's feedback and advised that current advice from NOPSEMA was that the full text of stakeholder correspondence was to be included in the sensitive information section of the EP. Woodside thanked WAFIC for confirming its willingness for its responses to be included.
Commonwealth Fisheries Association	On 14 May 2019 CFA advised via phone that oil and gas industry consultation was adequate in response to a Woodside phone call to assess Commonwealth fishery satisfaction with consultation activities for the proposed activity. CFA also advised Woodside it was not the representative organisation for the North West Slope Trawl and Western Deepwater Trawl fisheries and referred Woodside to the Small Pelagic Fishery Association.	On 14 May 2019 Woodside contacted the Small Pelagic Fishery Association seeking guidance on consultation with the North West Slope Trawl and Western Deepwater Trawl fisheries.
Small Pelagic Fishery Association	On 22 May the Small Pelagic Fishery Association advised Woodside it was not the representative organisation for the North West Slope Trawl and Western Deepwater Trawl fisheries.	On 17 May 2019 Woodside contacted AFMA to seek contact details for licence holders in the North West Slope Trawl and Western Deepwater Trawl fisheries.
Recfishwest	On 17 July 2019 Recfishwest emailed to advise likely charter operators who may be active in Area C.	Consultation information sheet including map provided. Engagement with Recfishwest to identify relevant charter operators. Direct consultation with relevant fishing charter operators. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Other Stakeholders		
Cape Conservation Group	On 2 April 2019 CCG emailed Woodside seeking more detail on potential environmental impacts from the survey in Area C. It sought information about timeframes, mitigation measures for whales, whale sharks and turtles, noise modelling and levels within the Ningaloo World Heritage Area, subsea features such as canyons and flow features, concurrent surveys by other operators and AMSA Ningaloo shipping restrictions for support vessels.	On 15 April Woodside emailed CCG seeking clarification on its question regarding AMSA Ningaloo shipping restrictions for support vessels. On 15 May 2019 Woodside emailed the CCG responses to its questions, including information about potential impacts of acoustic emissions on the ecological and social values of the Ningaloo Marine Park. The information also provided a breakdown of vessel sizes.
	On 2 May 2019 CCG emailed Woodside asking for a break down if there are differences between large and small support vessels, and their definitions.	
	CCG also asked for a copy of the draft EP for review.	On 31 May 2019 Woodside emailed the CCG advising it would not be providing a draft version of the EP as the EP would be available for viewing and comment under new transparency arrangements. Woodside offered to provide additional information if there were areas of specific interest to the CCG.

Stakeholder	Stakeholder feedback	Woodside response
	On 6 August 2019 CCG emailed asking when the surveys would take place, and expressing interest in understanding sights of whale and whale sharks. Request to be updated when the EP is available on the NOPSEMA website.	On 7 August 2019 Woodside emailed the CGG noting timing was still be confirmed and provided a link and details of the NOPSEMA public comment process.
Exmouth Game Fishing Club	During conversations with the Game Fishing Club on 8 March and 28 August 2019, the Club requested Woodside try to avoid seismic campaign during GAMEX. It also provided advice on fishing competition timing and active fishing days.	Woodside has committed to not acquire seismic data in Area C during GAMEX fishing days.
Exmouth Community Reference Group	At the Community Reference Group meeting on 7 March 2019 a query was raised regarding the proposed timing for the seismic activity in Area C.	Woodside advised the timing was proposed in Q1 2020 and the aim was to avoid GAMEX.
Fishing Charter Operators	No feedback received	Consultation information sheet including map provided. Engagement also carried out with Recfishwest and the Exmouth Game Fishing Club. Information sheet also posted on the Community Noticeboard in Exmouth town. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Exmouth Chamber of Commerce and Industry	On 8 March 2019 the Chamber noted the activity and recommended Woodside avoid timing with GAMEX.	Woodside has committed to not acquire seismic data in Area C during GAMEX fishing days.
Shire of Exmouth	On 8 March 2019 the Chamber noted the activity and recommended Woodside avoid timing with GAMEX.	Woodside has committed to not acquire seismic data in Area C during GAMEX fishing days.
Broader Exmouth community	No feedback received	Consultation information sheet on the oil and gas noticeboard in Exmouth. Woodside contact details provided should the community have questions. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Pendoley Environmental	On 29 October 2019, Pendoley Environmental agreed, the location of the six proposed 4D seismic surveys are highly unlikely to host inter-nesting flatback turtles from the Montebellos and do not represent important inter-nesting habitat. Flatback turtles are known to spend their inter-nesting time resting on the seabed, the areas described are too deep to support this behaviour (>73 m).	On 29 October 2019, Woodside emailed Pendoley Environmental seeking, based on two of their publications, confirmation that the deep-waters of the Pluto acquisition area (73–1185 m) and Harmony acquisition area (73–475 m) are highly unlikely to represent "important internesting habitat" for flatbacks.

Stakeholder	Stakeholder feedback	Woodside response
Wilderness Society	No feedback received	Consultation information sheet including map provided. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
WWF	No feedback received	Consultation information sheet including map provided. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.
Australian Conservation Foundation	No feedback received	Consultation information sheet including map provided. Woodside considers the level of consultation to be adequate and commits to ongoing consultation.

5.7 Ongoing Stakeholder Consultation

Woodside is committed to the engagements detailed in **Section 6.6.1** and **Section 7.8.2.2** based on stakeholder feedback.

6. ENVIRONMENTAL RISK ASSESSMENT, PERFORMANCE OUTCOMES, STANDARDS AND MEASUREMENT CRITERIA

6.1 Overview

This section presents the risk analysis, risk evaluation and environment performance outcomes, environmental performance standards and measurement criteria for the Petroleum Activities Program, using the methodology described in **Section 2.5** of the EP.

6.2 Risk Analysis and Evaluation

As required by Regulations 13(5) and 13(6) of the Environment Regulations, the analysis and evaluation demonstrate that the identified risks and impacts associated with the Petroleum Activities Program are reduced to ALARP, are of an acceptable level and consider all operations of the activity, including potential emergency conditions.

The risks and impacts identified during the ENVID (including decision type, current risk level, acceptability of risk and tools used to demonstrate acceptability and ALARP) have been divided into two broad categories:

- planned (routine and non-routine) activities – impacts
- unplanned events (accidents, incidents or emergency situations) – risks.

Within these categories, impact assessment groupings are based on stressor type (e.g. emissions, physical presence, etc). In all cases, the worst credible consequence was assumed.

The ENVID identified seven sources of impacts and eight sources of unplanned risk associated with the Petroleum Activities Program. A summary of the planned impacts and unplanned risks is provided in **Table 6-1**.

The risk analysis and evaluation for the Petroleum Activities Program indicate that all of the current environmental risks and impacts associated with the activity are reduced to ALARP and are of an acceptable level, as discussed further in **Sections 6.6** and **6.7**.

6.2.1 Cumulative Impacts

Woodside has assessed the cumulative impacts of the Petroleum Activities Program in relation to other relevant petroleum activities which could realistically result in overlapping temporal and spatial extents. The potential cumulative impact of concurrent seismic activities is assessed in **Section 6.6.3**.

Table 6-1: Environmental risk analysis and summary

Aspect	EP Section	Current Risk Rating				Acceptability of Impact/Risk
		Consequence	Residual Impact/Risk Level (ALARP Controls in Place)	Likelihood[6]	Current Risk Rating [7]	
Planned Activities (Routine and Non-routine)						
Physical Presence: Disturbance to Other Users	**6.6.1**	E	Social and Cultural – Slight, short-term impact (<1 year) to a community or areas/items of cultural significance.	-	-	Broadly acceptable
Routine Acoustic Emissions: Vessel and Mechanical Equipment Operations	**6.6.2**	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors.	-	-	Broadly acceptable
Routine Acoustic Emissions: Seismic Survey Equipment	**6.6.3**	E	Environment – slight, short term local impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	-	-	Acceptable
Routine Atmospheric Emissions: Fuel Combustion	**6.6.4**	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors (e.g. air quality).	-	-	Broadly acceptable
Routine Light Emissions: External Lighting on Project Vessels	**6.6.5**	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors (e.g. species).	-	-	Broadly acceptable
Routine Discharges: Bilge Water, Grey Water, Sewage, Putrescible Wastes and Deck Drainage Water	**6.6.6**	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors (e.g. water quality).	-	-	Broadly acceptable
Unplanned Activities (Accidents/Incidents)						
Accidental Hydrocarbon Release: Vessel Collision	**6.7.2**	C	Environment – Moderate, medium term impact (2–10 years) on ecosystems, species, habitat or physical or biological attributes.	0	M	Acceptable
Accidental Hydrocarbon Release: Bunkering	**6.7.3**	E	Environment – slight, short term local impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	1	L	Broadly acceptable
Unplanned Discharge: Deck Spills	**6.7.4**	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors (e.g. water quality).	2	L	Broadly acceptable
Unplanned Discharge: Loss of Hazardous or Non-Hazardous Waste	**6.7.5**	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors (e.g. water quality).	1	L	Broadly acceptable
Physical Presence: Vessel Collision with Marine Fauna	**6.7.6**	E	Environment – slight, short term local impact (<1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes.	1	L	Broadly acceptable
Physical Presence: Loss or Grounding of Equipment	**6.7.7**	F	Environment – No lasting effect (<1 month). Localised impact not significant to environmental receptors (e.g. benthic habitats).	1	L	Broadly acceptable
Introduction of Invasive Marine Species: Ballast Water and Biofouling	**6.7.8**	D	Environment – Minor, short-term impact (1–2 years) on species, habitat (but not affecting ecosystems function), physical or biological attributes	0	L	Broadly acceptable

[6] Likelihood rating given to unplanned activities (risk) and not to planned activities (impacts)

[7] Current risk rating, given to unplanned activities (risk) and not to planned activities (impacts)

6.3 Environmental Performance Outcomes, Standards and Measurement Criteria

Regulation 13(7) of the Environment Regulations requires that an EP includes environmental performance outcomes, environmental performance standards and measurement criteria that address legislative and other controls to manage the environmental risks of the activity to ALARP and Acceptable levels.

EPOs, EPSs and MCs for the Petroleum Activities Program have been identified to allow the measurement of Woodside's environmental performance and the implementation of this EP, to determine whether the EPOs and EPSs have been met.

The EPOs, EPSs and MCs specified are consistent with legislative requirements and Woodside's standards and procedures. They have been developed based on the Codes and Standards, Good Industry Practices and Professional Judgement outlined in **Section 2**, as part of the acceptability and ALARP justification process.

The EPOs, EPSs and MCs are presented throughout this section and in **Appendix D**. A breach of these environmental performance outcomes or standards constitutes a 'Recordable Incident' under the Environment Regulations (refer to **Section 7.10**).

6.4 Presentation

The risk analysis and evaluation (ALARP and acceptability), environmental performance outcomes, standards and measurement criteria are presented in the following tabular form throughout this section. Italicised text in the following example denotes the purpose of each part of the table with reference to the relevant sections of the Regulations and/or this EP.

<table>
<tr><td colspan="15">Context
Description of the context for the impact/risk. Regulation 13(1, 13(2) and 13(3)</td></tr>
<tr><td colspan="4">Description of the Activity – Regulation 13(1)</td><td colspan="6">Description of the Environment – Regulations 13(2)(3)</td><td colspan="5">Consultation – Regulation 11A</td></tr>
<tr><td colspan="15">Impacts and Risks Evaluation Summary
Summary of ENVID outcomes</td></tr>
<tr><td rowspan="2">Source of Risk
Regulation 13(1)</td><td colspan="7">Environmental Value Potentially Impacted
Regulations 13(2)(3)</td><td colspan="7">Evaluation
Sections 6.6 and 6.7</td></tr>
<tr><td>Soil and Groundwater</td><td>Marine Sediment</td><td>Water Quality</td><td>Air Quality (incl. Odour)</td><td>Ecosystems/Habitat</td><td>Species</td><td>Socio-Economic</td><td>Decision Type</td><td>Consequence/Impact</td><td>Likelihood</td><td>Risk Rating</td><td>ALARP Tools</td><td>Acceptability</td><td>Outcome</td></tr>
<tr><td>Summary of source of risk/impact</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="15">Description of Source of Risk or Impact</td></tr>
<tr><td colspan="15">Description of the identified risk/impact including sources or threats that may lead to the impact/risk or identified event. Regulation 13(1).</td></tr>
<tr><td colspan="15">Impact Assessment</td></tr>
<tr><td colspan="15">Discussion and assessment of the potential impacts to the identified environment value(s). Regulations 13(5)(6).
Description of potential impacts to environmental values aligned to Woodside Risk Matrix consequence descriptors.</td></tr>
</table>

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[8]	***Benefit in Impact/Risk Reduction***[9]	***Proportionality***	***Control Adopted***
ALARP Tool Used – Section 2.7.1				
Summary of control considered to ensure the impacts and risks are continuously reduced to ALARP. *Regulation 13(5)(c).*	*Technical/logistical feasibility of the control.* *Cost/sacrifice required to implement the control (qualitative measure).*	*Qualitative commentary of impact/risk that could be averted/ environmental benefit gained if the cost/ sacrifice is made and the control is adopted.*	*Proportionality of cost/sacrifice versus environmental benefit. If proportionate (benefits outweigh costs) the control will be adopted. If disproportionate (costs outweigh benefits) the control will not be adopted.*	*If control is adopted: reference to Control # provided.*
ALARP Statement *Made on the basis of the environmental risk assessment outcomes, use of the relevant tools appropriate to the decision type (**Section 2.6.1**) and a proportionality assessment. Regulation 10A(b).*				

Demonstration of Acceptability
Acceptability Statement *Made on the basis of the application of the process described in **Section 2.7.1**,* **Figure 2-7***, taking into account internal and external expectations, risk to environmental thresholds and use of environment decision principles. Regulation 10A(c).*

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO # **S:** *Specific performance which addresses the legislative and other controls that manage the activity and against which performance by Woodside in protecting the environment is measured.* **M:** *Performance against the outcome is measured by measuring implementation of the controls via the measurement criteria.* **A:** *Achievability/feasibility of the outcome demonstrated via discussion of feasibility of controls in ALARP demonstration. Controls are directly linked to the outcome.* **R:** *The outcome is relevant to the source of risk and the potentially impacted environmental value.* **T:** *The outcome states the timeframe during which the outcome will apply or by which it is achieved.*	**C#** *Identified control adopted to ensure the impacts and risks are continuously reduced to ALARP.* *Regulation 13(5)(c).*	**PS#** *Statement of the performance required of a control measure. Regulation 13(7)(a).*	**MC#** *Measurement criteria for determining whether the outcomes and standards have been met. Regulation 13(7)(c).*

[8] Qualitative measure.

[9] Measured in terms of reduction of likelihood (L), consequence (C) and current risk rating (CRR).

6.5 Potential Environment Risks Not Included Within the Scope of the Environment Plan

The ENVID identified a number of environmental risks that were assessed as not being applicable (not credible) (refer to **Section 2.5**) within or outside the survey areas as a result of the Petroleum Activities Program, and therefore, were determined to not form part of this EP. These are described in the following sections for information only.

6.5.1 Grounding of Equipment

Due to the minimum depth of the Operational Areas (40 m) and the maximum depth of the towed streamer array (18 m), grounding of equipment while being towed is not deemed credible.

6.6 Planned Activities (Routine and Non-routine)

6.6.1 Physical Presence: Disturbance to Other Users

Context		
Project vessels – **Section 3.6.4**	Socio-economic environment – **Section 4.6**	Stakeholder consultation – **Section 5**

Impacts Evaluation Summary

Source of Impact	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	*Marine Sediments*	*Water Quality*	*Air Quality (incl. Odour)*	*Ecosystems/Habitats*	*Species*	*Socio-Economic*	*Decision Type*	*Consequence/ Impact*	*Likelihood*	*Risk Rating*	*ALARP Tools*	*Acceptability*	*Outcome*
Displacement of other users – proximity of project vessels interfering with or displacing third party vessels (commercial fishing, recreational fishing and commercial shipping)							X	A	E	-	-	LCS GP	Broadly Acceptable	EPO 1
Potential interference with existing oil and gas operations, i.e. fixed facilities and associated vessel movements, seismic survey activities; establishment and maintenance of SNA							X							EPO 1

Description of Source of Impact

Project vessels (seismic support and chase) will be physically present in the Operational Areas for each survey during the Petroleum Activities Program. The seismic vessel and towed array, comprising the airgun array and streamer array, which includes header buoys, starboard and port spreaders or vanes, streamers and tail buoys, are surrounded by an SNA. The SNA will extend to a radius of 500 m around the seismic vessel and towed equipment, and the support and chase vessels will be used to ensure third party vessels are prevented from approaching or entering the SNA. Similarly, if there are any concurrent seismic surveys that overlap the Operational Areas, establishing and maintaining the SNA may interfere with or displace the vessels associated with those activities.

Impact Assessment

Displacement of Commercial Fishing Activities

Areas A, B and C are located within or in close to fished areas of one Commonwealth-managed fishery and six State fisheries (**Section 4.6.3** and **Table 4-8**).

Areas A, B and C are located in water depths ranging from about 40–1380 m (LAT). Thus, most of the Operational Areas for each survey are located outside the depth range where significant fisheries effort occurs, as the waters beyond the 100 m isobath are generally not considered productive for commercial fisheries. In other words, the Operational Areas of Areas B and C are outside the 100 m isobath and 16% of Area A lies within the 60 to 100 m isobath. The fisheries that have current or recent fishing effort within or adjacent to Areas A, B and C are the North West Slope Trawl Fishery (Commonwealth-managed) and the Mackerel Managed Fishery, Pilbara Trawl Managed Fishery, Pilbara Trap Managed Fishery and Pilbara Line Fishery (State-managed). The Pilbara Trap Managed Fishery, Pilbara Line Fishery and Mackerel Managed Fishery are those fisheries identified as potentially operating in the area during the surveys and overlapping the survey areas (**Table 4-8**). The Mackerel Managed Fishery covers an area of 1,614,113 km², of which 0.8% overlaps the three Areas (0.3% in Area A, 0.3% in Area B and 0.2% in Area C). In terms of the Pilbara trap and line fisheries, of the total area in which line fishing can occur, only 1.6% lies in Area A and 0.13% in Area C; for trap fishing 2.1% lies within Area A and 0.17% within Area C. No trawl fishing lies within any of the areas. The physical presence of the project vessels and the establishment and maintenance of the SNA has the potential to interfere with the movements of vessels operating in this small overlap with these fisheries, and to displace them from areas where they would normally fish.

This short-term presence of project vessels could potentially result in a minor interference (navigational hazard) and localised displacement/avoidance by commercial fishing within the immediate vicinity. Therefore, the potential impact to commercial fishing activities is considered to be slight and short-term.

Displacement of Commercial Shipping

The presence of project vessels may cause temporary disruption to commercial shipping. Consultation with AMSA confirms that heavy vessels and support vessels are likely to be encountered in Areas A, B and C. In particular heavy vessels are likely to be encountered within Area A, the north-west corner of which partially overlaps a marine fairway (**Figure 4-19**). Areas B and C do not overlap with any of the fairways. The use of the fairways is strongly recommended by AMSA, but is not mandatory and shipping vessels still have to adhere to the International Regulations for Preventing Collisions at Sea 1972 (COLREGS).

The potential impacts could include short-term displacement of vessels as they make slight course alterations to avoid the project vessels and associated towed seismic equipment within the SNA. Therefore, the potential impact is considered to be slight and short-term.

Displacement of Recreational Fishing, Tourism Operations, Research/Monitoring Projects

Stakeholder consultation did not identify any recreational fishing, tourism operations or research/monitoring projects within or adjacent to Areas A and B. There is the potential for some recreational fishing to occur within and adjacent to Area C, particularly during game fishing tournaments conducted out of Exmouth and North West Cape (i.e. GAMEX 2020; **Section 4.6.5**). If a third party vessel associated with recreational fishing, tourism and research/monitoring activities is within the area, displacement by the program activities would be minimal, given the transient nature of the seismic activities, and relate only to establishing and maintaining the SNA around the seismic vessel and towed array. Therefore, the potential impact is considered to be slight and short-term.

Interference with Existing Oil and Gas Operations

There are two existing oil and gas production facilities located within Area A – the Pluto and Wheatstone platforms – and two within Area C – the Ngujima-Yin and Ningaloo Vision FPSOs (**Section 4.6.7**). Additionally, it is possible that a drill rig may be present within Area A when acquiring the Pluto 4D M2 and Harmony 4D M1 (Brunello field) surveys. This rig would be drilling development wells for Woodside.

Uncontrolled access by project vessels in the vicinity of the Pluto and Wheatstone platforms, Ngujima-Yin and Ningaloo Vision FPSOs, and the Woodside drill rig could increase the potential for interference with these facilities and the movements and operations of support vessels. The platforms and FPSOs are currently surrounded by a 500 m radius Petroleum Safety Zone (PSZ), and similarly a PSZ will be in place around the Woodside drill rig while it is drilling.

The Petroleum Activities Program scope does not require survey activities to be conducted within the 500 m PSZs around the platforms, FPSOs and drill rig. If project vessels are required to enter the PSZs, they will do so in accordance with a project-specific communications protocol established between the project vessels and the platforms/FPSOs/drill rig, limiting the potential for any interference.

The potential for concurrent seismic activities was identified in **Section 4.6.7** and **Table 4-10.** There are four accepted EPs covering seismic surveys that could be conducted within the same timeframe as the Petroleum Activities Program, and potentially in areas overlapping or adjacent to Areas A, B and C. Before commencing the proposed 4D surveys Woodside will consult the titleholders/proponents of these four EPs to establish whether there is any likelihood of concurrent operations, which could interfere with/displace project vessels for both parties. Concurrent seismic surveys within close proximity to each other (i.e. within tens of kilometres) are routinely managed via concurrent operations plans and time-sharing arrangements.

The potential impact is considered to be slight and short-term.

Summary of Potential Impacts to Environmental Values(s)

Given the adopted controls, it is considered that physical presence of project vessels will not result in a potential impact greater than isolated and short-term local impacts to shipping, commercial/recreational fishing, tourism or research/monitoring activities, and other seismic surveys.

Demonstration of ALARP				
Control Considered	**Control Feasibility (F) and Cost/ Sacrifice (CS)[10]**	**Benefit in Impact/Risk Reduction[11]**	**Proportionality**	**Control Adopted**
Legislation, Codes and Standards				
No controls identified.				
Good Practice				
Notify Australian Hydrographic Service (AHS) of activities and movements no less than four working weeks before the scheduled activity commencement date.	F: Yes. CS: Minimal cost. Standard practice.	Notifying AHS will enable them to generate navigation warnings (Maritime Safety Information Notifications (MSIN) and NTM (including AUSCOAST warnings where relevant)).	Benefits outweigh cost/sacrifice. Control is also Standard Practice.	Yes **C 1.1**
Notify AMSA's JRCC of activities and movements 24–48 hours before operations commence.	F: Yes. CS: Minimal cost. Standard practice.	Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interfering with other marine users.	Benefits outweigh cost/sacrifice. Control is also Standard Practice.	Yes **C 1.2**
Notify DPIRD (Western Australia) (formerly the WA DoF) of activities within three months of activity.	F: Yes. CS: Minimal cost. Standard practice.	Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interfering with other marine users.	Benefits outweigh cost/sacrifice. Control is also Standard Practice.	Yes **C 1.3**
Establish and maintain a 500 m radius SNA around the seismic vessel and towed array.	F: Yes. CS: Minimal cost. Standard practice.	Presence of the SNA will reduce the likelihood of interfering with other marine users.	Benefits outweigh cost/sacrifice.	Yes **C 1.4**
A communications protocol will be in place between the project vessels and other users (known commercial fishing vessels within the survey Operational Areas and existing oil and gas facilities or drill rigs). The communications protocol will include the aspects of: • communications • work programming • hazard management • emergency response.	F: Yes. CS: Minimal cost. Standard practice.	Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interfering with other marine users.	Benefits outweigh cost/sacrifice.	Yes **C 1.5**

[10] Qualitative measure
[11] Measured in terms of reduction of consequence (C)

Demonstration of ALARP				
Control Considered	**Control Feasibility (F) and Cost/ Sacrifice (CS)[10]**	**Benefit in Impact/Risk Reduction[11]**	**Proportionality**	**Control Adopted**
At least one dedicated chase vessel will be employed to assist seismic and support vessels.	F: Yes. CS: Minimal cost. Standard practice.	Given the legislative controls in place, use of a chase vessel will provide a small reduction in likelihood of an interaction with a third party vessel.	Benefits outweigh cost/sacrifice.	Yes **C 1.6**
Woodside will engage with proponents identified as having potential concurrent MSS or drilling activities prior to commencing the Petroleum Activities Program and will develop a concurrent operations plan for any concurrent MSS or drilling activities identified within 50 km of the Petroleum Activities Program. The concurrent operations plan will include the following aspects: • Communications • Work programming • Hazard management • Emergency response.	F: Yes. Note a separation distance of 40 km has been adopted in **Section 6.6.3** to avoid cumulative impacts from seismic noise. CS: Minimal cost. Standard practice.	Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interfering with other marine users.	Standard activity. Business as usual. No additional cost/sacrifice.	Yes **C 1.7**
Professional Judgement – Eliminate				
Limit activities to avoid peak shipping and commercial fishing activities.	F: No. Shipping occurs year-round and cannot be avoided. Simultaneous operations (SIMOPS) with fishing seasons cannot be eliminated as exact timings for all activities are not confirmed. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No
Eliminate use of vessels.	F: No. The use of vessels is required to conduct the Petroleum Activities Program. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Substitute				
No additional controls identified.				
Professional Judgement – Engineered Solution				
No additional controls identified.				

Demonstration of ALARP				
Control Considered	Control Feasibility (F) and Cost/ Sacrifice (CS)[10]	Benefit in Impact/Risk Reduction[11]	Proportionality	Control Adopted
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of the physical presence of the project vessels on other users, such as shipping, commercial fisheries, recreational fishing, tourism operations, research/monitoring projects and concurrent seismic activities. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, physical presence of the project vessels is unlikely to result in potential impact greater than localised and short-term local concern to shipping and commercial/recreational fishing, tourism operations, research/monitoring projects and concurrent seismic activities. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet expectations of AMSA and AHS provided during consultation with stakeholders. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of physical presence of the project vessels to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 1 Marine users aware of the Petroleum Activities Program.	**C 1.1** Notify AHS of activities and movements no less than four working weeks before the scheduled activity commencement date.	**PS 1.1** Notifying AHS of activities and movements enables them to generate navigation warnings (MSIN and NTM (including AUSCOAST warnings where relevant)).	**MC 1.1.1** Consultation records demonstrate that AHS has been notified before the activity commences to allow generation of navigation warnings (MSIN and NTM (including AUSCOAST warnings where relevant)).
	C 1.2 Notify AMSA JRCC of the activities and movements 24–48 hours before operations commence.	**PS 1.2** Notifying AMSA JRCC prevents activities interfering with other marine users. AMSA's JRCC will require the vessels' details (including name, callsign and Maritime Mobile Service Identity), satellite communications details (including INMARSAT-C and satellite telephone), area of operation, requested clearance from other vessels and need to be advised when operations start and end.	**MC 1.2.1** Consultation records demonstrate that AMSA JRCC has been notified before commencing the activity within required timeframes.
	C 1.3 Notify DPIRD (Western Australia) (formally the WA DoF) within three months commencing activities.	**PS 1.3** Notification to DPIRD to inform other marine users of the activities to reduce activities interfering with other marine users for longer than necessary.	**MC 1.3.1** Consultation records demonstrate that DPIRD has been notified before commencing the Petroleum Activities Program.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	C 1.4 Establish and maintain a 500 m radius SNA around the seismic vessel and towed array.	**PS 1.4** SNA established, communicated and maintained around the seismic vessel and towed array during the Petroleum Activities Program to minimise interfering with other marine users.	**M.C 1.4.1** Records demonstrate that the SNA has been established and details have been communicated to approaching third party vessels, particularly regarding the need to avoid the area.
	C 1.5 Have a communications protocol in place between the project vessels and other users (known commercial fishing vessels and existing oil and gas facilities or drill rigs), within the survey operational areas. The communications protocol will include the aspects of: • communications • work programming • hazard management • emergency response.	**PS 1.5** Communications protocol developed for the project vessels and known commercial fishing vessels to actively manage concurrent activities.	**MC 1.5.1** Records demonstrate the communications protocol is implemented throughout the Petroleum Activities Program. **MC 1.5.2** Records demonstrate the communications protocol has been developed and distributed to known commercial fishing stakeholders prior to survey mobilisation.
	C 1.6 Employ at least one dedicated chase vessel to assist seismic and support vessels.	**PS 1.6** One dedicated chase vessel to assist the seismic and support vessels to mitigate interference associated with concurrent seismic and third party vessel operations.	**MC 1.6.1** Records demonstrate that a dedicated chase vessel is employed for the Petroleum Activities Program. **MC 1.6.2** Daily Reports demonstrate that at least one chase vessel or support vessel was present to mitigate interference associated with concurrent seismic and third party operations (unless absent for emergency activities).

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	C 1.7 Engage with proponents identified as having potential concurrent MSS or drilling activities before commencing the Petroleum Activities Program and develop a concurrent operations plan for any concurrent MSS or drilling activities identified within 50 km of the Petroleum Activities Program. The concurrent operations plan will include the aspects of: • communications • work programming • hazard management • emergency response.	**PS 1.7** A concurrent operations plan will be developed for any concurrent MSS or drilling activities identified within 50 km of the Petroleum Activities Program.	**MC 1.7.1** Records demonstrate Woodside has re-engaged with identified proponents before commencing the Petroleum Activities Program, and developed concurrent operations plan.

6.6.2 Routine Acoustic Emissions: Vessel, Helicopters and Mechanical Equipment Operation

Context		
Project vessels – **Section 3.6.4** Helicopters – **Section 3.6.5**	Biological environment – **Section 4.5**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary

Source of Impact	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	*Marine Sediments*	*Water Quality*	*Air Quality (incl. Odour)*	*Ecosystems/Habitats*	*Species*	*Socio-Economic*	*Decision Type*	*Consequence/Impact*	*Likelihood*	*Current Risk Rating*	*ALARP Tools*	*Acceptability*	*Outcome*
Generation of noise from project vessels and mechanical equipment during normal operations (excluding seismic survey equipment)						X		A	F	-	-	LCS GP	Broadly Acceptable	EPO 2

Description of Source of Impact

During the Petroleum Activities Program both atmospheric and underwater noise will be generated from the seismic, support and chase vessels, helicopters and mechanical equipment during normal operations. Studies of underwater noise associated with petroleum operations have generally reported that the main source of noise relates to using thrusters to maintain vessel position.

The sound level and frequency characteristics ('signature') of discernible ships depend on their size, number of propellers, number and type of propeller blades, blade biofouling condition and machinery/transmission maintenance condition. In general, the larger the ship the louder the source level and the lower its frequency.

A typical supply vessel's peak frequency or band ranges from 1–500 Hz at a peak source level of 170-190 dB re 1 µPa at 1 m. It is expected that similar noise levels will be generated by vessels used for this Petroleum Activities Program.

Helicopter engines and rotor blades are recognised as a source of noise emissions, which may constitute a source of environmental risk resulting in behavioural disturbance to marine fauna. Activities relevant to the Operational Areas will relate to helicopters landing and taking off from the vessel helidecks. Helicopter flights are at their lowest (i.e. closest point to the sea surface) during these periods of take-off and landing from helidecks, which constitutes a relatively short phase of routine flight operations. During these critical stages of helicopter operations, safety takes precedence.

Noise levels for typical helicopters used in offshore operations (Eurocopter Super Puma AS332) at 150 m separation distance have been measured at up to a maximum of 90.6 dB (BMT Asia Pacific, 2005). Unconstrained point source noise in the atmosphere (such as helicopter noise) spreads spherically (Truax, 1978), with noise received at the sea surface decreasing with increasing distance from the aircraft (Nowacek et al., 2007). Based on spherical geometric spreading (and not considering transmission loss from atmospheric absorption), the sound level is expected to decrease by 6 dB for every doubling of the distance from the source (Truax, 1978). Using this model, a maximum sound level of about 90 dB at 150 m would be reduced to about 76 dB directly below a helicopter travelling at an altitude of 500 m.

Impact Assessment

Elevated underwater noise can affect marine fauna, including cetaceans, in three main ways (Richardson et al., 1995; Simmonds et al., 2004):

1. By causing direct physical effects on hearing or other organs (injury).
2. By masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey).
3. Through disturbance leading to behavioural changes or displacement from important areas.

Permanent injury would be expected to occur at 230 dB re 1 µPa (peak) (Southall et al., 2007) for cetaceans. Noise generated by vessels likely to be used for this Petroleum Activities Program does not exceed that level so permanent or temporary injury to protected migratory whale species is not anticipated.

Water has a very high acoustic impedance contrast compared to air, and the sea surface is a strong reflector of noise energy (i.e. very little noise energy generated above the sea surface crosses into and propagates below the sea surface (and vice versa) – the majority of the noise energy is reflected). The angle at which the sound path meets the surface influences the transmission of noise energy from the atmosphere through the sea surface; angles ±>13° from vertical being almost entirely reflected (Richardson et al., 1995). Given this, and the typical characteristics of helicopter flights within the Operational Areas (duration, frequency, altitude and air speed), the opportunity for underwater noise levels that may result in behavioural disturbance are not considered to be credible. Note that helicopter noise during approach, landing and take-off is more likely to propagate through the sea surface due to the reduced air speed and lower altitude. Approach, landing and take-off are relatively short phases of the flight, resulting in little opportunity to generate underwater noise.

Areas A, B and C are located in water depths ranging from approximately 40 m to 1380 m. The fauna associated with these areas will be predominantly pelagic species of fish with the potential for the transient presence of other megafauna species such as turtles, whale sharks and large whales passing through the areas (**Section 4.5.2**). The Petroleum Activities Program will overlap temporally with the end of the seasonal southbound migration of pygmy blue whales (see **Table 4-5** for details on seasonality) for the NWMR. Surveys acquired at the end of the Petroleum Activities Program may also overlap temporally with the start of the northbound migration of pygmy blue whales through the region. Areas A and C overlap spatially with the pygmy blue whale migration BIA; however, there is no overlap between Area B and the migration BIA (**Figure 4-11**). Additionally, Area C has a very small overlap with the 'Possible Foraging BIA' adjacent to Ningaloo Reef/North West Cape (**Figure 4-11**).

Area C partially overlaps the humpback whale migration BIA in the area north of North West Cape and Exmouth Gulf **(Figure 4-12**). However, the surveys that will take place outside the humpback whale northbound and southbound migratory seasons are listed in **Table 4-5**.

The Petroleum Activities Program will overlap temporally with the peak nesting season for green, flatback and loggerhead turtles in the NWMR (see **Table 4-5** for details on seasonality). Area A overlaps spatially with the flatback turtle 'habitat critical' ('habitat critical' – 60 km internesting buffer) (**Table 4-6**). Area C also overlaps partially with the 'habitat critical' for loggerhead and green turtles around Exmouth Gulf and the Ningaloo Coast (20 km nesting buffer).

Areas A and C partially overlap the whale shark foraging BIA that extends north from North West Cape across the NWS (**Figure 4-15**). Surveys acquired at the end of the Petroleum Activities Program may also overlap temporally with the peak of annual whale shark aggregation at Ningaloo Reef (**Table 4-5**).

The Petroleum Activities Program is scheduled to commence in late December 2019, at the tail end of the pygmy blue whale southbound migration (**Section 4.5.2.5** and **Table 4-5**) within the NWMR. Noise logger data (as presented in **Section 4.5.2**) shows a peak at the end of November and rapidly declining numbers of individuals transiting the NWS from the beginning of December. Exposure of pygmy blue whales to noise emission levels that have the potential to cause injury or behavioural impacts is considered very low. This is because noise emission thresholds for such impacts are not reached by vessels and mechanical equipment and there is only a short period of the activity that overlaps with when pygmy blue whales may be encountered, and given numbers of pygmy blue whales are predicted to be low.

Areas A and C have a small spatial overlap with the green, flatback and loggerhead turtle 'habitat critical' internesting buffer zones (see above) and the timing of the Petroleum Activities Program is over the peak season for green, flatback and loggerhead turtle nesting (on beaches located 20-40 km away, refer to **Section 4.5.2**). Scientific literature and expert opinion on the turtle internesting range and patterns, however, show it is highly unlikely for significant numbers of turtles to be encountered within the offshore Areas A, B and C. Therefore, the potential for noise emissions exposure and subsequent impacts to turtles is extremely low to negligible.

Given the standard flight profile of a helicopter transfer, maintaining a >500 m vertical separation from cetaceans (as per the EPBC Regulations), and the predominantly seasonal presence of whales within the Operational Areas, interactions between helicopters and cetaceans resulting in behavioural impacts are considered to be highly unlikely. In the highly unlikely event that cetaceans are disturbed by helicopters, impacts are expected to consist of short-term behavioural responses such as increased swimming speed; the consequence of such disturbance is considered to have no lasting effect and be of no significance.

It is reasonable to expect that cetaceans may demonstrate avoidance or attraction behaviour to the normal operational noise generated by the Petroleum Activities Program. When migrating through the area cetaceans may exhibit no behavioural responses, or may deviate short distances around project vessels, but continue on their migration pathway. Hence, any avoidance or attraction behaviours displayed are expected to be localised and temporary, based on the limited duration of each survey (ranging from 11–45 days). Predicted noise levels are not considered to be ecologically significant at a population level and the potential impacts are considered to be localised with no lasting effect (as described below).

Summary of Potential Impacts to Environmental Values(s)
Given the adopted controls, it is considered that vessel and machinery noise will not result in a potential impact greater than localised and temporary disruption to a small proportion of the population for any transient megafauna species exposed to noise emissions from vessels or mechanical equipment, with no lasting effect. No impact on critical habitat or activity is anticipated.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[12]	***Benefit in Impact/ Risk Reduction***[13]	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Apply EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans including the following measures: • Project vessels will not travel greater than six knots within 300 m of a cetacean or turtle (caution zone) and not approach closer than 100 m from a whale. • Project vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow riding). • If the cetacean or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than six knots. • Vessels will not travel greater than eight knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark. ***Exception***: The above requirement does not apply to project vessels operating under limited/constrained manoeuvrability including seismic vessels towing equipment and acquiring data, and in an emergency.	F: Yes. CS: Minimal reduction in vessel speed and manoeuvrability resulting in minimal delay.	By managing the interactions with cetaceans and restricting the proximity between vessels an cetaceans, impacts from vessel-generated noise are reduced.	Control is a legislative requirement – must be adopted.	Yes **C 2.1**
Good Practice				
No additional controls identified.				

[12] Qualitative measure
[13] Measured in terms of reduction of consequence (C)

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[12]***	***Benefit in Impact/ Risk Reduction[13]***	***Proportionality***	***Control Adopted***
Professional Judgement – Eliminate				
Eliminate generation of noise from vessels.	F: No. Noise from project vessels cannot be eliminated due to operating requirements. CS: Inability to conduct the Petroleum Activities Program. Loss of project.	Not considered – control not feasible.	Not considered – control not feasible.	No
Conduct the Petroleum Activities Program away from sensitive receptors.	F: No. The location of the Petroleum Activities Program is determined by the predicted location of hydrocarbons and the legislative requirement to explore for hydrocarbons. CS: Requirement to conduct activity.	Not considered – control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Substitute				
No additional controls identified.				
Professional Judgement – Engineered Solution				
No additional controls identified.				
Risk Based Analysis				
N/A.				
Company Values				
N/A.				
Societal Values				
N/A.				
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of project vessel noise emissions. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, project vessel noise disturbance is unlikely to result in a potential impact greater than localised and temporary disruption to a small proportion of the population, with no lasting effects, and no impact on critical habitat or activity. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet the requirements of Part 8 (Division 8.1) of the EPBC Regulations 2000. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of vessel noise emissions to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 2 Minimise impacts of noise generated from the Petroleum Activities Program[14] on Threatened and Migratory cetacean species listed under the EPBC Act in the Operational Areas.	**C 2.1** Apply EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans including the following measures: • Project vessels will not travel greater than six knots within 300 m of a cetacean or turtle (caution zone) and not approach closer than 100 m from a whale. • Project vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow riding). • If the cetacean or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than six knots. • Vessels will not travel greater than eight knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark. ***Exception***: The above requirement does not apply to project vessels operating under limited/constrained manoeuvrability including but not limited to seismic vessel towing equipment and acquiring data, and in the event of an emergency.	**PS 2.1** Compliance with EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans, to minimise impacts from underwater noise emissions.	**MC 2.1.1** Records demonstrate compliance with the EPBC Regulations 2000 (Part 8 Division 8.1). **MC 2.1.2** A copy of Vessel Masters' signed declaration that they have read and understood the requirements of EPBC regulations.

[14] This Outcome and associated Control and Standard do not apply to vessels operating under limited/constrained manoeuvrability – e.g. seismic vessel towing equipment and acquiring data, support vessels loading/back-loading/bunkering with the seismic vessel, and emergency situations.

6.6.3 Routine Acoustic Emissions: Seismic Survey Equipment

Context		
Seismic source – **Section 3.6.2**	Biological environment – **Section 4.5** Socio-economic environment – **Section 4.6**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary

Source of Impact	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	***Marine Sediments***	***Water Quality***	***Air Quality (include Odour)***	***Ecosystems/Habitats***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence***	***Likelihood***	***Current Risk Rating***	***ALARP Tools***	***Acceptability***	***Outcome***
Generation of noise from seismic survey equipment					X	X	X	B	E			LCS GP	Acceptable	EPO 3

Description of Source of Impact

The Petroleum Activities Program will use a seismic source, consisting of an airgun array with a maximum capacity of 3150 in^3, towed at a water depth of 6–8 m. The source will be used to generate acoustic pulses by periodically discharging compressed air into the water column, typically at intervals of about six to ten seconds as the vessel transits along planned survey lines within the Acquisition Area for each survey.

While seismic data will be acquired within the Acquisition Areas for each survey, the seismic source may be discharged up to full capacity (power) within an approximately 4 km extension buffer at the line start and end points of each Acquisition Area for the purpose of run-ins, run-outs and soft starts (see **Table 3-4** for line orientations for each survey). The seismic source will not be discharged outside of this approximate 4 km buffer within the Operational Area. Source testing (i.e. bubble tests) will occur within Acquisition Areas. The Acquisition Area and Operational Area for each survey are described further in **Section 3.4.4** and presented in **Figure 3-1** and **Figure 3-2**.

The 3150 in^3 and 2650 in^3 seismic sources produce far-field source levels up to a maximum of 255 dB re 1 μPa^2m^2 (PK) and per-pulse source SEL of 229–230 dB re 1 μPa^2m^2s (at 0–2000 Hz) directly beneath the array. Though the aim of a seismic survey is to direct the seismic sound energy downwards towards the seafloor, energy will also radiate at angles close to horizontal, potentially propagating this sound energy over long distances (Laws and Hedgeland, 2008).

Impact Assessment

Background

Elevated underwater noise can affect marine fauna, including marine mammals (cetaceans, dugong), turtles and fishes in three main ways (Richardson et al., 1995; Simmonds et al., 2004):

1. By causing direct physical effects on hearing or other organs. Hearing loss may be temporary (temporary threshold shift – TTS), or permanent (PTS), with PTS considered to represent injury (refer **Table 6-2**).
2. Through disturbance leading to behavioural changes or displacement from important areas. The occurrence and intensity of disturbance is highly variable and depends on a range of factors relating to the animal and situation.
3. By masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey).

The area over which seismic sound may adversely impact marine species depends upon multiple factors including the extent of sound propagation relative to the location of receptors, and the sensitivity and range of spectral hearing of different species (Slabbekoorn et al., 2010; Popper and Hawkins, 2012).

Table 6-2: Description of potential impacts of seismic noise on marine fauna

Potential impact	Description
Permanent Threshold Shift in Hearing (PTS)	PTS is considered a change to hearing sensitivity from which marine fauna do not recover (permanent hair cell or receptor damage). PTS is considered injurious in marine mammals. There is no published data on the sound levels that cause PTS in marine mammals. Hence, PTS effects in marine mammals should be viewed as theoretical, as they have never actually been demonstrated in either captive or wild animals. Impact assessment evaluates dual metric criterion requiring consideration of both PK and accumulated SEL thresholds assigned to PTS. Southall et al. (2007) published the first scientific recommendations for marine mammal noise exposure criteria, which explicitly states, "*we define the minimum exposure criterion for injury as the level at which a single exposure is estimated to cause onset of PTS*". That definition is reiterated within the Finneran et al. (2015) review of TTS studies where it is classified as the level necessary to induce 40 dB of TTS. Similarly during the initial revision of the marine mammal acoustic thresholds in 2013 the US National Ocean and Atmospheric Administration (NOAA) provided explicit guidance that PTS effects (not TTS) are considered auditory injury (NOAA, 2013). This position is further reiterated on the NOAA public guidance page for marine mammal acoustic thresholds (NOAA, 2019). Additionally, the classification of PTS onset as injury has also been defined by the UK Joint Nature Conservation Committee (JNCC) in 2017 as part of a public advisory note associated with assessing a wind farm impact assessment (JNCC, 2017) and an earlier public guidance document entitled, 'The Protection of Marine European Protected Species from Injury and Disturbance' (JNCC, 2010).
Temporary Threshold Shift in Hearing (TTS)	Exposure to sufficiently intense sound causing auditory fatigue has the potential to lead to a temporary reduction in hearing sensitivity in any living animal capable of perceiving acoustic stimuli. As the sound exposure increases yet further, a higher level will eventually be reached at which the threshold shift will be permanent, and the effect is called a permanent threshold shift. Unlike PTS, TTS is not classified as an injurious effect. Ward (1997) concludes that "TTS is within the normal bounds of physiological variability and tolerance and does not represent physical injury". In addition, Southall et al. (2007) indicates that the onset of tissue injury from noise exposure is considered as PTS-onset, but TTS is not considered as auditory injury because the reduced hearing sensitivity following exposure to intense sound results primarily from fatigue, not loss, of cochlear hair cells and supporting structures, and is reversible. Accordingly, the NMFS does not consider TTS to constitute auditory injury, and have explicitly stated this in recent 'Incidental Take of Marine Mammals' authorisation notices in the US Federal Register (e.g. Federal Register / Vol. 84, No. 166, August 27 2019). Kujawa and Liberman (2009, 2015) demonstrated that high levels of TTS (>40 dB) in mice and guinea pigs can cause neuron degeneration of synaptic contacts between hair cells and nerves (synaptopathic injury). These experiments have raised discussion as to whether recoverable TTS exposure has the potential to result in more permanent neurological change in other species. In other experiments, shorter or less intense noise exposures that result in smaller TTS changes do not result in synaptopathic injury or neuronal loss (Hickox 2014; Fernandez et al., 2015; Jensen et al., 2015; 2017). In other studies, 20 -30 dB TTS generally has not been associated with synaptopathic change, whereas 40 – 50 dB TTS 24 hour post exposure (2 hour continuous exposure 8 -16 kHz) clearly has been associated with synaptopathic damage (Pienkowski et al. 2018). Given PTS onset in marine mammals is conservatively set at the onset of 40 dB of TTS; the high level TTS exposures (>40 dB) in these experiments where synaptopathic injury has been observed would all be classified as a PTS level exposure marine mammals. Furthermore, the responses of mammalian ears to impulsive noise are believed to be different from those elicited by continuous noise (Henderson and Hamernik, 1986) and there is no indication to date that TTS exposure in marine mammals, resulting from impulsive noise sources, leads to similar synaptopathy.
Behavioural Responses	The context of sound exposure plays a critical and complex role in behavioural responses in marine mammals (Gomez et al., 2016). For example, different species (and different individuals or groups within a species) may respond differently to varying levels of sound depending on their behaviours and motivation at the time (e.g. foraging, socialising, resting and reproduction) and other factors such as the type of sound, duration of exposure, and the suddenness of the onset of the received sound (Gomez et al., 2016). The NMFS in the U.S use an impulsive noise criteria threshold of 160 dB re 1 µPa (SPL) for potential behavioural disturbance to marine mammals (NMFS, 2014). The threshold for behavioural response represents the level at which a moderate behavioural response may occur,

	such as changes in swimming speed, direction and dive profile; localised deviations in migratory patterns; brief to moderate shift in group distribution; short term cessation or modification of vocal behaviour. (McCauley et al., 2000; Southall et al., 2007; Tyack, 2008). Avoidance, however, is not directly related to sound level thresholds but also influenced by the state of the individuals (e.g. their reproductive, health, and foraging condition) and the context of exposure. It is considered that avoidance behaviour represents only a minor effect on either the individual or the species unless avoidance results in displacement of whales from areas of biological importance such as nursery, resting or feeding areas during an important period for the species. Higher received levels are not always associated with stronger behavioural responses and vice versa, and a clear dose-response relationship has not been identified (Southall et al., 2007). In addition, a behavioural response does not necessarily equate to a significant avoidance or deviation in cetacean movements that would actually displace individuals or the population from the wider area. Similary, proximity of the animal to the sound source, irrespective of received level has been identified as an influencing factor, with behavioural response in humpback whales being both dependent on the proximity of whale to the vessel source and also the received level (i.e. at the same received level no behavioural response was detected when the source was greater than 3 km away) (Dunlop et al. 2018).
Masking	Acoustic masking may occur when a noise impedes the ability of an animal to perceive a signal (Wood et al., 2012; Erbe et al., 2016). For this to occur the noise must be loud enough, have similar frequency content to the signal, and must happen at the same time (Wood et al., 2012). The sound generated by seismic surveys comprises brief, low frequency pulses (in the order of tens of milliseconds), occurring several seconds apart. At great distances from the seismic source, sound levels will be quieter, but transmission of the sound via multiple pathways (water, seabed) and reverberation mean that the pulse duration increases and can be greater than 1 second in length. However, given the short pulse duration relative to the duration of marine mammal vocalisations (several seconds to several minutes or longer), marine mammals are likely to be able to detect calls in between seismic pulses, despite some acoustic features of these vocalisations potentially being obscured (Wood et al., 2012). The short, intermittent pulse duration relative to the approximately 6-8 second shot point interval proposed for the Petroleum Activities Program means that the potential for masking is limited. Currently, there are no specific received level thresholds for reliably assessing or regulating masking responses to seismic noise (Gomez et al., 2016).

Without adequate control measures in place, noise emitted from the seismic source used during the Petroleum Activities Program has the potential to impact a range of receptors, being:

- cetaceans
- dugong
- turtles
- seabirds and migratory shorebirds
- fishes and elasmobranchs
- benthic invertebrates
- plankton
- fish spawning
- commercial fisheries
- tourism and recreation
- commercial divers
- marine protected areas.

Sound Exposure Thresholds

The levels of acoustic exposure that may result in injury or behavioural changes in marine fauna is an area of increasing research. Due to differences in experimental design, methodology and units of measure, comparison of studies to determine sound exposure thresholds, or noise effect criteria, can be problematic. On assessing the available science, thresholds have been defined for informing the impact assessment and for interpreting the numerical noise modelling. These sound exposure thresholds are summarised below. These criteria have been selected because they include standard thresholds, thresholds suggested by the best available science, and sound levels presented in the scientific literature for species with no suggested thresholds:

- marine mammal behavioural threshold, based on the current interim US National Marine Fisheries Service (NMFS) (NMFS, 2014) level of 160 dB re 1 µPa SPL (L_p) for impulsive sound sources
- peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from the US NOAA Technical Guidance (NMFS, 2018) for the onset of PTS and TTS in marine mammals

- sound exposure guidelines for fish, fish eggs and larvae (Popper et al., 2014)
- a threshold for PTS effects in turtles of 232 dB re 1 µPa (PK), and of 226 dB re 1 µPa (PK) for TTS effects in turtles (Finneran et al., 2017), and a behavioural response threshold of 166 dB re 1 µPa SPL (L_p) (National Science Foundation (NSF), 2011), as applied by the US NMFS, along with a sound level associated with an increased level of behavioural response 175 dB re 1 µPa (SPL) (McCauley et al., 2000a, 2000b; NSF, 2011)
- PK-PK ($L_{pk\text{-}pk}$) levels at the seafloor of 209 dB re 1 µPa and 202 dB re 1 µPa, to help assess effects of noise on crustaceans by comparing results in Payne et al. (2008) and Day et al. (2016)
- a sound level of 226 dB re 1 µPa PK (L_{pk}) reported for comparing to Heyward et al. (2018) for sponges and corals
- the distance to an unweighted single-pulse SEL of 160 dB re 1 µPa²s was modelled to assess the size of the low-power zone required under the EPBC Act Policy Statement 2.1 (DEWHA, 2008)
- an SPL human health assessment threshold of 145 dB re 1 µPa (L_p) for sound exposure to people swimming and diving, derived from Ainslie (2008) and Parvin (2005).

Noise thresholds have been defined for both the per-pulse sound energy released, as well as the total sound energy (accumulated) that marine fauna is subjected to over a defined period of time. For recent regulatory assessments of seismic surveys, the period of total sound energy integration (i.e. accumulation) has been typically defined as 24 hours; hence, was the period used for modelling and in this assessment. For fish this period is based on available research (Popper et al., 2014), which found fish experiencing TTS in hearing recovered to normal hearing levels within 18 to 24 hours, and for marine mammals the period is required to be either 24 hours or the length of the activity, whichever is shorter (NMFS, 2018).

Importantly, the 24-hour accumulated sound metric reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. More realistically, marine mammals and many fish (pelagic and some demersal) would not stay in the same location or at the same range for 24 hours. Popper et al. (2014) discuss the complications in determining a relevant sound exposure period of mobile seismic surveys, as the levels received by the receptor change between impulses due to the mobile source. For marine mammals and many fish, sound exposures at the closest point to the seismic source are the primary exposures contributing to a receptor's accumulated level (Gedamke et al., 2011). Hence, thresholds based on a 24-hour exposure period are considered to be a conservative measure of potential effect. To provide a more realistic assessment of the sound exposure received, bespoke animal movement and exposure modelling was undertaken for pygmy blue whales, as outlined below.

Cetaceans

The sound exposure thresholds applied for cetaceans in the acoustic modelling study, and in this impact assessment, are outlined in **Table 6-3**.

In March 2019, Southall et al. (2019) published a detailed review of all criteria associated with the onset of PTS and TTS, as a follow -up to the interim criteria published in 2007 (Southall et al., 2007). The Southall et al. (2019) criteria have not been referenced in this impact assessment because:

- all noise exposure criteria in NMFS (2018) and Southall et al. (2019) are identical (for impulsive and non-impulsive sounds)
- NMFS (2018) and Southall et al. (2019) do not provide criteria for behavioural disturbance; this aspect will be dealt with in separate documents which have not yet been published
- the auditory weighting functions are almost identical (i.e. no quantitative differences, only terminology)
- Southall et al. (2019) no longer consider an integration period for SEL of 24 hours to account for cumulative exposures as appropriate. As no guidance is provided for an alternative time period, it is suggested at this time that the 24-hour rule for 'reset' as required under NMFS (2018) continue to be applied for the acoustic modelling. However, the impact assessment can use these comments in conjunction with text about biological relevance and the mobility of fauna. This approach is suggested as it will be complex to determine an alternative valid reset period, as outlined by Southall et al. (2019).

Table 6-3: Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on cetaceans

Hearing group	NMFS (2014)	NMFS (2018)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L_p; dB re 1 µPa)	*Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)*	*PK (L_{pk}; dB re 1 µPa)*	*Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)*	*PK (L_{pk}; dB re 1 µPa)*
Low-frequency cetaceans	160	183	219	168	213
Mid-frequency cetaceans		185	230	170	224

High-frequency cetaceans		155	202	140	196

** Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential to exceed the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered. Lp denotes sound pressure level period and has a reference value of 1 µPa. Lpk, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa. LE denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa^{2}s. Subscripts indicate the designated marine mammal auditory weighting.*

Fishes and Elasmobranchs

The sound exposure thresholds applied for fishes and elasmobranchs (sharks and rays) in the acoustic modelling study, and in this impact assessment, are outlined in **Table 6-4**.

Table 6-4: Criteria for seismic noise exposure for fish, adapted from Popper et al. (2014)

Type of animal	Mortality and potential mortal injury	Impairment			Behaviour
		Recoverable injury	*TTS*	*Masking*	
Fish: No swim bladder (particle motion detection)	>219 dB SEL_{24h} or >213 dB PK	>216 dB SEL_{24h} or >213 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	186 dB SEL_{24h}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae	>210 dB SEL_{24h} or >207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Peak sound level (PK) dB re 1 µPa; SEL_{24h} dB re 1µPa^2·s. All criteria are presented as sound pressure, even for fish without swim bladders, since no data for particle motion exists. Relative risk (high, moderate, or low) is given for animals at three distances from the source, defined in relative terms as near (N), intermediate (I), and far (F).

** It should be noted that there are no studies that demonstrate mortality or potential mortal injury to fish from seismic acquisition. These values are theoretical and precautionary. These thresholds are largely adopted from maximum received levels from studies where no effect was demonstrated at these received levels.

Acoustic Modelling

Woodside commissioned JASCO Applied Sciences to perform comprehensive computer numerical modelling of underwater noise propagation related to using the seismic source, relevant to the various water depths, bathymetry and seabed properties associated with the different Acquisition Areas covered by the Petroleum Activities Program (McPherson et al., 2019; **Appendix H**). The objective of this acoustic modelling study was to evaluate the effects of sound on marine fauna including cetaceans, turtles, fishes, elasmobranchs, benthic invertebrates and zooplankton, and on socio-economic receptors such as commercial fisheries, tourism and recreation, commercial divers and marine protected areas. Two seismic sources were considered: a 3150 in³ seismic source towed at a 6 m depth used for five of the proposed 4D surveys; and a 2650 in³ seismic source towed at a 5 m depth used for one survey.

A specialised airgun array source model was used to predict the acoustic signature of the two seismic sources, and complementary underwater acoustic propagation models were used in conjunction with the modelled array signatures to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at 23 defined locations within Areas A, B and C, and accumulated sound exposure fields were predicted for one representative scenario for likely survey operations over 24 hours for each of the six surveys. The single impulse locations considered the entire line length when the seismic source would be operational at full power, including run-out sections of lines. The lengths of the line run-outs are approximately equal to half the length of the streamers. Therefore, some single impulse modelling sites and sections of the acquisition lines considered for each 24h SEL scenario are outside the Acquisition Areas (Refer to **Figure 3-2** for single impulse modelling locations closest to the Ningaloo Coast World Heritage Area (WHA) in context of the Acquisition Areas for Laverda and Cimatti surveys within Area C). The modelling methodology considered source directivity and range-dependent environmental properties in each of the areas assessed. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$), and either per-impulse (i.e. single-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria (see above). A conservative sound speed profile that would be most supportive of sound propagation conditions for the period of the surveys in each of Areas A, B and C was defined and applied to all of the modelling (McPherson et al., 2019).

The modelling scenarios for five of the surveys were designed considering sail lines as acquired during previous 4D or 3D surveys. The Scarborough 4D B1 scenario was designed with a new acquisition line plan. Single impulse sound fields relevant to identified receptors were sampled at fixed receiver locations for each of Areas A, B and C. Fixed receiver locations were only defined when no part of the identified receptor was within the Acquisition Area, and typically, the single impulse sound fields sampled represented the closest potential impulse to the receptor. The modelling study considered the sections of the water column (≤24, 129 and 506 m) in relation to potential PTS, TTS and behavioural disturbance impacts to pygmy blue whales.

These chosen depth limits are related to the biologically relevant depths pygmy blue whales are known to dive duration various life stages. Blue whales are known to primarily migrate and feed in the first few hundred metres of the water column (Croll et al., 2001; Goldbogen et al., 2011; Owen et al., 2016). A single pygmy blue whale tagged with a multi-sensor tag in Australian waters was 35 km north of the Perth Canyon. As the whale moved north, the tag remained on the animal for 7.6 days, falling off when it was off the coast of Geraldton. This whale spent 94% of its time and completed 99% of its migratory dives at depths less than 24 m, while the mean maximum depth of feeding dives was 129 m and the maximum dive depth was 506 m (Owen et al., 2016). Therefore, in addition to the most conservative maximum over-depth results, this modelling study has considered the biologically relevant sections of the water column ≤24, 129 and 506 m in relation to potential behavioural disturbance, PTS and TTS for pygmy blue whales.

Contours of the modelled underwater sound fields have been computed, sampled either as the maximum value over all modelled depths (maximum-over-depth: MOD) or at the seafloor for each of the 23 single-pulse locations, and for the six cumulative SEL_{24h} scenarios. The modelled distances for each sound exposure threshold are computed from these contours. Two distances relative to the source are reported for each sound level:

1. R_{max} – the maximum range to the given sound level over all azimuths.
2. $R_{95\%}$ – the range to the given sound level after the 5% farthest points were excluded.

The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment. In some environments a sound level contour might have small anomalous isolated fringes, in which case the literal use of R_{max} can misrepresent the area of the region exposed to such effects. In these instances, $R_{95\%}$ is considered more representative. In environments that have bathymetric features that affect sound propagation, the $R_{95\%}$ neglects to account for these; therefore, R_{max} might better represent the region of effect in specific directions. For this impact assessment the R_{max} values have been considered.

Animal Movement and Exposure Modelling (ANIMAT Modelling)

In addition to the propagation modelling outlined above, Woodside commissioned JASCO to perform an acoustic exposure analysis study for pygmy blue whales (*Balaenoptera musculus brevicauda*) for five of the six planned 4D survey Acquisition Areas within Areas A and C for the Petroleum Activities Program (Weirathmueller et al., 2019; **Appendix H**). This report describes the modelled predictions of sound levels that individual pygmy blue whales may receive during operations of these surveys with specific consideration of the migratory and possible foraging Biologically Important Areas (BIAs) within and adjacent to the proposed survey areas (**Figure 6-1**) and the specific actions. Sound exposure estimates were determined by moving large numbers of simulated animals (animats) through a modelled time-evolving sound field, computed using the existing sound source and sound propagation model (Weirathmueller et al., 2019). This approach provides the most realistic prediction of the maximum expected root-mean-square sound pressure level (SPL, L_p) and peak pressure level (PK, L_{pk}), and the temporal accumulation of sound exposure level (SEL, L_E) that are now considered the most relevant sound metrics for impact assessment. The most recent science in the peer-reviewed literature regarding sound propagation and animal movement modelling was used.

Sound level exposure estimates were calculated by comparing pre-determined exposure threshold criteria with computed sound fields generated by the sound source associated with the seismic operation, which were then sampled using computational models of animal movement. A detailed sound modelling study has been conducted for each individual survey within the two survey areas (Weirathmueller et al., 2019); the results have been used in this acoustic exposure analysis.

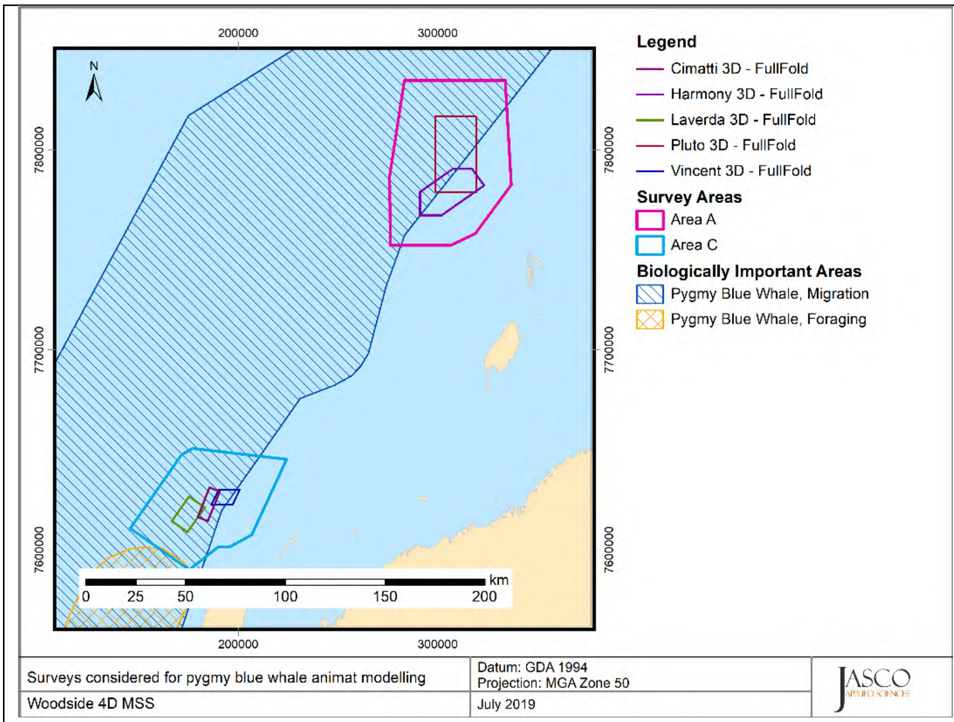

Figure 6-1: Overview of the features for the pygmy blue whale exposure modelling for the 4-D seismic campaign

The modelling assumed that the seismic vessel will sail along the proposed survey lines at ~4.5 knots, with an impulse interval of either 12.5 or 18.75 m depending on the survey. The exposure scenarios were designed considering acquisition lines from previous 3D or 4D surveys.

Density Estimates of Pygmy Blue Whales for ANIMAT Modelling

Density estimates that informed the animat modelling were derived from the acoustic detection data published by McCauley and Jenner (2010), which revealed a maximum of three pygmy blue whales on a single day passing through the area during their southward migration (November to late December). The listening range of the noise logger was estimated to be 120 km, which was considered in this analysis to be a 60km radius, which is a conservative approach. Based on an average swimming speed for the southbound pygmy blue whales of five knots (9.26 km/hr), McCauley and Jenner (2010) calculated a transit time through the area of 0.54 days; therefore, the number of animals detected per day equates to an estimated density for vocalising animals in the area of 0.0031207 animals per km^2 for their study. As not all animals are emitting calls during their migration, this density estimate has to be corrected for the percentage of animals calling ('calling rate'). McCauley and Jenner (2010) proposed that 8.5–20% of the animals present in an area could be vocalising, considering information relating to humpback whales (8.5%, Cato et al. (2001)), and pygmy blue whales (<20%, (McCauley et al. 2001). To take a precautionary approach this impact assessment has adopted the lower bound calling percentage (8.5%), assuming a 2.35 times higher number of total animals when compared to the 20% vocalisation rate of pygmy blue whales observed in the Perth Canyon.

McCauley et al. (2018) provides an estimate for the annual growth rate of pygmy blue whales at Portland (Victoria) of 4.3% per year. However, as pointed out by the authors, this growth rate applies only to the proportion of the population using the south eastern Australian coast, and as such may not reflect the growth rate of the full population. However, in the absence of other population growth estimates, this estimate has been applied as a conservative estimate to the proportion of the population also using the WA coast. The maximum number of three pygmy blue whales per day occurred in associated with the population estimate of 662–1559 whales presented in McCauley and Jenner (2010). If the population increases, it is estimated that the number of whales present on any one day would also increase proportionally. Therefore, the population increase estimate of 4.3% per year, and a corresponding Scaling Factor of 188%, has been applied in this impact assessment. This results in a revised estimate of the maximum number of animals which could be detected within the listening area per day being 5.64, and a real-world density of 0.0690392 animals per km^2. Further detail on the how the density estimates were derived is outlined in **Appendix H**.

Animal Behaviour of Pygmy Blue whales for ANIMAT modelling

Two ANIMAT behavioral profiles were considered for pygmy blue whales, defined as foraging and migration. The research summarised in this section was used to inform the species ANIMAT behavioural profile detailed in Appendix H). The input values within this section are based on best available science and where uncertainty exists due to limited sample sizes, conservatism has been applied as described below.

Detailed, fine-scale diving behaviour of a migrating pygmy blue whale was derived from Owen et al. (2016) who equipped an individual with a multi-sensor tag off the west coast of Australia. The study identified areas of high residence using the horizontal movement data; the analysis of the dive data showed that the depth of migratory dives was highly consistent over time and unrelated to local bathymetry. Blue whales (*Balaenoptera musculus*) are known to primarily migrate and feed in the first few hundred metres of the water column (Croll et al. 2001, Goldbogen et al. 2011), with the deepest dive being reported from a pygmy blue whale being 506 m (Owen et al. 2016). Dives were identified as migratory, feeding, or exploratory behaviour. The mean depth of migratory dives (82% of all dives) was 14 m ± 4 m, and the whale spent 94% of observed time and completed 99% of observed migratory dives at water depths of less than 24 m. A total of 21 feeding dives were identified during the duration of the tag deployment (one week) with a mean maximum depth of 129 ± 183 m (range 13–505 m). The mean maximum depth of exploratory dives (107 ± 81 m, range 23–320 m) was similar to the mean maximum depth of feeding dives (129 m) and did not appear to be related to seafloor depth.

To incorporate conservatism into the modelling, the behaviour of pygmy blue whales was modelled without migration bias, i.e. the animats were resident in the animat modelling area over the entire modelling period. In reality, pygmy blue whales can be expected to transit through the area in less than half a day (based on McCauley and Jenner 2010); accordingly, the approach used is conservative as it results in higher exposure levels and higher number of animals exposed to levels exceeding the criteria thresholds.

The two migratory behaviours (migratory dives and exploratory dives) were modelled at an even probability of occurrence (i.e. probability for transitioning from one behaviour to another was 0.5 for both) while dive data published by Owen et al. (2016) suggest a higher likelihood (82%) for migratory dives to occur. This approach was chosen in the absence of quantitative information on the true proportion between the two dive behaviours. It represents another conservative measure, given the assumption that typically exposure levels are higher at depth as compared to the surface. Table B-1 and Table B-2, within **Appendix H** provide an overview of the behavioural input values adopted for both Foraging ANIMATS and Migratory ANIMATS, respectively.

Environmental Value(s) Potentially Impacted

This impact assessment examines potential impacts and key controls (e.g. EPBC Policy Statement 2.1; and adaptive management procedures) for a range of sensitive receptors that may be present within Areas A, B and C and surrounding waters during the period when the surveys are planned to be acquired. Given the overlap (in some cases) and close proximity of the survey Acquisition Areas to each other, the assessment described below is based on the ‘worst-case’ outcomes for each of Areas A, B and C, rather than for individual surveys. It is important to note that the boundaries of Areas A, B and C represent the Operational Areas for each survey, and not the Acquisition Areas within which the seismic source will be discharged at full power.

Cetaceans

Based on the information presented in **Section 4.5.2**, there is the potential for pygmy blue whales to be present within and adjacent to Areas A, B and C during the southbound migration (October to January), and also during the northbound migration from April to July.

Area C overlaps the humpback whale migration BIA that extends across the North West Shelf, and Area A is located adjacent to the BIA (**Figure 4-12**). However, given the timing of seismic acquisition for surveys in Areas A and C (late December to May; **Table 4-5**), there will be no overlap with the period for the northbound or southbound migrations of humpback whales in the region (June to October). While the Scarborough survey in Area B may be acquired at any time in the period January to July, the Acquisition Area for this survey is located at least 160 km from the boundary of the migration BIA, and consequently it is unlikely that significant numbers of humpback whales would be encountered if the survey was to overlap the northbound migration.

Other species of whale (e.g. sei, fin, sperm and southern right whales) may transit the region mainly during the winter months; there are no defined BIAs or critical habitats for these species that overlap or are adjacent to Areas A, B and C. Similarly, while other species of cetaceans may occur within or adjacent to Areas A, B and C (e.g. Indo-Pacific humpback dolphin and spotted bottlenose dolphin: refer **Table 4-3**), there are no BIAs or critical habitats for these species in the region. Therefore, the presence of these cetacean species within or adjacent to Areas A, B and C is likely to be limited to infrequent occurrences of individuals or small groups transiting surrounding waters. **Table 6-6** presents the results of the acoustic modelling study for maximum predicted R_{max} distances to PTS (injury), TTS and behavioural response thresholds in medium and high frequency cetaceans for Areas A, B and C.

Stone et al. (2015) undertook a comprehensive study on marine mammal observations during seismic surveys from 1994-2010. Data from 1,196 seismic surveys in UK and adjacent waters between 1994 and 2010 were examined to assess the effects of seismic operations on marine mammals and overall trends. Over 190,000 hours were recorded as monitoring for marine mammals (over 181,000 hours visual monitoring and over 9,000 hours acoustic monitoring), with airguns firing for 38.8% of this time. On surveys with ‘large arrays’, marine mammals often approached closer to the airguns when they were not firing than when they were firing, this was significant for the majority of high frequency cetacean species including but not limited to bottlenose dolphins, white-beaked dolphins and Atlantic white-sided dolphins. For species where the results were significant, the difference in the median closest distance of approach between when the airguns were firing and when they were not firing ranged between 300 m and 1,500 m. The results of this study demonstrate the potential impacts to high frequency cetaceans are highly unlikely given the short ranges to potential injury thresholds (<220 m) within **Table 6-6** and evidence of demonstrated avoidance behaviour beyond these ranges.

Table 6-5 presents the results of the acoustic modelling study for maximum predicted MOD R_{max} distances to PTS (injury), TTS and behavioural response thresholds in low frequency whales (pygmy blue whales) for Areas A, B and C. Data are presented for PTS (injury), TTS and behavioural disturbance thresholds. **Table 6-6** presents the same results for medium and high frequency cetaceans. **Table 6-7** presents the maximum MOD distances and areas predicted for PTS impacts to low, medium and high frequency cetaceans; **Table 6-8** presents these values for mean diving depths of pygmy blue whales.

Table 6-5: Maximum predicted MOD R_{max} distances to thresholds assigned to PTS (injury), TTS and behavioural response in low frequency whales (pygmy blue whales) for Areas A, B and C (McPherson et al., 2019a)

Potential impact	Sound exposure threshold	Area A	Area B	Area C
		R_{max} (km)	R_{max} (km)	R_{max} (km)
PTS onset	219 dB re 1 µPa (PK)	0.03	0.03	0.03
	183 dB re 1 µPa²·s (SEL_{24h})	1.1	5.96	2.14
TTS onset	213 dB re 1 µPa (PK)	0.06	0.05	0.06
	168 dB re 1 µPa²·s (SEL_{24h})	59.7	92.3	47.2
Behavioural response	160 dB re 1 µPa (SPL)	7.9	6.8	6.5
Low power zone assessment	160 dB re 1 µPa²·s (single-pulse SEL)	2.6	2.1	2.3

Table 6-6: Maximum predicted R_{max} distances to thresholds associated with PTS onset, TTS onset and behavioural response in medium frequency (MF) and high frequency (HF) cetaceans for Areas A, B and C (McPherson et al., 2019a)

Potential impact	Acoustic Threshold Metric	Area A		Area B		Area C	
		HF R_{max} (km)	*MF R_{max} (km)*	*HF R_{max} (km)*	*MF R_{max} (km)*	*HF R_{max} (km)*	*MF R_{max} (km)*
PTS onset	Peak	0.22	<0.02	0.19	<0.02	0.19	<0.02
	SEL_{24h}	<0.04	-	0.07	-	0.03	-
TTS onset	Peak	0.39	<0.02	0.38	<0.02	0.39	<0.02
	SEL_{24h}	0.40	<0.04	2.3	-	1.26	-
Behavioural response	160 dB re 1 µPa (SPL)	7.9		6.8		6.5	

A dash indicates the threshold was not reached.

The results for the criteria applied for marine mammal PTS and TTS consider both metrics within the criteria (single-pulse PK and multiple-pulse SEL_{24h}). In accordance with NMFS (2018), the longest distance associated with either metric must be applied for an impact assessment.

Table 6-7: Maximum predicted MOD distances and areas to SEL_{24h} based cetacean PTS thresholds (McPherson et al., 2019a)

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Area A				Area B		Area C					
		Pluto 4D		Harmony 4D		Scarborough 4D		Laverda 4D		Cimatti 4D		Vincent 4D	
		R_{max} (km)	*Area (km²)*	*R_{max} (km)*	*Area (km²)*	*R_{max} (km)*	*Area (km²)*	*R_{max} (km)*	*Area (km²)*	*R_{max} (km)*	*Area (km²)*	*R_{max} (km)*	*Area (km²)*
Low-frequency cetaceans	183	0.86	73.7	1.10	96.4	5.96	816	0.70	49.4	2.14	115	2.07	101
Mid-frequency cetaceans	185	–	–	–	–	–	–	–	–	–	–	–	–
High-frequency cetaceans	155	<0.04	4.1	<0.04	0.37	0.07	13.3	0.05	5.45	0.03	2.40	0.03	2.23

A dash indicates the threshold was not reached.

Table 6-8: Maximum predicted MOD distances and areas to SEL_{24h} based cetacean PTS threshold for pygmy blue whales (McPherson et al., 2019a)

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	Depth limit (m)	Area A				Area B		Area C					
			Pluto 4D		Harmony 4D		Scarborough 4D		Laverda 4D		Cimatti 4D		Vincent 4D	
			R_{max} (km)	*Area (km²)*	*R_{max} (km)*	*Area (km²)*	*R_{max} (km)*	*Area (km²)*	*R_{max} (km)*	*Area (km²)*	*R_{max} (km)*	*Area (km²)*	*R_{max} (km)*	*Area (km²)*
Pygmy blue whales, LF cetacean weighted	183	506	0.86	73.4	1.10	96.4	5.95	528	0.44	42.8	1.35	88.1	2.03	95.7
		129	0.40	57.7	0.50	73.0	5.93	341	0.35	38.2	0.58	54.3	2.00	77.5
		24	0.22	33.6	0.24	45.1	4.50	160	0.20	27.2	0.25	36.7	1.38	50.8

The chosen depth limit is related to mean dive depths for pygmy blue whales.

Table 6-7 presents the maximum predicted MOD distances and areas to the SEL_{24h} based PTS thresholds for LF, MF and HF cetaceans. For LF cetaceans the spatial extent at which PTS thresholds may be reached ranges from a minimum of approximately 74 km² (Pluto) to a maximum of approximately 816 km² (Scarborough). The SEL_{24h} based PTS threshold for MF cetaceans was not reached for any of the six surveys. For HF cetaceans, the spatial extent at which PTS thresholds may be reached ranges from a minimum of approximately 0.4 km² (Harmony) to a maximum of approximately 13 km² (Scarborough). **Table 6-8** presents the maximum predicted distances and areas to the SEL_{24h} based PTS threshold for pygmy blue whales at the three different dive depths modelled. Note that these impact ranges and areas based on the SEL_{24h} metric do not take into account representative pygmy blue whale animal movement and behaviour, as assessed via the ANIMAT modelling (see below).

The 24 hour SEL is a cumulative metric that reflects the dosimetric (measured dose) impact of noise levels within 24 hours, based on the conservative assumption that an animal is consistently exposed to such noise levels at a fixed position. The modelling results show that the corresponding SEL_{24h} radii for LF and HF cetaceans are larger than those for peak pressure criteria, but they represent an unlikely worst-case scenario. More realistically, whales would not stay in the same location or at the same range for 24 hours. This would particularly be the case for an animal migrating through offshore waters that don't represent critical habitat or a narrow restricted migratory pathway. Therefore, a reported radius for SEL_{24h} criteria does not mean that a whale travelling within this radius of the source will experience PTS or TTS, but rather that an animal could be exposed to the sound levels associated with these effects if it remained in that range for 24 hours (McPherson et al., 2019). Refer to the animal movement and exposure modelling results within **Table 6-9 and Table 6-10** for a more representative assessment of the sound exposure level received by a moving animal.

In terms of potential masking of vocalisations of foraging pygmy blue whales, the intermittent nature and relatively short duration of individual seismic pulses is unlikely to result in any significant masking of whale calls, although it may cause whales to cease or alter their vocalisations at times, as outlined in Wood et al. (2012) and Erbe at al. (2016).The potential for masking impacts to migrating pygmy blue whales within the migration BIA is also limited. Migrating whales would be exposed to the seismic pulses for less than a day, and therefore this sound exposure would not cause long-term masking for these individuals.

Pygmy Blue Whale Animal Movement and Exposure Modelling

Summaries of the ANIMAT modelling results for migrating and foraging pygmy blue whales, for each of the five seismic survey areas, are provided in **Table 6-9** and **Table 6-10.**

Table 6-9: Area A: Summary of ANIMAT simulation results for migratory pygmy blue whales (Weirathmueller et al., 2019; Appendix H). The 95th percentile exposure ranges (km), and the number of real-world individuals exposed above threshold (using the estimated densities) are provided. Estimates related to injury criteria (NMFS, 2018) and behaviour (NMFS, 2014) are normalised to 24-hours from the 7 days of operation simulated to aid comparison to acoustic modelling results. For comparison, maximum distances to threshold from previously completed acoustic modelling are provided.

Threshold		Maximum distance (km) to threshold from acoustic modelling	Migrating Pygmy Blue Whales	
Threshold description	Sound Level (dB)		Range, P_{95} (km)	Number of individuals (no mitigation*)
Pluto 4-D MSS				
TTS, PK	213†	0.06	-	0.06
TTS, SEL_{24h}	168‡	59.7	4.95	2.84
PTS, PK	219†	0.03	-	0.04
PTS, SEL_{24h}	183‡	0.86	0.09	0.09
Behavioural response	160#	8.5	4.89	3.23
Harmony 4-D MSS				
TTS, PK	213†	0.05	-	0.06
TTS, SEL_{24h}	168‡	38.8	4.18	1.99
PTS, PK	219†	0.03	-	0.04
PTS, SEL_{24h}	183‡	1.10	0.09	0.08
Behavioural response	160#	6.3	4.17	2.41

† PK (L_{pk}; dB re 1 μPa)
‡ LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 μPa²·s)
 # SPL (L_p; dB re 1 μPa)
A dash indicates where ranges were not relevant for PK exposures
**Estimates assume no mitigation measures are applied and no behavioural avoidance*

Table 6-10: Area C: Summary of animal movement and sound exposure results for migratory and foraging pygmy blue whales (Weirathmueller et al., 2019; Appendix H). The 95th percentile exposure ranges (km), and the number of real-world individuals exposed above threshold (using the estimated densities) are provided. Estimates related to injury criteria (NMFS, 2018) and behaviour (NMFS, 2014) are normalised to 24-hours from the 7 days of operation simulated to aid

comparison to acoustic modelling results. For comparison, maximum distances to threshold from previously completed acoustic modelling are provided.

Threshold		Maximum distance (km) to threshold from acoustic modelling	Migrating Pygmy Blue Whales		Foraging Pygmy Blue Whales	
Threshold description	Sound Level (dB)		Range, P_{95} (km)	Number of individuals (no mitigation*)	Range, P_{95} (km)	Number of individuals (no mitigation*)
Laverda 4-D MSS						
TTS, PK	213†	0.06	-	0.06	-	0.00
TTS, SEL_{24h}	168‡	55.3	18.57	5.49	35.49	0.34
PTS, PK	219†	0.03	-	0.038	-	0.00
PTS, SEL_{24h}	183‡	0.70	0.10	0.09	0.00	0.00
Behavioural response	160#	4.2	2.81	1.97	0.00	0.00
Cimatti 4-D MSS						
TTS, PK	213†	0.05	-	0.056	-	0.00
TTS, SEL_{24h}	168‡	47.2	12.40	3.63	29.66	0.04
PTS, PK	219†	0.03	-	0.02	-	0.00
PTS, SEL_{24h}	183‡	2.14	0.09	0.08	0.00	0.00
Behavioural response	160#	6.5	5.19	2.46	0.00	0.00
Vincent 4-D MSS						
TTS, PK	213†	0.05	-	0.056	-	0.00
TTS, SEL_{24h}	168‡	32.4	11.01	3.38	0.00	0.00
PTS, PK	219†	0.03	-	0.038	-	0.00
PTS, SEL_{24h}	183‡	2.07	0.09	0.094	0.00	0.00
Behavioural response	160#	6.2	4.43	2.94	0.00	0.00

† PK (L_{pk}; dB re 1 µPa)
‡ LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)
 # SPL (L_p; dB re 1 µPa)
A dash indicates where ranges were not relevant for PK exposures
**Estimates assume no mitigation measures are applied and no behavioural avoidance*

Area A

As described in **Section 4.5.2,** Area A overlaps a portion of the pygmy blue whale migration BIA (refer **Figure 4-11**). Given the planned acquisition window for the Pluto and Harmony surveys late December to May), there is the potential for seismic acquisition to overlap with the end of the southbound migration in January, as well as a portion of the northbound migration in April to May (refer **Table 4-5**).

In Area A, considering the NMFS (2018) SEL_{24h} threshold criterion for injury (PTS), LF cetaceans are predicted to experience injury (PTS) within 1.1 km from the nearest survey line, based on applying the multiple-pulse SEL_{24h} threshold across all water depths modelled (**Table 6-5**).These impact ranges are based on the cumulative SEL_{24h} metric; therefore, PTS would only occur if individuals remained within these ranges of the operating seismic source for the full 24 hour duration, which is extremely unlikely to occur. When incorporating representative pygmy blue whale animal movement and behaviour into the propagation model, the 95th percentile exposure ranges to the injury PTS threshold are reduced to 90 m, with an estimated 0.09 individual whales exposed over a 24 hour period. These values do not incorporate industry standard mitigation measures or potential behavioural avoidance.

The maximum predicted distance to the auditory fatigue TTS threshold for LF cetaceans is 59.7 km from the nearest survey line, based on applying the multiple-pulse SEL_{24h} threshold for all water depths modelled (refer **Table 6-5**) assumes individuals remained within these ranges for a full 24-hour duration. When incorporating representative pygmy blue whale animal movement and behaviour into the propagation model (**Table 6-9**), the 95th percentile exposure range to the auditory fatigue TTS threshold are reduced to 4.95 km from the active array, with an estimated 2.83 individual whales exposed over a 24-hour period. These values do not incorporate industry standard mitigation measures or potential behavioural avoidance.

As shown in **Table 6-5**, predicted maximum R_{max} distances to PTS and TTS thresholds for LF cetaceans based on the single-pulse (PK) metric are considerably lower than those predicted using the multiple-pulse SEL_{24h} thresholds (**Table 6-7** and **Table 6-8**). Application of the 219 dB re 1 µPa (PK) PTS threshold and of the 213 dB re 1 µPa (PK) TTS threshold indicates that predicted R_{max} radii from individual shot points are in the range of 30–60 m – i.e. a whale would have to be within a very close distance of the source (tens of metres) to be exposed to sound levels from a single pulse high enough to cause PTS or TTS effects. When incorporating representative pygmy blue whale animal movement and behaviour into the propagation model, predicted maximum distances to PTS and TTS thresholds based on the single-pulse (PK) metric are not reached.

Predicted maximum distances to the NMFS (2014) marine mammal behavioural threshold (single-pulse 160 dB re 1 µPa SPL) for Area A range from 7.9 to 8.5 km, across all water depths modelled (refer **Table 6-5**). When incorporating representative pygmy blue whale animal movement and behaviour into the propagation model, the 95th percentile exposure ranges to behavioural response for the Harmony and Pluto surveys are reduced to 4.17 km and 4.89 km, respectively with a corresponding 2.41 and 3.23 animals exposed over a 24 hour period; assuming no mitigation or behavioural avoidance.

The migration BIA for pygmy blue whales across the North West Shelf is based on the 500 m and 1000 m isobaths and the movements of a limited number (n=11, of which only five individuals were tracked for any distance north of North West Cape – refer **Figure 4-11**) of animals tracked via satellite tags during the northbound migration in 2009 and 2011 (Double et al., 2012, 2014). Based on passive acoustic detections of pygmy blue whales off Exmouth, McCauley and Jenner (2010) estimated 662–1559 pygmy blue whales pass the noise logger site during the 2004 southbound migration down the WA coast. At the location where Area A overlaps the migration BIA, the defined corridor is approximately 100 km wide, and therefore cannot be described as a narrow, confined or restricted corridor. Passive acoustic detections of pygmy blue whales during the southbound migration in December 2014 to January 2015, from an array of 14 ocean bottom seismographs (OBS) deployed on the Exmouth Plateau northwest of North West Cape, indicated that the animals tended to travel southward much further away from the WA coast, at distances of up to 400 km from shore, than that expected from data collected on their northbound migration (Gavrilov et al., 2018).

No satellite tracking data is currently available for pygmy blue whales moving down the WA coast during the southbound migration, so there is no indication of travelling speeds or occupancy/residency times. As described in above, blue whales are known to primarily migrate and feed in the first few hundred metres of the water column (Croll et al., 2001; Goldbogen et al., 2011; Owen et al., 2016). No information about dive depths is available for southbound pygmy blue whales along the WA coastline, but there is no reason to believe that diving behaviour during the southbound migration will be significantly different to that displayed during the northbound migration.

When incorporating representative pygmy blue whale animal movement and behaviour into the propagation model along with conservative estimates of animal density, ANIMAT results show an estimated 0.04 individual whales are potentially exposed over a 24-hour period, with this value expected to be reduced further when mitigation measures are implemented. The ANIMAT modelling conservatively assumes pygmy blue whales do not exhibit avoidance behaviour from the seismic source, however Moulten (2010) has documented that blue whales were seen farther (~677 m) from the seismic ship during periods when the airguns were active (1904 m) vs. silent (1,227 m); based on analysing 9,180 hours of seismic survey observations in eastern Canada from 2003 to 2008. Additionally, Stone et al. (2015) undertook comprehensive study of 181,000 hours of marine mammal observations during 1,196 seismic surveys from 1994-2010 in UK and concluded as a combined group, on average, baleen whales were shown to stay 500 m further away from the airguns when they were active compared to when they were off, suggesting the group exhibit natural avoidance.

Given their ranges to defined injury thresholds are so small (90 m) and estimated animals exposed is only 0.04 within any 24-hour period, it's highly unlikely pygmy blue whales will be exposed to these levels when considering literature suggesting blue whales and baleen whales exhibit natural avoidance. This potential impact is further reduced given the control measures that will be in place during survey acquisition. Therefore, the potential impacts of noise emissions on pygmy blue whales from the seismic source during acquisition of the Pluto and Harmony surveys in Area A are considered to be slight and short-term and restricted to temporary behavioural changes (avoidance) in individuals during either their southbound or northbound migrations.

The Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015a) includes a specific action that "*Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area*".

Double et al. (2014) acknowledged that: "*While anthropogenic noise may alter blue whale behaviour, it is unlikely to pose a conservation risk unless it causes population level consequences such as changes in growth, reproduction and survival of individuals. Elevated ambient noise has been responsible for abandonment or avoidance of critical habitat by a number of cetacean species…Critical habitat includes habitat used to meet essential lifecycle requirements such as foraging and breeding.*"

Based on the timing and duration (up to 56 days) of the Petroleum Activities Program in Area A, the absence of critical habitats (i.e. feeding, breeding, calving areas) or a constricted migratory pathway within the area and surrounding waters, and the control measures proposed (discussed in the Demonstration of ALARP and EPO, EPS and MC sub-sections below), predicted noise levels from seismic acquisition are not considered likely to cause injury effects, or any ecologically significant impacts at a population level for pygmy blue whales or any other species of large whale that may be present within or adjacent to Area A during the Petroleum Activities Program. Acquisition of the Pluto and Harmony 4D surveys in Area A will not overlap the peak of the southbound migration period for pygmy blue whales in the region.

Given the spatial overlap with the pygmy blue whale migration BIA, and the temporal overlap with the end of the southbound migration in January, additional adaptive management procedures will be implemented to manage impacts to pygmy blue whales if higher numbers than expected are encountered during this period. These procedures are based on the cessation of acquisition at night-time or periods of poor visibility if there are three consecutive days during which there have been three or more whale-instigated shutdowns (see **Figure 6-2**).

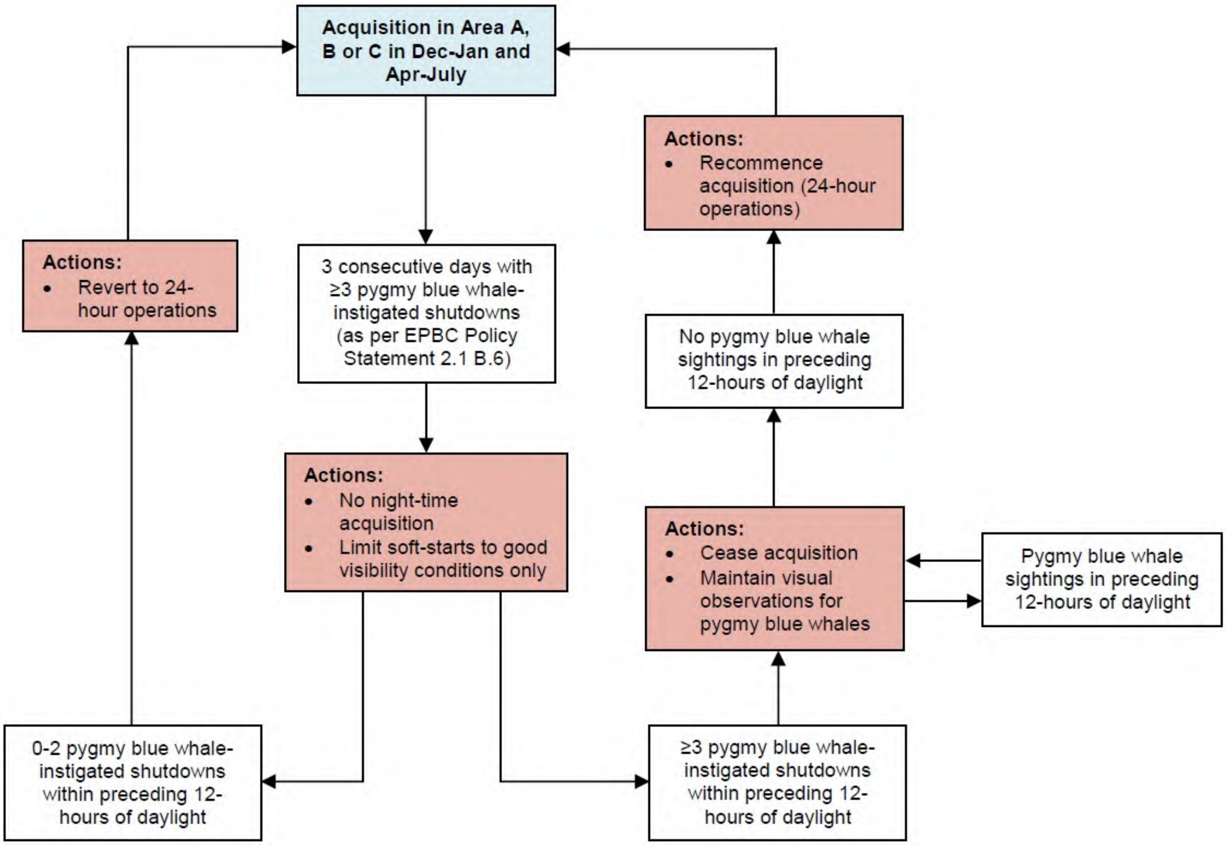

Figure 6-2: Pygmy blue whale adaptive management procedures to be applied during acquisition in Area A, B or C in December-January and April-July

<u>Area B</u>

As described in **Section 4.5.2**, Area B overlaps the pygmy blue whale distribution BIA (refer **Figure 4-11**), and is located approximately 27 km west of the migration BIA. As discussed above, it is likely that pygmy blue whales travel across a much broader area of the North West Shelf and Exmouth Plateau than that delineated by the migration BIA, during both the northbound and southbound migrations. The Scarborough survey may be acquired at any time in the period January to July; therefore, acquisition will not overlap the peak period for the southbound migration (November to December; refer **Table 4-5**). It is possible that a few isolated individuals may still be moving south across the Exmouth Plateau in late January. However, acquisition of the Scarborough survey could overlap the April to July period, and hence coincide with the peak period for the northbound migration of pygmy blue whales (May to June; refer **Table 4-5**).

In Area B, considering the NMFS (2018) SEL_{24h} threshold criterion, the maximum predicted distance to the PTS thresholds for pygmy blue whales is 5.96 km from the nearest survey line, based on applying the multiple-pulse SEL_{24h} threshold across all water depths (**Table 6-7** and **Table 6-8**). At the ≤24 m dive depth the predicted R_{max} range to the PTS criterion reduces to 4.5 km.

The maximum predicted distance to the TTS thresholds for pygmy blue whales is 92.3 km from the nearest survey line, based on applying the multiple-pulse SEL_{24h} threshold for all water depths modelled. Application of the single-pulse PK PTS and TTS thresholds indicates that predicted R_{max} radii from individual shot points are in the range of 30–50 m. The predicted maximum distance to the NMFS (2014) marine mammal behavioural threshold for Area B is 6.8 km (refer **Table 6-5**). ANIMAT modelling for pygmy blue whales was not undertaken on Area B due to the lack of interaction of injury or behavioural response threshold radii with migratory or foraging BIAs, however if undertaken the expected ANIMAT ranges to PTS, TTS and behavioural response are estimated to be equivalent to the ANIMAT results for Areas A and C (**Table 6-9** and **Table 6-10**).

Area C

As described in **Section 4.5.2**, Area C overlaps a portion of the pygmy blue whale migration BIA (refer **Figure 4-11**). The Acquisition Areas for the Laverda, Cimatti and Vincent surveys overlap ~285 km² of the migration BIA, which represents ~0.09% of the overall area of the BIA. Area C also overlaps a very small part (18 km²; ~0.2%) of the possible foraging BIA offshore from Ningaloo Reef and North West Cape.

The Cimatti and Vincent 4D surveys will be acquired in the period March to end May 2020, with Laverda planned to be acquired between March and April. Therefore, there is the potential for acquisition to overlap the beginning of the northbound migration for pygmy blue whales in the region (refer **Table 4-5**). As described above, the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015a) includes an action that anthropogenic noise in BIAs for blue whales should be managed to ensure individuals are not displaced from foraging areas.

In Area C, considering the NMFS (2018) SEL_{24h} threshold criterion, the maximum predicted distance to the PTS thresholds for pygmy blue whales is 2.14 km from the nearest survey line, based on applying the multiple-pulse SEL_{24h} threshold across all water depths modelled (**Table 6-7** and **Table 6-8**). These impact ranges are based on the cumulative SEL_{24h} metric; therefore, PTS would only occur if individuals remained within these ranges of the operating seismic source for the full 24-hour duration, which is extremely unlikely to occur. When incorporating representative pygmy blue whale migratory animal movement and behaviour into the propagation model for the survey areas within Area C, the 95th percentile exposure ranges to the injury PTS threshold are reduced to 90-100 m, with an estimated 0.08 - 0.09 individual whales exposed within a 24 hour period. Similarly, an ANIMAT assessment of the potential impacts to pygmy blue whales within the adjacent foraging BIA confirm no injury is possible with no individuals exposed. These values do not incorporate industry standard mitigation measures or potential behavioural avoidance.

The maximum predicted distance to the auditory fatigue TTS threshold for LF cetaceans is 55.3 km from the nearest survey line, based on applying the multiple-pulse SEL_{24h} threshold for all water depths modelled (refer **Table 6-5**) and assuming individuals remained within these ranges a the full 24 hour duration. When incorporating representative pygmy blue whale animal movement and behaviour to assess potential impacts within the migratory BIA (**Table 6-9**), the 95th percentile exposure range to the auditory fatigue TTS threshold are reduced significantly to 18.57 km, 12.40 km and 11.01 km for the Laverda, Cimatti and Vincent surveys, respectively.

Application of the single-pulse PK PTS and TTS thresholds indicates that predicted R_{max} radii from individual shot points are in the range of 30–60 m, however none of the PK TTS thresholds are exceeded when animal movement and behaviour was incorporated into the model.

The predicted maximum distance to the NMFS (2014) marine mammal behavioural threshold for Area C is 6.5 km, across all water depths modelled (refer **Table 6-5**). However, with the inclusion of migratory animal movement and behaviour into the propagation model the 95th percentile exposure range to the behavioural response threshold reduces to 2.81 km, 5.19 and 4.43 km, for the three surveys, with approximately 1.97, 2.46 and 2.94 migrating animals exposed within a 24-hour period.

As described in **Section 4.5.2**, the possible foraging BIA for pygmy blue whales adjacent to Ningaloo Reef and North West Cape appears to be based on the movements of a single individual that showed circling tracks while travelling north through the area during the northbound migration (refer **Figure 4-11**).

Of the three surveys in Area C, the Laverda Acquisition Area is the closest to the boundary of the defined possible foraging BIA, located approximately 14 km away at the closest point. The Acquisition Areas for the Cimatti and Vincent surveys are located at minimum distances of 23 km and 32 km, respectively, from the boundary of the possible foraging BIA. An assessment against the pygmy blue foraging BIA was undertaken by incorporating animal movement and behaviour into the acoustic propagation model and considered the closest acquisition lines to the foraging BIA boundary. The ANIMAT results confirm that no animals will be exposed to injury or behavioural response levels within the foraging BIA for the three surveys within Area C (**Table 6-10)**. The same assessment concluded an estimated 0.64, 0.08 and 0 individual whales exposed to received levels associated with auditory fatigue, over a 24-hour period, for the Laverda, Cimatti and Vincent surveys, respectively.

However, as described in the modelling report (McPherson et al., 2019), the array directionality (i.e. distances to identified isopleths were greater in the broadside direction than in the endfire direction) and frequency content, coupled with the bathymetry, had a considerable effect on propagation at longer distances, with generally larger lobes of sound energy extending into the deeper waters at all modelling sites. This is clearly shown in the sound level contour maps and vertical slice plots for modelling Sites 17 and 18 (for the Laverda survey) in the modelling report (McPherson et al., 2019). An overlay of the low-frequency weighted 168 dB re 1 $\mu Pa^2 \cdot s$ SEL_{24h} isopleth, which represents the possible TTS onset range for the Laverda survey, on the polygon that represents the possible foraging BIA, indicates that there is an area of overlap of approximately 130 km^2. This represents approximately 1.37% of the total area of the foraging BIA. There is no overlap between the 168 dB re 1 $\mu Pa^2 \cdot s$ SEL_{24h} isopleth for the Cimatti and Vincent surveys and the foraging BIA.

Based on the available evidence, marine fauna that have experienced TTS as a result of exposure to high intensity sound recover from any temporary loss of hearing sensitivity within relatively short periods of time (minutes to hours; 24 hours maximum). This short-term, transitory impact is highly unlikely to displace any pygmy blue whales from the possible foraging BIA.

The current schedule is based on acquisition of the Laverda 4D survey in March to early April, and completion of the Cimatti and Vincent surveys in April to May. Woodside will conduct the Petroleum Activities Program with the objective of ensuring there will be no overlap between acquisition of the surveys in Area C and the peak of the northbound migration of pygmy blue whales in the region (May-July; refer **Table 4-5**). To ensure no overlap of TTS with the foraging BIA for pygmy blue whales during peak migration periods, acquisition of Laverda will not occur during May-June.

Cetaceans – Impact Assessment Conclusion

The potential impacts of noise emissions from the seismic source on cetaceans during acquisition of the Petroleum Activities Program are considered to be slight and short-term, and restricted to temporary behavioural changes (avoidance) in individuals moving through the region during the southbound and northbound migrations. Based on current proposed timing and limited duration of the Petroleum Activities Program, the absence of critical habitats or a constricted migratory pathway within the area, and the adaptive management procedures proposed (**Figure 6-2** and discussed in the Demonstration of ALARP and EPO, EPS and MC sub-sections below), predicted noise level from seismic acquisition are not considered likely to cause injury effects or displace any individuals from the possible foraging BIA, or result in any ecologically significant impacts at a population level for pygmy blue whales or any other species of large whale that may be present within or adjacent to Areas A, B or C during the Petroleum Activities Program.

Dugong

Although dugongs were not identified as occurring within Areas A, B or C, they may be present in inshore and coastal waters near Areas A and C. The species is distributed along the WA coast throughout the Gascoyne, Pilbara and Kimberley regions, with notable populations in the:

- Ningaloo Marine Park (State waters) (approximately 9.5 km southeast of Area C)
- Exmouth Gulf (approximately 21 km southeast of Area C), which forms a listed foraging/breeding/nursing/calving BIA with the Ningaloo Marine Park (BIA is approximately 8 km from Area C).

Dugongs can hear low frequency sound but are considered less sensitive to sound than most cetaceans. Although outside of the scope and jurisdiction of the NMFS (2018) report, auditory weightings and PTS/TTS threshold criteria are also defined by NMFS (2018) and Southall et al. (2019) for sirenians (dugongs and manatees). The auditory hearing range of sirenians is sensitive to a slightly lower and narrower range of frequencies than mid-frequency cetaceans (NMFS, 2018; Southall et al., 2019).

Turtles

The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) identifies acute noise interference from anthropogenic noise sources, such as seismic surveys, as a threat to the stocks of green, flatback and loggerhead turtles in the North West Shelf and Pilbara region (refer **Table 4-6**).

Without adequate control measures in place, noise emissions from the seismic source have the potential to impact turtles by causing changes to hearing (PTS and TTS) as a result of high sound levels at close range to the seismic source, or behavioural disturbance impacts at greater distances. Based on the information presented in **Section 4.5.2**, there is the potential for green, flatback, loggerhead and hawksbill turtles to be present within and adjacent to Areas A and C during the nesting seasons for these species in the region (generally October to March; with peak periods over December to February – refer **Table 4-5**). There are no known nesting or foraging sites or BIAs for leatherback turtles in the region, and accordingly this species has been excluded from this impact assessment.

Table 6-9 presents the results of the acoustic modelling study for maximum predicted R_{max} distances to PTS, TTS and behavioural response thresholds in turtles for Areas A, B and C.

Table 6-11: Maximum predicted R_{max} distances (in km) to PTS, TTS and behavioural response thresholds in turtles for Areas A, B and C (McPherson et al., 2019a)

Potential impact	Sound exposure threshold	Area A	Area B	Area C
		R_{max} (km)	R_{max} (km)	R_{max} (km)
PTS	232 dB re 1 µPa (PK)	<0.02	<0.02	<0.02
TTS	226 dB re 1 µPa (PK)	<0.02	<0.02	<0.02
Behavioural response	166 dB re 1 µPa (SPL)	2.9	1.5	3.3
	175 dB re 1 µPa (SPL)	1.0	0.74	0.80

There is a paucity of data about turtle responses to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. For turtles, a PTS threshold of 232 dB re 1 µPa (PK) and TTS threshold of 226 dB re 1 µPa (PK) from Finneran et al. (2017) has been applied, as it represents updated information compared to the information in Popper et al. (2014). Behavioural response thresholds for turtles of 166 dB re 1 µPa (SPL) (NSF, 2011) and 175 dB re 1 µPa (SPL) (Moein et al., 1995) have been applied in the acoustic modelling study and this impact assessment.

Area A

Flatback turtles have a breeding peak in the region between December and February, and a nesting peak in December and January. Given the planned acquisition window for the Pluto and Harmony surveys (any time in the period late

December to May), there is the potential for seismic acquisition to overlap with the peak periods for both breeding and nesting around the Montebello Islands.

As described in **Section 4.5.2**, Area A overlaps a portion of the 'habitat critical' for flatback turtles around the Montebello Islands, which is based on a 60 km internesting buffer surrounding nesting locations at the Montebello Islands, Barrow Island and coastal islands from Cape Preston to Locker Island (Commonwealth of Australia, 2017; refer **Table 4-6**;). Additionally, Area A overlaps a portion of the flatback turtle internesting buffer BIA, which is similar to the habitat critical area but based on a 60 km radius around the Montebello Islands (refer **Figure 4-13**).

In Area A, considering the Finneran et al. (2017) threshold criterion of 232 dB re 1 µPa (single-pulse PK), injury (PTS) effects in turtles are predicted to occur only at extremely close ranges (<20 m) to the operating seismic source. Similarly, based on applying the Finneran et al. (2017) threshold criterion of 226 dB re 1 µPa (single-pulse PK), TTS effects in turtles are not predicted to occur outside a maximum radius of 20 m from each individual shot point (refer **Table 6-9**).

Predicted maximum distances to the NMFS (NSF, 2011) and Moein et al. (1995) behavioural thresholds (single-pulse 166 dB re 1 µPa SPL and 175 dB re 1 µPa SPL, respectively) for Area A range from 1.0 to 2.9 km (refer **Table 6-9**). The Acquisition Areas for the Pluto and Harmony surveys overlaps the 'habitat critical' for flatback turtles around the Montebello Islands (**Figure 6-4**). Therefore, there is the potential for sound levels to exceed the 166 dB re 1 µPa SPL behavioural threshold criterion within the parts of the Acquisition Areas for both surveys that overlap the identified 'habitat critical' area.

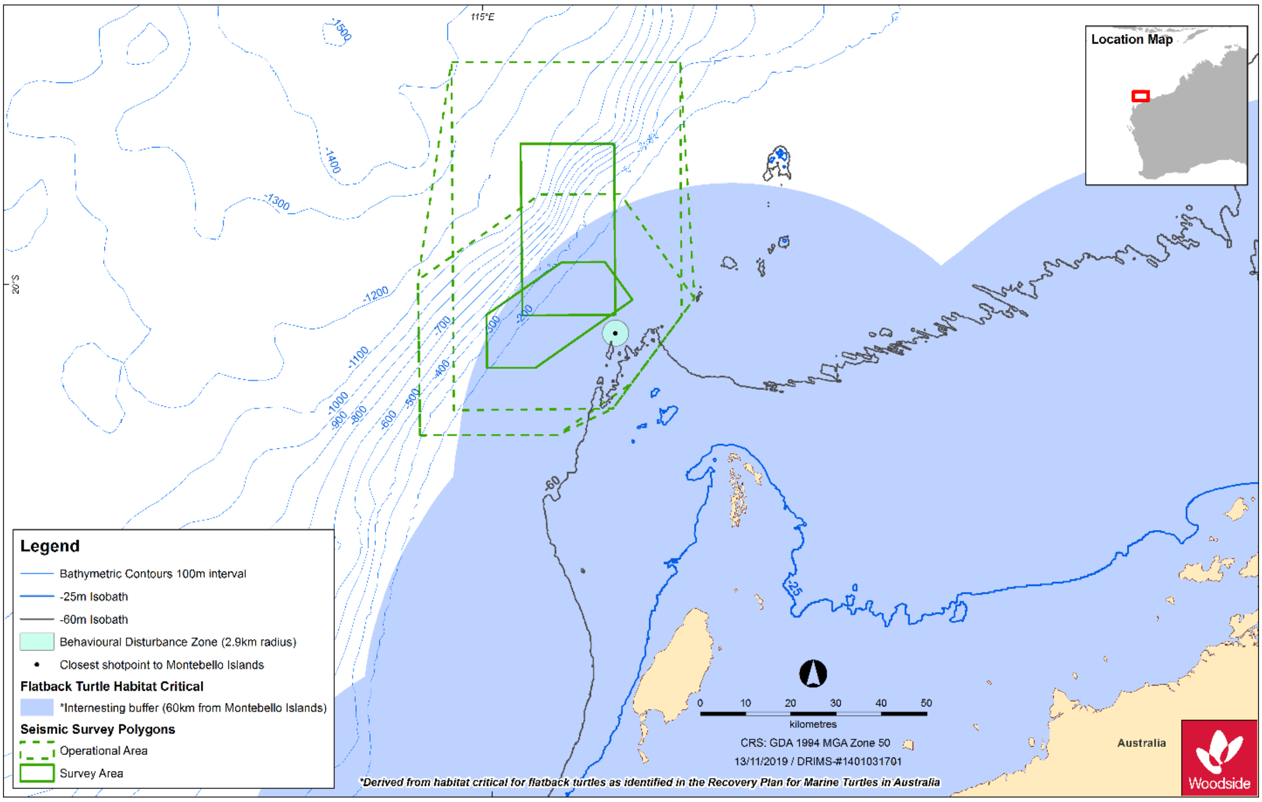

Figure 6-3: Identified 'habitat critical' for flatback turtles around the Montebello Islands

The 60 km internesting buffer for flatback turtles in the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) is based primarily on the movements of tagged internesting flatback turtles along the North West Shelf reported by Whittock et al. (2014), which found that flatback turtles may demonstrate internesting displacement distances up to 62 km from nesting beaches. However, these movements were confined to longshore movements in nearshore coastal waters or travel between island rookeries and the adjacent mainland (Whittock et al., 2014). There is no evidence to date to indicate flatback turtles swim out into deep offshore waters during the internesting period.

A more recent paper by the same authors (Whittock et al., 2016) has more precisely defined flatback turtle internesting habitat along the North West Shelf. The Whittock et al. (2016) study developed a habitat suitability map to identify areas where internesting flatback turtles may be present along the North West Shelf, based on data compiled for a suite of environmental variables and satellite tracks of 47 internesting flatback turtles from five different mainland and island rookeries tracked over 1289 days. Whittock et al. (2016) defined suitable internesting habitat as water 0–16 m deep and within 5–10 km of the coastline, while unsuitable internesting flatback habitat was defined as waters >25 m deep and >27 km from the coastline. The area within the 60 km internesting flatback BIA and 'habitat critical' buffers deemed unsuitable for internesting flatback turtles, based on the latest available evidence from Whittock et al. (2016), is shown in **Figure 6-4**.

As shown in **Figure 6-3**, the Pluto and Harmony Acquisition Areas are located approximately 19 km from the closest waters > 25 m in depth; therefore, there is a buffer distance of at least 16 km between areas where the 166 dB re 1 µPa SPL behavioural threshold criterion for turtles may be exceeded and waters that may represent suitable internesting habitat for flatback turtles.

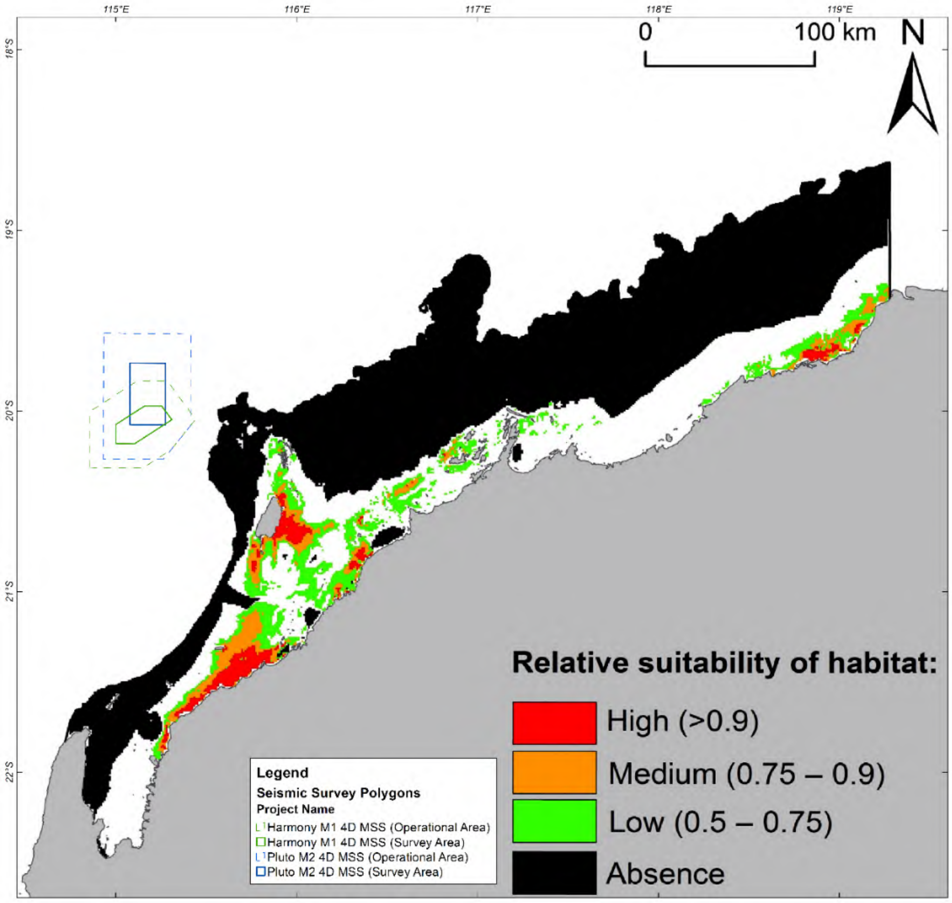

Figure 6-4: Relative suitability of habitat for flatback turtles within the internesting BIA and 'habitat critical' adjacent to the Pilbara coastline (modified from Whittock et al., 2016)

The primary environmental variables that influenced flatback internesting movement were bathymetry, distance from coastline, and sea surface temperature. Suitable areas of internesting habitat were located close to many known flatback turtle rookeries across the region (Whittock et al., 2016). This modelling study clearly demonstrates that all of the internesting buffer BIA and 'habitat critical' overlapped by Area A, or immediately adjacent to it, do not represent suitable habitat for flatback turtles during internesting periods. Hence it is highly unlikely that significant numbers of flatback turtles will be in these offshore, deep waters during the period when the Pluto and Harmony surveys will be acquired.

This interpretation of the suitability of deep, offshore waters adjacent to the Montebello Islands as internesting habitat for flatback turtles has been confirmed by the lead author of the Whittock et al. (2014, 2016) papers:

> "*…the location of the six proposed 4D seismic surveys are highly unlikely to host inter-nesting flatback turtles from the Montebellos and do not represent important inter-nesting habitat. Flatback turtles are known to spend their inter-nesting time resting on the seabed, the areas you describe are simply too deep to support this behaviour (>73 m).*" (Pendoley Environmental Pty Ltd, personal communication, October 2019; see **Table 5-3**; **Appendix F**).

The evidence that suitable internesting habitat for flatback turtles is likely to be limited to relatively shallow waters within close proximity of the coastline is further supported by data from satellite telemetry of 11 flatback turtles after nesting on the Lacepede Islands (Thums et al., 2017). This study found that "*During the inter-nesting phase, flatback turtles remained at an average distance of 15.75 ± 12.25 km from West Lacepede Island, in water depths of 16 ± 3 m…*" (Thums et al., 2017).

The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017) recommends that "*a precautionary approach should be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season*". As described above, acquisition of the Pluto and Harmony 4D surveys will overlap the nesting season for flatback turtles at the Montebellos Islands; however, it is clear from the data available currently that the deep, offshore waters at the outer extent of the 'habitat critical' for flatback turtles around the

Montebello Islands—as identified in the Recovery Plan—do not represent important internesting habitat for this stock of flatback turtles.

Furthermore, the Recovery Plan identifies an action for addressing key threats that is relevant in the context of the Petroleum Activities Program, which is "*Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival*…" (Commonwealth of Australia, 2017). In the event that any flatback turtles present within the identified 'habitat critical' during acquisition of the Pluto and Harmony 4D surveys do exhibit behavioural responses as a result of exposure to acoustic emissions from the seismic source (i.e. within ~ 3 km of the operating source) it is highly unlikely that they would be displaced from the 'habitat critical' area, as they would be more likely to swim inshore into shallower waters rather than offshore into deeper water depths, and would therefore be moving further away from the operating seismic source. Soft starts will be implemented during line run-ins for all surveys acquired during the Petroleum Activities Program and, as pointed out in the Recovery Plan, the soft start provision may also afford protection for turtles. Use of soft starts is likely to elicit a behavioural (avoidance) reaction in any individuals < 3 km from the operating source, which means that these animals are highly unlikely to be exposed to received sound levels at which TTS or PTS effects could occur.

During the previous Pluto 4D M1/B1 MSS, which was acquired over the period 18th November 2015 to 5th February 2016 (i.e. overlapping the nesting season for flatback turtles at the Montebello Islands) there were only four sightings of turtles—one flatback, one leatherback and two unidentified turtles (RPS, 2016). The sightings of the flatback turtle and the two unidentified turtles were recorded in shallower waters of less than 100 m depth in the south-eastern corner of the operational area closest to the Lowendal, Montebello and Barrow islands, and the sighting of the leatherback turtle was off the edge of the continental shelf in a water depth of approximately 1200 m (RPS, 2016). A 500 m shutdown distance was applied during the Pluto 4D M1/B1 MSS, and there were no turtle-instigated shutdowns of the seismic source during the survey. As the Pluto and Harmony 4D surveys will be acquired in a location that is spatially on the edge of an area that is considered to provide biologically important habitat for turtles (i.e. the identified 'habitat critical' and internesting buffer BIA around the Montebello Islands), and as the surveys will overlap the nesting season, additional adaptive management procedures will be implemented to manage the likelihood of encountering higher numbers of turtles than expected. These procedures are based on the cessation of acquisition at night-time or periods of poor visibility if there are three consecutive days during which there have been three or more turtle-instigated shutdowns (see **Figure 6-5**).

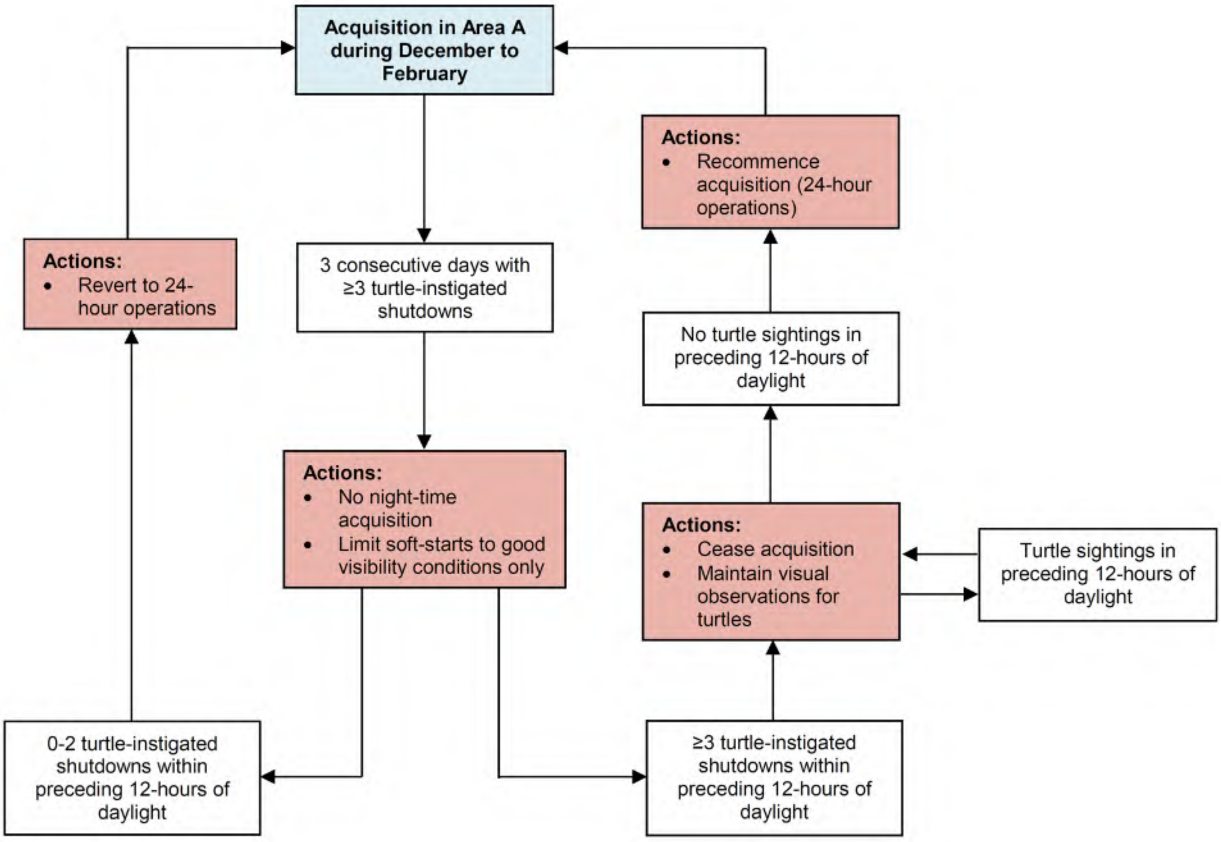

Figure 6-5: Turtle adaptive management procedures to be applied during acquisition in Area A in December to February

The boundary of the 'habitat critical' for green turtles around the Montebello Islands, which is based on a 20 km radius around the islands, is located approximately 20 km from the Acquisition Areas for the Pluto and Harmony surveys.

Hence, no impacts from noise emissions from the seismic source are likely to occur to any green turtles present within this 'habitat critical' during internesting periods.

Therefore, the potential impacts of noise emissions from the seismic source on flatback and green turtles during acquisition of the Pluto and Harmony surveys in Area A are considered to be slight and short-term, and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area close to the operating seismic source. Based on current proposed timing and duration (up to 56 days) of the Petroleum Activities Program in Area A, the absence of suitable habitat for internesting turtles, and the control measures proposed (**Figure 6-5**; and discussed in the Demonstration of ALARP and EPO, EPS and MC sub-sections below) predicted noise levels from seismic acquisition are not considered likely to cause injury (PTS) effects, displace any individuals from the 'habitat critical' or internesting BIA, or result in any ecologically significant impacts at a population level for any species of turtle that may be present within or adjacent to Area A during the Petroleum Activities Program.

Area B

The Scarborough survey Operational Area is located in the offshore waters of the Exmouth Plateau, in water depths of 961–1242 m. At the closest point, the Operational Area is located at least 152 km from the boundary of the flatback turtle internesting BIA around the Montebello Islands, and at least 173 km from the ''habitat critical'' for flatback and green turtles (refer **Figure 4-13**). Therefore, the Operational Area does not contain any suitable internesting or foraging habitat for either species of turtle. Given the maximum impact radii for PTS, TTS and behavioural response thresholds predicted by the acoustic modelling study (refer **Table 6-9**), the potential impacts of noise emissions from the seismic source on flatback and green turtles during acquisition of the Scarborough survey in Area B are considered to be localised and of no lasting effect, and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area close to the operating seismic source.

Area C

The Laverda, Cimatti and Vincent 4D surveys in Area C, which will be acquired in the period March to May 2020, will not overlap the peak periods for breeding or nesting for flatback, green, loggerhead and hawksbill turtles in the region (refer **Table 4-5**).

As described in **Section 4.5.2**, Area C does not overlap the 'habitat critical' for flatback turtles, which is based on a 60 km internesting buffer surrounding nesting locations at the coastal islands from Cape Preston to Locker Island. Area C overlaps a very small portion of the green turtle 'habitat critical' around North West Cape, which is based on a 20 km internesting buffer (refer **Table 4-6**). Area C also overlaps small parts of the internesting BIAs for flatback, green, loggerhead and hawksbill turtles around the Muiron Islands and North West Cape (refer **Figure 4-13**).

There is no overlap between the Laverda and Cimatti Acquisition Areas and the 'habitat critical' for green turtles. At the closest points, the Laverda and Cimatti Acquisition Areas are located approximately 14 km and 13 km from the green turtle 'habitat critical', respectively.

As discussed above, the offshore, deep waters of Area C (39–1382 m water depths) are extremely unlikely to represent suitable habitat for internesting flatback or green turtles (Pendoley Environmental Pty Ltd, personal communication, October 2019). Suitable internesting habitat for green turtles is also likely to be limited to relatively shallow waters within close proximity of the coastline. Hays et al. (2000) deployed time-depth recorders on green turtles that had nested on Ascension Island in the South Atlantic, to examine their diving behaviour during the subsequent internesting interval. All the turtles performed dives where they remained at a fixed depth for a long period, surfaced briefly and then dived to the same depth again. It is generally believed these dive profiles are caused by the turtles resting on the seabed. The maximum depth that turtles routinely reached on these resting dives was between 18 and 20 m, with resting dives deeper than 20 m being extremely rare (Hays et al., 2000).

None of the Acquisition Areas for the Laverda, Cimatti and Vincent surveys overlap any of the internesting BIAs for flatback, green, loggerhead and hawksbill turtles. At the closest point, the Vincent Acquisition Area is located approximately 3 km from the boundary of the flatback turtle internesting BIA, this represents the minimum distance between any of the Acquisition Areas and the internesting BIAs for all four turtle species.

In Area C, considering the 232 dB re 1 µPa (single-pulse PK) threshold criterion, distance to PTS thresholds in turtles are predicted to occur only at extremely close ranges (<20 m) of the operating seismic source. Similarly, based on applying the 226 dB re 1 µPa (single-pulse PK) threshold criterion, TTS in turtles are not predicted to occur outside a maximum radius of 20 m from each individual shot point (refer **Table 6-9**).

Site 18 was the closest single shot location to the green turtle 'habitat critical' boundary modelled for the Laverda survey. Site 18 is located approximately 13 km from the 'habitat critical' boundary. Predicted maximum distances to the single-pulse 166 dB re 1 µPa SPL and 175 dB re 1 µPa SPL behavioural thresholds for Site 18 range from 0.6 to 1.3 km. Therefore, no behavioural disturbance to green turtles within the 'habitat critical' for green turtles around North West Cape is likely to occur, based on a minimum separation distance between the closest shot point with the source at full power and the 'habitat critical' boundary of 13 km.

Turtles – Impact Assessment Conclusion

The potential impacts of noise emissions from the seismic source on flatback, green, loggerhead and hawksbill turtles during acquisition of the Petroleum Activities Program are considered to be slight and short-term, and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area close to the operating seismic source. Based on current proposed timing and duration of the Petroleum Activities Program, the absence of suitable habitat for internesting turtles, and the adaptive management procedures proposed (**Figure 6-5**; and discussed in the Demonstration of ALARP and EPO, EPS and MC sub-sections below), predicted noise levels from seismic acquisition are not considered likely to cause injury (PTS) effects, displace any individuals from the internesting BIA or 'habitat critical' areas, or result in any ecologically significant impacts at a population level for any species of turtle that may be present within or adjacent to Areas A, B or C during the Petroleum Activities Program. Acquisition of the 4D surveys will not displace any individuals from identified 'habitat critical' and will therefore be consistent with the objectives and actions of the Recovery Plan for Marine Turtles in Australia.

Seabirds and Migratory Shorebirds

As described in **Section 4.5.2**, 15 species of listed birds were identified by the EPBC Act Protected Matters Search (**Appendix C**) as potentially occurring within Areas A, B or C, of which six are listed as Threatened (**Table 4-3**). Thirteen of these were identified within Area A (five listed as Threatened), seven within Area B (two listed as Threatened), and fourteen within Area C (six listed as Threatened). Seven species were identified as occurring within all three Areas:

- red knot (Endangered and Migratory)
- common sandpiper (Migratory)
- common noddy (Migratory)
- sharp-tailed sandpiper (Migratory)
- pectoral sandpiper (Migratory)
- lesser frigatebird (Migratory)
- southern giant petrel (Endangered and Migratory).

Seabird species that spend the majority of their lives within the region breed at locations along the coast of Australia and at offshore islands. Area A overlaps a breeding BIA for the wedge-tailed shearwater, and Areas A and C are located adjacent to a number of other nesting or foraging BIAs:

- Australian fairy tern breeding (July to October) and foraging BIAs, located 17 and 7 km from Areas A and C, respectively
- roseate tern breeding (mid-March to July) and foraging BIAs, located 23 and 57 km from Areas A and C respectively
- wedge-tailed shearwater foraging (in association with nesting BIAs August to April), located 21 and 10 km from Areas A and C, respectively.

Impacts to foraging seabirds have not been observed previously during seismic surveys. Only birds diving and foraging within Areas A, B and C have the potential to be exposed to increased sound levels generated by the operating seismic source while diving for small pelagic fishes near the sea surface. Such behaviours may result in a startle response during diving. Birds resting on the surface of the water in proximity to the seismic vessel have limited potential to be affected by sound emissions underwater, due to the limited transmission of sound energy between the water/air interface but may be startled by seismic pulses close to the seismic source. However, given the likely avoidance response from fish and other prey species in waters immediately surrounding the seismic source, birds are unlikely to forage near the operating seismic source. In the unlikely event that birds dive and forage near the seismic source, this is likely to only affect individual birds, resulting in a startle response, with the affected birds expected to move away from the area as a result. The consequence of this is expected to be negligible and impacts at a population level are extremely unlikely to occur. Wedge-tailed shearwaters, fairy terns and roseate terns will not be displaced from the wider areas of their breeding and foraging BIAs.

<u>Seabirds – Impact Assessment Conclusion</u>

The behaviour and distribution of some fishes may be affected for short periods during and after exposure to the seismic source, which may result in short-term and localised changes in the distribution of target prey species for some seabirds. However, these effects are unlikely to be discernible to foraging birds in the context of the normal movements and variation in the distribution of fishes. The behaviours and distribution of prey at any one time will remain largely unaffected throughout the BIAs and in Areas A, B and C. Therefore, impacts to seabird and migratory shorebird populations are highly unlikely to occur.

Fishes and Elasmobranchs

The EPBC Protected Matters Search (refer **Section 4.5.2**) identified 29 pipefish and six seahorse species within Area A, and 26 pipefish and five seahorse species within Area C. No pipefish or seahorses were identified as potentially occurring within Area B, largely due to the water depths in Area B (>900 m). Pipefish and seahorses occur in nearshore and coastal waters comprising suitable habitat, such as seagrass, mangrove, coral reef and sandy habitats around coastal islands and shallow reef areas. Due to water depths and absence of known habitat, pipefish and seahorses are unlikely to occur within Areas A, B or C. Consequently, these listed marine species are not considered in this impact assessment.

Without adequate control measures in place, noise emissions from the seismic source have the potential to impact fishes (bony fishes; teleosts) and elasmobranchs (sharks and rays) by causing mortality/potential mortal injury (PMI), recoverable injury and hearing impairment (TTS and masking) as a result of high sound levels at close range to the seismic source, or behavioural disturbance impacts at greater distances. As described in **Section 4.5.1** and

Section 4.5.2, Areas A, B and C are likely to overlap habitats that support diverse communities of fishes and elasmobranchs.

The modelling study assessed the ranges for quantitative criteria based on the Popper et al. (2014) guidelines, and considered both PK and SEL_{24h} metrics for both water column and seafloor associated with mortality/PMI and impairment in the following groups:

- fish without a swim bladder (also appropriate for sharks in the absence of other information)
- fish with a swim bladder that do not use it for hearing
- fish that use their swim bladders for hearing
- fish eggs and fish larvae.

The most relevant metric for perceiving underwater sound for most fish species is particle motion but, except for a few species (Popper and Fay, 2011; Popper et al., 2014), there is an almost complete lack of relevant data on particle motion sensitivity in fishes (Popper and Hawkins, 2018). The majority of fish species detect sounds from below 50 Hz up to 500–1500 Hz. A smaller number of species can detect sounds to over 3 kHz, while a very few species can detect sounds to well over 100 kHz. The critical issue for understanding whether an anthropogenic sound affects hearing is whether it is within the hearing frequency range of a fish and loud enough to be detectable above background ambient noise. For this impact assessment, it is assumed all fishes can detect signals below 500 Hz and so can 'hear' the seismic source.

Table 6-10 presents the results of the acoustic modelling study for maximum predicted R_{max} distances to injury and TTS thresholds in fishes for Areas A, B and C. Data is presented for both the water column (MOD) and at the seafloor, apart from Area B, where results are presented only for the water column. Due to the water depths in Area B (960–1240 m), the sound exposure thresholds for fish injury and TTS were not exceeded at the seafloor for the single site modelled.

Table 6-12: Maximum predicted R_{max} distances (I km) to injury and TTS thresholds for fish, fish eggs, and larvae for single-pulse and SEL_{24h} modelled scenarios, for both water column and at the seafloor, for Areas A, B and C (McPherson et al., 2019)

Relevant hearing group	Potential impact	Sound exposure threshold	Water column (MOD)			Seafloor	
			R_{max} (km)			R_{max} (km)	
			Area A	*Area B*	*Area C*	*Area A*	*Area C*
Fish: No swim bladder (incl. sharks)	Injury	213 dB re 1 µPa (PK)	0.06	0.05	0.06	0.06	-
		219 dB re 1 µPa^2·s (SEL_{24h})	0.06	<0.09	<0.06	-	-
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	2.54	14.0	5.16	2.38	2.78
Fish: Swim bladder not involved in hearing Swim bladder involved in hearing	Injury	207 dB re 1 µPa (PK)	0.11	0.11	0.11	0.13	0.05
		219 dB re 1 µPa^2·s (SEL_{24h})	0.06	<0.09	<0.06	-	-
	TTS	186 dB re 1 µPa^2·s (SEL_{24h})	2.54	14.0	5.16	2.38	2.78
Fish eggs, and larvae	Injury	207 dB re 1 µPa (PK)	0.11	0.11	0.11	0.13	0.05
		210 dB re 1 µPa^2·s (SEL_{24h})	0.06	0.09	0.06	-	-

A dash indicates the level was not reached.

The following fish types have been identified for this assessment:

- site-attached species associated with the Ancient Coastline at 125 m Depth Contour KEF
- demersal fish species, including commercial fish species such as tropical snappers and emperors (families *Lutjanidae* and *Lethrinidae*)
- pelagic fish species, including commercial fish species such as mackerel
- whale sharks.

<u>Ancient Coastline at 125 m Depth Contour KEF</u>

As shown in **Table 6-10**, the maximum predicted R_{max} distances to the injury thresholds of 213 dB re 1 µPa (PK) and 207 dB re 1 µPa (PK) at the seafloor for all hearing groups of fishes, and for fish eggs and larvae, range from 50 m in Area C to 130 m in Area A. The maximum predicted R_{max} distances to the TTS threshold of 186 dB re 1 µPa²s (SEL_{24h}) at the seafloor for all hearing groups of fishes, and for fish eggs and larvae, range from 2.38 km in Area A to 2.78 km in Area C.

The area of overlap between the Ancient Coastline at 125 m Depth Contour KEF and the Acquisition Areas for the Pluto and Harmony surveys in Area A is approximately 75 km², which represents less than 0.5% of the designated area of the KEF. Given the maximum predicted R_{max} distances for injury and TTS effects in Area A of 130 m and 2.38 km, respectively, there is the potential for some fishes at the seafloor to experience recoverable injury and TTS effects.

However, these potential impacts are not likely to be ecologically significant at a population level for the following reasons:

- There is very limited spatial and temporal overlap with the KEF – <0.5% of the total area of the KEF, and 56 days of seismic acquisition.
- A recent ROV survey of the proposed Scarborough project trunkline route within the Montebello AMP assessed benthic habitats within the Ancient Coastline KEF. The results of this survey indicated that benthic habitat was typically bare sand with various bedforms. No moderate or high relief features or areas of consolidated hard substrate were present. Benthic organisms (sponges and soft corals) typically occurred as single or very low density aggregations (Advisian, 2019). The environmental values of the KEF refer to potential areas of hard substrate or rocky escarpments that may provide enhanced biodiversity or biologically important habitat in areas otherwise dominated by soft sediments. However, these features were not observed within the portion of the KEF surveyed.
- The sound exposure thresholds applied are highly conservative and the criteria predicting the largest impact ranges (across all of the modelled sites and scenarios) have been used, providing further conservatism in the impact assessment.
- The area of potential impact assumes the area will receive the same sound levels at the same time for the period of a survey, which is not the case. The received sound levels at a location will reduce and increase as the seismic vessel moves through the area during a survey.
- Mortality of fish (both immediate and delayed) is considered highly unlikely based on no documented cases of fish mortality upon exposure to seismic airgun sound under experimental or field operating conditions (ERM, 2017).
- The area of potential impact for the assessed species is a low proportion of the area they are likely to inhabit. Thus, population effects are not likely as a significant proportion of the population remains unaffected.
- The potential area of impact for fish TTS is assessed as being acceptable based on hearing loss (and subsequent decrease in fitness) being temporary and recovery taking place in a relatively short timeframe after the source array has moved away from the exposed fish, and the sound levels are reduced. Popper et al. (2005) reports that fish that showed TTS recovered to normal hearing levels within 18–24 hours.
- Popper (2018) in his review of TTS for the Santos Bethany 3D MSS, which considered similar fish species as present in Area A, noted:
  - It is highly unlikely that there would be physical damage to fishes as a result of the survey, unless the animals are very close to the source (perhaps within a few metres).
  - Most fishes in the Bethany region (and given the similarity in fish species, this also applies for the North West Shelf region), being species that do not have hearing specialisations, are not likely to have much (if any) TTS as a result of the Bethany 3D survey.
  - If TTS takes place, its level is likely to be sufficiently low that it will not be possible to easily differentiate it from normal variations in hearing sensitivity. Even if fishes do show some TTS, recovery will start as soon as the most intense sounds end, and recovery is likely to even occur, to a limited degree, between seismic pulses. Based on very limited data, recovery within 24 hours (or less) is very likely.
  - Nothing is known about the behavioural implications of TTS in fishes in the wild. However, since the TTS is likely very transitory, the likelihood of it having a significant impact on fish fitness is very low.

Based on qualitative approach applied in Popper et al. (2014), the likelihood of behavioural effects occurring is assessed as high within tens of metres of the seismic source (refer **Table 6-10**). Site-attached fish communities at 125 m depth are therefore not likely to exhibit behavioural responses to noise emissions from the seismic source.

As described above, the area of overlap between the Pluto and Harmony Acquisition Areas and the KEF is extremely small (75 km² – <0.5%). The SPRAT profile for the Ancient Coastline at 125 m Depth Contour KEF states "*Little is known about fauna associated with the hard substrate of the escarpment, but it is likely to include sponges, corals, crinoids, molluscs, echinoderms and other benthic invertebrates*". There is little published information about the fish communities associated with the KEF but due to the presence of epibenthic communities associated with hard substrate, it was considered that some demersal and site-attached fish species may be present. A recent study by Santos for the portion of the KEF within the Keraudren 3D MSS area indicated that a consistent structurally complex seabed feature that may provide unique habitat for demersal and site-attached fish was not evident (Santos, 2019). However, an area of high relief and greater demersal fish abundance and diversity was described in the 95 to 115 m depth range outside of the Keraudren survey area.

None of the three Acquisition Areas in Area C overlap the KEF. At the closest point the Vincent Acquisition Area is located approximately 18 km from the KEF; therefore, no impacts to fish communities of the KEF are likely to occur as a result of acquisition of the Laverda, Cimatti and Vincent surveys.

<u>Continental Slope Demersal Fish Communities KEF</u>

The Continental Slope Demersal Fish Communities KEF overlaps the Acquisition Areas for all five surveys in Areas A and C (refer **Section 4.7.4**; **Figure 4-23**). However, the minimum water depths for the areas of overlap between the KEF and the Acquisition Areas are:

- Pluto – 199 m
- Harmony – 301 m
- Vincent – 282 m
- Cimatti – 451 m
- Laverda – 801 m.

As shown in **Table 6-10**, the maximum predicted R_{max} distance to the injury threshold at the seafloor for the hearing group of fishes with swim bladders (which would represent most demersal fish), range from 50 m in Area C to 130 m in Area A. The maximum predicted R_{max} distances to the injury thresholds for adult fish (with swim bladder), and fish eggs and larvae, in the water column is <110 m for both Areas A and C. Therefore, no injury effects are likely to occur to any demersal fishes at or close to the seafloor within or adjacent to any of the Acquisition Areas in either Areas A or C.

Based on the maximum predicted R_{max} distances to the TTS threshold for both Areas A and C (5.16 km in the water column; 2.78 km at the seafloor), individuals in demersal fish communities at or close to the seafloor within the Acquisition Areas could experience TTS effects. However, these effects are not likely to be significant for the reasons outlined above. Demersal fish species, such as snapper, emperor and cod, though not as strong swimmers as pelagic fish species, cannot be regarded as 'site-attached' as they can move away from an approaching seismic source. Thus, TTS effects are unlikely to occur as an individual would have to remain within a range of either 5.16 km (in the water column) or 2.78 km (at the seafloor) of the operating seismic source for a full 24 hour period to be exposed to sound levels that could cause TTS.

Demersal fish communities at water depths ranging from 199–801 m are not likely to exhibit any behavioural responses to noise emissions from the seismic source.

Pelagic Fishes

Most pelagic fishes likely to be present in the region would belong to the Suborder Scombroidei, which includes all of the large, pelagic, fast-swimming fish species: Family Sphyraenidae (barracudas); Family Gempylidae (snake mackerels); Family Trichiuridae (cutlassfishes); Family Scombridae (mackerels and tunas); Family Xiphiidae (swordfishes); and Family Istiophoridae (billfishes).

Scombridae species are hearing generalists (narrower frequency range with higher auditory thresholds), in that most species in these families possess a swim bladder but lack the mechanical connection to the inner ear and the otoliths. As a group, they seem able to detect mid-range frequencies (~300–1000 Hz).

As shown in **Table 6-10**, the maximum predicted R_{max} distance to the injury threshold in the water column for the hearing group of fishes with swim bladders, is <110 m in Areas A, B and C. The maximum predicted R_{max} distances to the TTS threshold for this fish hearing group are 2.54 km (Area A), 14 km (Area B) and 5.16 km (Area C).

Large, pelagic, fast-swimming fish species such as mackerel, billfishes and tunas are highly unlikely to experience TTS effects as they can swim away from a seismic source. Individuals would have to remain within ranges of approximately 2.5 to 14 km of the operating seismic source for a full 24-hour period to be exposed to sound levels that could cause TTS. Pelagic fishes are most likely to exhibit behavioural responses (avoidance) by moving away from an operating seismic source that approaches within a few tens of metres of them.

Whale Sharks

Areas A and C overlap the foraging BIA for whale sharks that extends northeast from North West Cape across the North West Shelf (refer **Figure 4-15**). This BIA is centred on the 200 m isobath and covers the period from July (post-aggregation at Ningaloo) through to November. Satellite tracks of whale sharks moving in a northeast direction from Ningaloo show individuals transiting Areas A, B and C. Based on the temporal limits of this BIA (July to November), there is unlikely to be any overlap between the Petroleum Activities Program and movements of whale sharks within this BIA. However, it is possible individuals may transit through Areas A, B and C during their annual migration to the aggregation area off Ningaloo Reef, particularly in the weeks before the start of the aggregation (i.e. early March through to April). Hence, it is possible whale sharks may be in Area C during acquisition of the Laverda, Cimatti and Vincent surveys.

No sound exposure thresholds currently exist for acoustic impacts to sharks from seismic sources. As a conservative and precautionary approach, the Popper et al. (2014) exposure guidelines for fish with no swim bladder for injury; 213 dB re 1 µPa (PK) and 219 dB re 1 $\mu Pa^2 \cdot s$ (SEL_{24h}); and TTS (186 dB re 1 $\mu Pa^2 \cdot s$ (SEL_{24h}), have been used for this assessment.

As shown in **Table 6-10**, the maximum predicted R_{max} distance to the injury threshold in the water column for the hearing group of fishes without swim bladders, is 60 m in Areas A and C, and 90 m in Area B. The maximum predicted R_{max} distances to the TTS threshold for this fish hearing group are 2.54 km (Area A), 14 km (Area B) and 5.16 km (Area C). Again, it is important to appreciate that individual whale sharks would have to remain within ranges of approximately 2.5 to 14 km of the operating seismic source (which is also moving) for a full 24-hour period to be exposed to sound levels that could cause TTS.

It is expected that the potential effects to whale sharks associated with acoustic noise will be the same as for other pelagic fish species, resulting in minor and temporary behavioural change such as avoidance. This aligns with Popper et al. (2014) guidelines, which detail that there is the potential for a high risk of behavioural impacts in fish species near (tens of metres) the seismic source, with the level of risk declining to low at thousands of metres from the seismic source.

Given the ranges to behavioural and TTS impacts outlined above, there is no likelihood of any effects occurring to whale sharks aggregating at Ningaloo Reef at the start of the aggregation season in March. At the closest point, the Cimatti and Vincent Acquisition Areas (where acquisition may occur from late March through to early May) are located at least 25 km from the designated 'foraging (high density prey)' BIA off Ningaloo Reef.

Seismic noise has not been identified as a threat to whale sharks (or other shark species identified as possibly present in the region) in either the Approved Conservation Advice (Threatened Species Scientific Committee, 2015) or previously in force Whale Shark Recovery Plan 2005–2010 (DEH, 2005). Noise pollution is not identified as a pressure to whale sharks in the Marine Bioregional Plan for the NWMR (DSEWPaC, 2012), or in the Ningaloo Coast: World Heritage nomination report (Commonwealth of Australia, 2010).

Fishes and Elasmobranchs – Impact Assessment Conclusion

The potential impacts of noise emissions from the seismic source on fishes and elasmobranchs during the Petroleum Activities Program are considered to be localised and of no lasting effect and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source. Based on the timing and duration (up to 148 days) of seismic acquisition in Areas A, B and C, and the control measures proposed (discussed in the Demonstration of ALARP and EPO, EPS and MC sub-sections below), predicted noise levels from seismic acquisition are not considered likely to cause injury or TTS effects, displace any whale sharks from the foraging (high density prey) BIA off Ningaloo Reef, or result in any ecologically significant impacts at a population level for any species of fishes that may be present within or adjacent to Areas A, B or C during the Petroleum Activities Program.

Benthic Invertebrates

Research is ongoing into the relationship between sound and its effects on crustaceans, including the relevant metrics for both effect and impact. Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and mollusc 'hearing'. Water depth and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, thus more relevant to effects on crustaceans and molluscs (including bivalves) (McPherson et al., 2019).

While the silver-lipped pearl oyster (*Pinctada maxima*) has been recorded at maximum water depths of 100 m, adults are mostly found in shallow waters (10–15 m) in inshore, coastal areas, and the species is targeted in the Pearl Oyster Managed Fishery out to water depths of approximately 30–40 m. Consultation between other seismic survey titleholders and the PPA has confirmed there may be pearl oyster brood stock out to a depth of approximately 50 m, but any seismic survey activity in water depths >70 m was of no concern to the PPA with regards to potential impacts on adult shell (Santos, 2019). Minimum water depths in the Acquisition Areas for the six surveys that comprise the Petroleum Activities Program in Areas A, B and C range from 73 m to 806 m. Therefore, all seismic acquisition will take place in water depths well outside the normal range for pearl oyster broodstock. Potential impacts to adult pearl oyster have, therefore, not been considered as part of this impact assessment for benthic invertebrates.

Accordingly, the following benthic invertebrates have been identified for this assessment:

- crustaceans, sponges and corals associated with the Ancient Coastline at 125 m Depth Contour KEF.

A range of sound exposure thresholds, from 202 dB re 1 µPa PK-PK to 212 dB re 1 µPa PK-PK, based on the findings of the Payne et al. (2008) and Day et al. (2016) studies, were applied in the acoustic modelling study (**Table 6-11**). The Payne et al. (2008) 202 dB re 1 µPa PK-PK is considered to be associated with no impacts to benthic crustaceans (such as prawns, scampi and lobsters), whereas the 209–212 re 1 µPa PK-PK thresholds could be associated with some level of sub-lethal effects in these animals.

Table 6-13: Maximum predicted R_{max} distances to effect thresholds for crustaceans at the seafloor for Areas A and C

Sound exposure threshold	Area A	Area C
	R_{max} (m)	R_{max} (m)
212 dB re 1 µPa (PK-PK)	129	72
211 dB re 1 µPa (PK-PK)	147	99
210 dB re 1 µPa (PK-PK)	165	127
209 dB re 1 µPa (PK-PK)	185	154
202 dB re 1 µPa (PK-PK)	375	424

As shown in **Table 6-11**, at a sound exposure threshold of 209 dB re 1 µPa PK-PK, maximum predicted R_{max} distances were between 154 m and 185 m for Areas C and A, respectively. Due to the water depths in Area B (960–1240 m) the sound exposure threshold of 202 dB re 1 µPa PK-PK was not exceeded at the seafloor for the single site modelled.

The PK sound level at the seafloor directly underneath the seismic source was estimated at all modelling sites considered for seafloor fish receptors and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals

(Heyward et al., 2018); it was found that the level was not reached at any of the five sites that were considered as part of the modelling study.

As described above, the area of overlap between the Ancient Coastline at 125 m Depth Contour KEF and the Acquisition Areas for the Pluto and Harmony surveys in Area A is approximately 75 km², which represents less than 0.5% of the designated area of the KEF. Given the maximum predicted R_{max} distances for impacts to crustaceans ranging from 154 m to 185 m, there is the potential for some crustaceans on the seafloor within the KEF to experience sound levels that could result in some low-level, sub-lethal effects (e.g. impairment of reflexes, damage to statocysts and reduction in numbers of haemocytes). These sub-lethal effects could reduce fitness of some individuals. However, it is unlikely this would occur to the majority of individuals within the Acquisition Areas for each survey; therefore, impacts at a population level due to reduced fitness would be unlikely as there would be sufficient unaffected individuals to maintain the population.

At received noise levels of 209 dB re µPa (PK-PK) (Day et al., 2016) did not observe any impacts to embryonic development, with hatched larvae found to be unaffected in terms of egg development, the number of hatched larvae, larval dry mass and energy content and larval competency (i.e. survival in adverse conditions); thus, recruitment should be unaffected. Therefore, impacts at a population level due to reduced recruitment would be unlikely to occur.

Benthic Invertebrates – Impact Assessment Conclusion

The potential impacts of noise emissions from the seismic source on benthic invertebrates during the Petroleum Activities Program are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any species of invertebrate that may be present on the seafloor within or adjacent to Areas A, B or C.

Plankton

Plankton is a collective term for all marine organisms that are unable to swim against a current. This group is diverse and includes phytoplankton (plants) and zooplankton (animals), as well as fish and invertebrate eggs and larvae. There is no scientific information about the potential for noise-induced effect in phytoplankton and no functional cause-effect relationship has been established. Noise-induced effects on zooplankton, such as copepods, cladocerans, chaetognaths and euphausiids, have been investigated in a number of sound exposure experiments. Parry et al. (2002) studied the abundance of plankton after exposure to airgun sounds but found no evidence of mortality or changes in catch-rate at a population-level.

Plankton includes fish eggs and larvae that are transported by currents and winds and hence cannot evade seismic sources. Larval fish species studied appear to have hearing frequency ranges similar to those of adults and similar acoustic startle thresholds (Popper et al., 2014). Swim bladders may develop during the larval stage and may render larvae susceptible to pressure-related injuries such as barotrauma. Effects of sound upon eggs, and larvae containing gas bubbles, is focused on barotrauma rather than hearing (Popper et al., 2014). Larval stages are often considered more sensitive to stressors than adult stages, but exposure to seismic sound reveals no differences in larval mortality or abundance for fish, crabs or scallops (Carroll et al., 2017).

McCauley et al. (2017) showed potential for zooplankton mortality and reduction in abundance out to more extended ranges (1.2 km) at levels up to 178 dB re 1 µPa PK-PK pressure using a single 150 cui airgun. Various aspects of the study methodology were reviewed by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) who noted that some aspects of the study warranted further investigation (Richardson et al., 2017), specifically;

- why there was no attention of the impact with distance
- why there was an immediate decline in abundance faster than the rate dead zooplankton would sink to the seabed or be predated
- the fact the study was based on a very small size: six exposure samples for each of the two days.

In addition to the CSIRO review, International Association of Geophysical Contractors (IAGC) commissioned five independent scientists (IAGC, 2017) to critically review McCauley et al. (2017), which summarised the results as preliminary due to a number of limitations associated with the experimental design including:

- inadequate sample size
- water column movement data insufficient to support the contention of a ‘hole’ in the plankton field
- towed net and acoustic survey data disagreeing about zooplankton class size
- bottom sampling that should have been undertaken but was not conducted.

CSIRO (Richardson et al., 2017) also modelled the effect proposed by McCauley et al. (2017) in the context of ocean ecosystem dynamic and zooplankton population dynamic. The CSIRO report found that even if the full effect claimed by McCauley et al. (2017) did in fact exist, plankton abundance would not be adversely affected during the extensive movement of water masses carrying plankton through survey areas, and the rapid reproductive cycle and high reproductive potential characteristics of planktonic organisms. The CSIRO study showed that it would take approximately three days after the end of a typical 4000 cui seismic exploration survey for the plankton to recover to original levels. The results of Richardson et al. (2017) are considered appropriate to this impact assessment, given the study was conducted using a 4000 cui 35-day survey in the North West Shelf across similar depths to the proposed Petroleum Activities Program. Additional to the results of Richardson et al. (2017), this impact assessment has applied specific sound exposure thresholds for fish eggs and larvae from Popper et al. (2014) (refer **Table 6-10**).

Areas identified as places where zooplankton populations may be more important (e.g. as a food source) are:

- possible foraging BIA for pygmy blue whales adjacent to Ningaloo Reef and North West Cape
- foraging (high density prey) BIA for whale sharks adjacent to Ningaloo Reef
- key spawning areas for commercially targeted fish species (assessed under "Fish Spawning" below).

For this impact assessment the sound exposure thresholds for mortality/PMI to fish eggs and larvae from Popper et al. (2014) (refer **Table 6-12**) have been applied.

Table 6-14: Maximum predicted R_{max} distances (in km) to mortality/PMI thresholds in the water column for fish eggs and larvae and zooplankton, for Areas A and C (McPherson et al., 2019)

Sound exposure threshold	Area A	Area B	Area C
	R_{max} (km)	*R_{max} (km)*	*R_{max} (km)*
210 dB re 1 µPa^2·s (SEL_{24h})	0.06	0.09	0.06
207 dB re 1 µPa (PK)	0.11	0.11	0.11

As shown in **Table 6-12**, the maximum predicted R_{max} distance for mortality/PMI effects in fish eggs and larvae, based on applying the Popper et al. (2014) single-pulse 207 dB re 1 µPa (PK) threshold is <110 m, for Areas A, B and C. Based on applying this sound exposure threshold, and the outcomes of the modelling study, there would be no impacts to zooplankton communities (including fish eggs and larvae) within the possible foraging BIA for pygmy blue whales, or the foraging (high density prey) BIA for whale sharks adjacent to Ningaloo Reef, as neither of these BIA are overlapped by any of the Acquisition Areas for surveys in Area C.

As described above, acquisition of the Laverda survey will not overlap with either the northbound or southbound migrations of pygmy blue whales, when animals may be present and opportunistically feeding in the possible foraging BIA. Additionally, the Laverda survey will not overlap with the start of the whale shark aggregation at Ningaloo Reef.

The seasonal aggregation of whale sharks at Ningaloo is believed to be linked to localised seasonal 'pulses' of food productivity (TSS, 2015). If whale sharks are moving south to the foraging BIA to feed, it has to be assumed that they do not rely on feeding while migrating and that feeding in that instance is opportunistic. Mortality/PMI effects to zooplankton, fish eggs and larvae are not likely to impact on whale sharks being able to feed on this prey source, as the plankton will still be available within the water column.

Any potential impacts to zooplankton communities have to be assessed in the context of natural mortality in these populations. Any potential impacts to zooplankton (including fish eggs and larvae) resulting from seismic noise emissions are likely to be inconsequential compared to natural mortality rates, which are very high – exceeding 50% per day in some species and commonly exceeding 10% per day (Tang et al., 2014). For example, in a review of mortality estimates (Houde and Zastrow, 1993), the mean mortality rate for marine fish larvae was M=0.24, a rate equivalent to a loss of 21.3% per day. In the experiment conducted by McCauley et al. (2017), zooplankton mortality rate background levels were 19%. Sætre and Ona (1996) calculated that under the 'worst-case' scenario, the number of larvae killed during a typical seismic survey was 0.45% of the total population. They concluded that mortality rates caused by exposure to airgun sounds are so low compared to natural mortality that the impact from seismic surveys must be regarded as insignificant.

Plankton – Impact Assessment Conclusion

The potential impacts of noise emissions from the seismic source on plankton during the Petroleum Activities Program are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any fish eggs and larvae, or zooplankton that may be present in the water column within or adjacent to Areas A, B or C.

Fish Spawning

Without adequate control measures in place, high intensity impulsive sound emitted from the seismic source has the potential to result in behavioural changes in fish or masking of fish vocalisations, which may temporarily divert efforts away from spawning aggregations, egg production and recruitment success (Hawkins and Popper, 2017). Any dispersion of spawning aggregations will depend on the biology of the species and the extent of the dispersion or deflection (DFO, 2004). This impact assessment is focused on fish spawning and recruitment for key indicator commercial fish species.

Recent information obtained from DPIRD Fisheries (DPIRD Subject Matter Expert, personal communication, April 2019) has clarified depth ranges and key spawning periods for a range of key indicator species for the Pilbara Demersal Scalefish Managed Fisheries (Pilbara Trawl, Trap and Line) and Mackerel Managed Fishery:

- red emperor – depth range 10–180 m, spawns Sept–June (bimodal peaks Sept–Nov and Jan–Mar)
- Rankin cod – depth range 10–150 m, spawns June–Dec and Mar (peak Aug–Oct)
- goldband snapper – depth range 50–200 m, spawns Oct–May
- blue–spotted emperor – depth range 5–110 m, spawns Jul–Mar
- ruby snapper – depth range 150–480 m, spawns Dec–Apr (peak Jan–Mar)
- Spanish mackerel – depth range 1 m to at least 50 m, spawns Sept–Jan.

It is believed that all of these species undergo group spawning throughout their range, rather than aggregating at specific locations. The spawning peaks for a number of these species (red emperor, goldband snapper, ruby snapper and Spanish mackerel) overlap the timing of the surveys that will be acquired during the Petroleum Activities Program. None of the ranges for these key indicator species overlap Area B.

For each of the surveys in Areas A and C, Woodside has conducted a spatial analysis of overlap between a zone around each Acquisition Area within which significant behavioural responses could be expected to occur and the depth ranges for each key indicator species identified above (refer **Section 4.6.3.1**, **Figure 4-9** and **Figure 4-10**). For the purposes of this assessment it has been assumed that each species could spawn anywhere within its defined depth range, which is highly unlikely.

As described above, Popper et al. (2014) do not define exact sound level thresholds or ranges at which masking and behavioural responses may occur, but rather have adopted an approach that uses relative risk criteria (**Table 6-4**) that range from High to Low. For these criteria the ranges, relative to the source, were quantified as near (within tens of metres), intermediate (within hundreds of metres) and far (within thousands of metres). These criteria do not use specific acoustic thresholds, but instead assess potential impacts based on distances from the source. It is also difficult to predict possible population impacts in fishes due to behavioural responses because behaviours are generally context dependent.

For the purposes of this spatial analysis of potential overlap with spawning depth ranges, a sound exposure threshold of 170 dB re 1 µPa (single-pulse SPL) has been applied. This threshold is based on a review of literature relating to behavioural responses in fishes exposed to seismic noise. Carroll et al. (2017) provides one of the most recent, and comprehensive, reviews of potential impacts on fishes from marine seismic surveys, including a detailed review of studies that examined behavioural responses (Supplementary Material B to Carroll et al., 2017). From this review and the findings of a number of particularly relevant studies it can be concluded that:

- Fish exhibit a range of different behavioural responses to noise from seismic surveys that are dependent on the context in which they are exposed to the sound, their hearing sensitivity and their activities and motivation at the time.
- Fish may exhibit lower level, subtle behavioural responses to an approaching seismic source at received sound levels greater than approximately 160 dB re 1 µPa (SPL). These responses include a change in position in the water column (e.g. moving closer to the seabed), but the intensity of the response varies according to hearing sensitivity and context (Pearson et al., 1992; McCauley et al., 2000a; Slotte et al., 2004; Woodside, 2011; Fewtrell and McCauley, 2012).
- At received levels of approximately 170 dB re 1 µPa (SPL) and above some studies observed more noticeable, higher level 'startle' or 'alarm' responses, including changes in school structure, increased swimming speed and apparent avoidance of the sound source (Simmonds and MacLennan, 2005; McCauley et al., 2000a, 2003; Fewtrell and McCauley, 2012; Popper et al., 2014; Carroll et al. 2017).
- A number of studies indicate that fishes appear to resume normal behaviour shortly after cessation of acoustic disturbance (within minutes / less than an hour), with no evidence of long-term effects (Wardle et al., 2001; Pearson et al., 1992; Santulli et al., 1999; McCauley et al., 2000a, 2003; Fewtrell and McCauley, 2012; Miller and Cripps, 2013; Sivle et al., 2016).

McCauley et al. (2000a, 2003) reported that captive fishes of various species (including snappers, emperors, groupers, trevally, bream, herring and others) exposed to seismic sound showed a common startle response (C-turns), alarm responses (e.g. swimming faster, darting movements and sudden changes in school structure), or less obvious changes such as moving closer to the seabed or huddling closer together. Subtle responses such as moving closer to the seabed were suggested to commence when sound levels exceeded an SEL of 151 dB re 1 μPa^2.s (equivalent to approximately 160 dB re 1 µPa SPL).

Similar behaviours in pink snapper and trevally were noted by Fewtrell and McCauley (2012) in response to comparable sound levels. These are regarded as lower level, minimal responses that are likely to be an indication of awareness and perception of the sound rather than a reaction that could result in potential impacts. More obvious startle and alarm responses were apparent in sound exposure trials when received SELs were approximately 159 – 172 dB re 1 μPa^2.s (equivalent to approximately 168 – 181 dB re 1 µPa SPL). In situations where behavioural responses were observed, fishes were considered to have resumed normal behaviour within 4 – 31 minutes after cessation of the seismic activity (McCauley et al., 2000a, 2003).

Based on the single pulse sound fields derived from the acoustic modelling study (McPherson et al., 2019), the maximum predicted MOD R_{max} distance to the 170 dB re 1 µPa SPL sound exposure threshold was 2.4 km (Site 6; Area A). Therefore, an impact range of 2.5 km has been applied for this spatial analysis as the predicted maximum range from the seismic source, operating at full power, at which higher level behavioural responses may occur. This response range is consistent with the relative risk criteria applied by Popper et al. (2014), which indicates a Moderate level of risk of behavioural responses at thousands of metres for the fish hearing group with a swim bladder involved in hearing (primarily particle pressure detection) (see **Table 6-4**). Five of the six key indicator commercial fish species are likely to fall within this hearing group category, the exception being Spanish mackerel.

For the purposes of this assessment it is assumed that these higher level behavioural responses could result in dispersion of spawning aggregations of the six key indicator species listed above. For the spatial analysis a 'full power area' was defined as a 2.5 km extension to each Acquisition Area along the axes of the planned line turns – i.e. a polygon that incorporates all shot points where the source is discharged at full power. The 2.5 km behavioural response zone was applied around the full power area for each survey in Areas A and C, and the resulting polygons were overlain on the spawning depth ranges for the six key indicator species across a defined spawning area (North West Shelf). **Table 6-13** and **Table 6-14** show the areas and percentage overlaps of these 2.5 km behavioural response zones for the five surveys in Areas A and C with the spawning areas for the six key indicator species.

Table 6-15: Spatial overlap between key indicator commercial fish species and the 2.5 km behavioural response zone for surveys in Area A

Fish species	Depth range (m)	Range area (km²)	Area A			
			Pluto 4D M2		Harmony 4D M1	
			Overlap (km²)	*%*	*Overlap (km²)*	*%*
Red emperor	10-180	99,349	334.20	0.34	497.00	0.50
Rankin cod	10-150	92,575	223.41	0.24	367.47	0.40
Goldband snapper	50-200	68,748	379.40	0.55	537.85	0.78
Blue-spotted emperor	5-110	77,912	94.80	0.12	160.87	0.21
Ruby snapper	150-480	43,566	482.52	1.11	413.38	0.96
Spanish mackerel	1-50	48,501	–	0	–	0

A dash indicates that there is no overlap between the species depth range and the behavioural response zone.

Table 6-14: Spatial overlap between key indicator commercial fish species and the 2.5 km behavioural response zone for surveys in Area C

Fish species	Depth range (m)	Range area (km²)	Area C					
			Laverda 4D M1		Cimatti 4D M1		Vincent 4D M2	
			Overlap (km²)	*%*	*Overlap (km²)*	*%*	*Overlap (km²)*	*%*
Red emperor	10-180	99,349	–	0	–	0	–	0
Rankin cod	10-150	92,575	–	0	–	0	–	0
Goldband snapper	50-200	68,748	–	0	–	0	–	0
Blue-spotted emperor	5-110	77,912	–	0	–	0	–	0
Ruby snapper	150-480	43,566	–	0	46.89	0.11	175.72	0.40
Spanish mackerel	1-50	48,501	–	0	–	0	–	0

A dash indicates that there is no overlap between the species depth range and the behavioural response zone.

Table 6-15: Combined spatial overlap between key indicator commercial fish species and the 2.5 km behavioural response zone for all surveys in Areas A and C

Fish species	Depth range (m)	Range area (km²)	Combined overlap (km²)	Combined % of range area
Red emperor	10-180	99,349	532.88	0.54
Rankin cod	10-150	92,575	385.41	0.42
Goldband snapper	50-200	68,748	589.72	0.86
Blue-spotted emperor	5-110	77,912	173.18	0.22

Ruby snapper	150-480	43,566	846.26	1.94
Spanish mackerel	1-50	48,501	–	0

As shown in **Table 6-13**, the percentage overlap between the depth ranges for the six key indicator species and the 2.5 km behavioural response zone for surveys in Area A ranges from zero (for Spanish mackerel) to a maximum of 1.1% (for ruby snapper). In Area C, there is no overlap between the 2.5 km behavioural response zone for the Laverda survey and the depth ranges for all six of the key indicator species (**Table 6-14**). For the Cimatti and Vincent surveys there is no overlap between the 2.5 km behavioural response zone and the depth ranges for five of the six key indicator species. The exception is ruby snapper, which has a deeper depth range than the other species. The behavioural response zones for the Cimatti and Vincent surveys overlap approximately 47 km^2 (0.1%) and approximately 176 km^2 (0.4%) of the ruby snapper depth range, respectively.

Table 6-15 shows the combined spatial overlap between the depth ranges for the key indicator commercial fish species and the 2.5 km behavioural response zone for all five surveys in Areas A and C (i.e. when overlaid over each other, where relevant). In this case, the percentage overlap between the depth ranges for the six key indicator species and the 2.5 km behavioural response zone ranges from zero (for Spanish mackerel) to a maximum of 1.9% (for ruby snapper).

It is well established that there are a number of triggers or cues that will affect the timing of spawning aggregations of tropical fishes, including water temperature, tidal cycle, photoperiod, rainfall levels and lunar cycle. As described by Claydon (2004), there are four levels to the periodicity of spawning aggregations: seasonal, lunar, diel, and tidal. The seasonality of spawning for the five key indicator commercial fish species that are the focus for this impact assessment (Spanish mackerel have been omitted for this temporal analysis, based on the absence of any spatial overlap with the defined depth range for the species) are outlined above, based on the most recent information obtained from DPIRD Fisheries. Within these seasons, it is likely that most, if not all of these five species will have a lunar periodicity of spawning aggregation formation. For species that form aggregations monthly during a limited spawning season, aggregations typically form around either the new moon or the full moon (Domeier and Colin, 1997; Samoilys 1997; Claydon et al. 2004; De Mitcheson et al., 2008; Ikegami et al., 2014).

As indicated above, the highest level of spatial overlap with a defined depth range for a key indicator fish species is 1.9%, and this assumes that fish could be forming spawning aggregations anywhere within this area, which is conservative. Additionally, within the potential spawning area overlapped by the combined behavioural response zone for the surveys in Areas A and C not all fish will be spawning at the same time, given the lunar periodicity of spawning aggregation formation. Based on the assumption that spawning may occur a few days either side of the new or full moons in the months of the spawning season, over the six month period during which the surveys in Areas A and C are planned to be acquired (late December 2019 to May 2020; **Table 4-5**) there may be six to 12 potential spawning events (each lasting several days), given that spawning aggregations may not be triggered by the lunar cycle each month.

It is important to note that in addition to a very limited spatial overlap with spawning habitat for key indicator commercial fish species, the potential for impacts occurring to spawning aggregations is also limited to a relatively short period of time when spawning aggregations may coincide with survey acquisition in Areas A and C, based on the assumptions outlined above. Additionally, as described in the plankton impact assessment section above, mortality and potential mortal injury effects to fish eggs and larvae resulting from a spawning aggregation would be limited to very short distances from the seismic source (<110 m), and are likely to be inconsequential when compared to natural rates of mortality in zooplankton communities.

For the Pilbara line, trap and trawl fisheries, the three indicator species for assessment and stock status are red emperor, blue-spotted emperor and Rankin cod (Santos, 2019). A 2016 assessment of these three indicator species estimated the spawning biomass of red emperor stock to be currently above the threshold level and the stocks of blue-spotted emperor and Rankin cod had been well above the target spawning biomass levels for the past five years (Gaughan and Santoro, 2018), in which time there had been both ongoing commercial fishing and seismic survey activity.

Given the very short ranges to injury thresholds for fish eggs and larvae shown in **Table 6-13** (<110 m from the seismic source), an impact range for higher level behavioural responses in adult fish (2.5 km), the very limited extent of spatial overlap (0.2–1.9%) between the behavioural response zone for surveys in Areas A and C and the identified depth ranges for the key indicator species, and the limited temporal overlap with spawning aggregations it is highly unlikely that the Petroleum Activities Program will cause any significant impacts to spawning and recruitment in any key indicator commercial fish species. Therefore, no population level impacts are expected to occur to commercial fish species as a result of the Petroleum Activities Program.

<u>Fish Spawning – Impact Assessment Conclusion</u>

Based on current proposed timing and duration (up to 148 days) of seismic acquisition, the potential impacts of noise emissions from the seismic source on spawning of key indicator commercial fish species during the Petroleum Activities Program are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any key indicator species that may be spawning within or adjacent to Areas A, B or C during acquisition activities.

Commercial Fisheries

Increased sound levels associated with seismic acquisition may modify the behaviour and distribution of commercially targeted fish species within or adjacent to Areas A, B and C.

As noted by Salgado Kent et al. (2016) "*The issue of changes in commercial fisheries catch rates due to seismic surveys is almost always contentious in Australia*". They acknowledge that there has been some effort to relate fisheries catch data to seismic survey effort, but to date none of the Australian efforts to relate finfish catch rates with seismic surveys have yielded results of any meaning. Research to date has identified effects, and no effects, from seismic surveys on catch rates and abundance. This is likely due to the importance of the context of exposure. In many instances, fish may move away from an area when a seismic survey is being conducted. This could impact the catchability and catch rates for the target species of any commercial fisheries occurring in the same area at the same time.

Based on a review of publicly available information (ABARES Fishery Status reports; DPIRD Fisheries annual State of the Fisheries reports; 10 nm × 10 nm FishCube data) and stakeholder consultation, catch and effort in a number of Commonwealth and State-managed commercial fisheries potentially occurs in and adjacent to Areas A and C (refer **Table 4-8**).

Area A

- North West Slope Trawl Fishery
- WA Mackerel Managed Fishery
- Pilbara Trap Managed Fishery
- Pilbara Line Fishery.

Area C

- WA Mackerel Managed Fishery
- Pilbara Trap Managed Fishery
- Pilbara Line Fishery.

No recent fishing activity has occurred in any Commonwealth or State-managed fisheries with licence areas overlapping Area B (refer **Table 4-8**).

The potential impacts to key indicator commercial fish species targeted by these fisheries in Areas A and C are assessed in the sub-sections above, covering injury, TTS and behavioural effects on adult fish, injury and recruitment impacts on fish eggs and larvae, and potential behavioural impacts on spawning aggregations.

Potential impacts to commercial catch rates are assessed as slight and short-term, based on the following:

- Mortality of fish (both immediate and delayed) is considered highly unlikely based on no documented cases of fish mortality upon exposure to seismic airgun sound under experimental or field operating conditions (ERM, 2017).
- In the DPIRD Fisheries risk assessment of impacts from seismic surveys (Webster et al., 2018), it is emphasised that consequence for individual fish only considers mortality and that the risk assessment is not for application to larger scale impacts such as regional aggregations, fisheries, management units and populations.
- Large areas of catch and effort area are out of range of the predicted impact thresholds from the Petroleum Activities Program.
- The stock assessment for all key indicator commercial fish species (mackerel, red emperor, blue-spotted emperor and Rankin cod) indicates adequate stock status, breeding stock and fishery catch levels (Gaughan and Santoro, 2018).
- Fish recovery from TTS or behavioural effects is expected in days to weeks. No population level effects are predicted to target fish species, hence no lasting effects on their catchability, and consequently to commercial catch rates, are expected.
- There are no effects predicted to the ecosystems or habitats of the North Coast fishing bioregion, therefore the proposed seismic activities do not threaten the sustainability of the fisheries that cover significantly smaller areas than the overall distribution of fish in the North Coast fishing bioregion.

Commercial Fisheries – Impact Assessment Conclusion

Based on the timing and duration (up to 148 days) of seismic acquisition, the potential impacts on commercial catch rates of noise emissions from the seismic source during the Petroleum Activities Program are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any key indicator commercial fish species targeted by commercial fisheries within or adjacent to Areas A and C.

Tourism and Recreation

No tourism or recreational activities (e.g. fishing, diving/snorkelling) are likely to take place within or immediately adjacent to Areas A, B or C, due to the offshore, deep water locations of these areas. However, significant levels of recreational fishing, including important annual fishing competitions, and diving/snorkelling activities occur in waters adjacent to Ningaloo Reef and North West Cape. This impact assessment considers the potential impacts from noise emissions from discharging the seismic source during surveys acquisition in Area C on recreational fishing and diving/snorkelling activities in adjacent waters.

Recreational Fishing

As described in **Section 4.6.5**, it is possible that acquisition of the Laverda, Cimatti and Vincent surveys in Area C in early 2020 could coincide with two annual fishing competitions run by the Exmouth Game Fishing Club – the Heavy Tackle Tournament (three days of fishing, 25-27 January 2020) and GAMEX 2020 (six days of fishing, 15-20 March 2020). An additional tournament, the Billfish Bash is generally held for three days of fishing just prior to GAMEX, however, this event will not occur in 2020. GAMEX and the Billfish Bash target billfishes, marlins and sailfishes, primarily black marlin (*Istiompax indica*), blue marlin (*Makaira nigricans*) and sailfish (*Istiophorus platypterus*). As described above, these scombroid species are hearing generalists that possess a swim bladder, but lack the mechanical connection to the inner ear and the otoliths. As shown in **Table 6-13**, the maximum predicted R_{max} distance to the injury threshold in the water column for the hearing group of fishes with swim bladders is <110 m in Area C. The maximum predicted R_{max} distance to the TTS threshold for this fish hearing group is 5.16 km for Area C.

Billfishes and sailfishes are most likely to exhibit behavioural responses (avoidance) by moving away from an operating seismic source that approaches within a few tens of metres of them. Although large, pelagic, fast-swimming fish species such as mackerel, billfishes and tunas are highly unlikely to experience TTS effects as they are able to swim away from a seismic source. Woodside has committed to not undertake any seismic survey activity within Area C during the GAMEX tournament fishing days (15-20 March). If seismic acquisition were to overlap the timing of GAMEX, individual marlin or sailfish would have to remain within a range of approximately 5 km of the moving seismic source for a full 24-hour period to be exposed to sound levels that could cause TTS. It should also be recognised that TTS is temporary and recovery occurs in a relatively short timeframe (minutes to hours) after the seismic source has moved away from the exposed fish, and the sound levels are reduced.

Therefore, it is highly unlikely that any impacts will occur to target species, particularly with respect to the 'catchability' of individual fish.

Diving and Snorkelling

Significant levels of recreational diving and snorkelling activity occur in the waters adjacent to Ningaloo Reef and the Muiron Islands, particularly diving on SCUBA at several dive sites around the Muiron Islands, and snorkelling associated with whale shark interaction trips out from Tantabiddi boat ramp during the annual aggregation. Diving also takes place within these areas for scientific research purposes in addition to for recreation purposes.

To assess the potential impacts from operating the seismic source in the Acquisition Areas for the Laverda, Cimatti and Vincent surveys in Area C, the acoustic modelling study included modelling of received sound levels for a single-impulse sound exposure threshold of 145 dB re 1 µPa (SPL) (McPherson et al., 2019), which represents a human health assessment threshold for sound exposure to divers and swimmers, derived from Ainslie (2008) and Parvin (2005). This does not imply that this level is associated with the onset of injury. Based on a number of studies examining the potential effects of underwater noise emissions on both military and recreational divers, Parvin (2005) suggested 145 dB re 1 µPa (SPL) as a safety criterion for recreational divers and swimmers, within a frequency range between 100 and 500 Hz. Seismic airgun sources are broadband sources, and therefore, for this assessment the most precautionary and conservative diver acoustic impact threshold has been used.

For Area C, the maximum predicted R_{max} distances to the 145 dB re 1 µPa (SPL) threshold are 36.3 km (Laverda), 37.9 km (Cimatti) and 28 km (Vincent). However, as described in the modelling report (McPherson et al., 2019), the array directionality (i.e. distances to identified isopleths were greater in the broadside direction than in the endfire direction) and frequency content, coupled with the bathymetry, had a considerable effect on propagation at longer distances, with generally larger lobes of sound energy extending into the deeper waters at all modelling sites. This is clearly shown in the example sound level contour maps and vertical slice plots for modelling Site 18 in **Figure 6-6** and **Figure 6-7**.

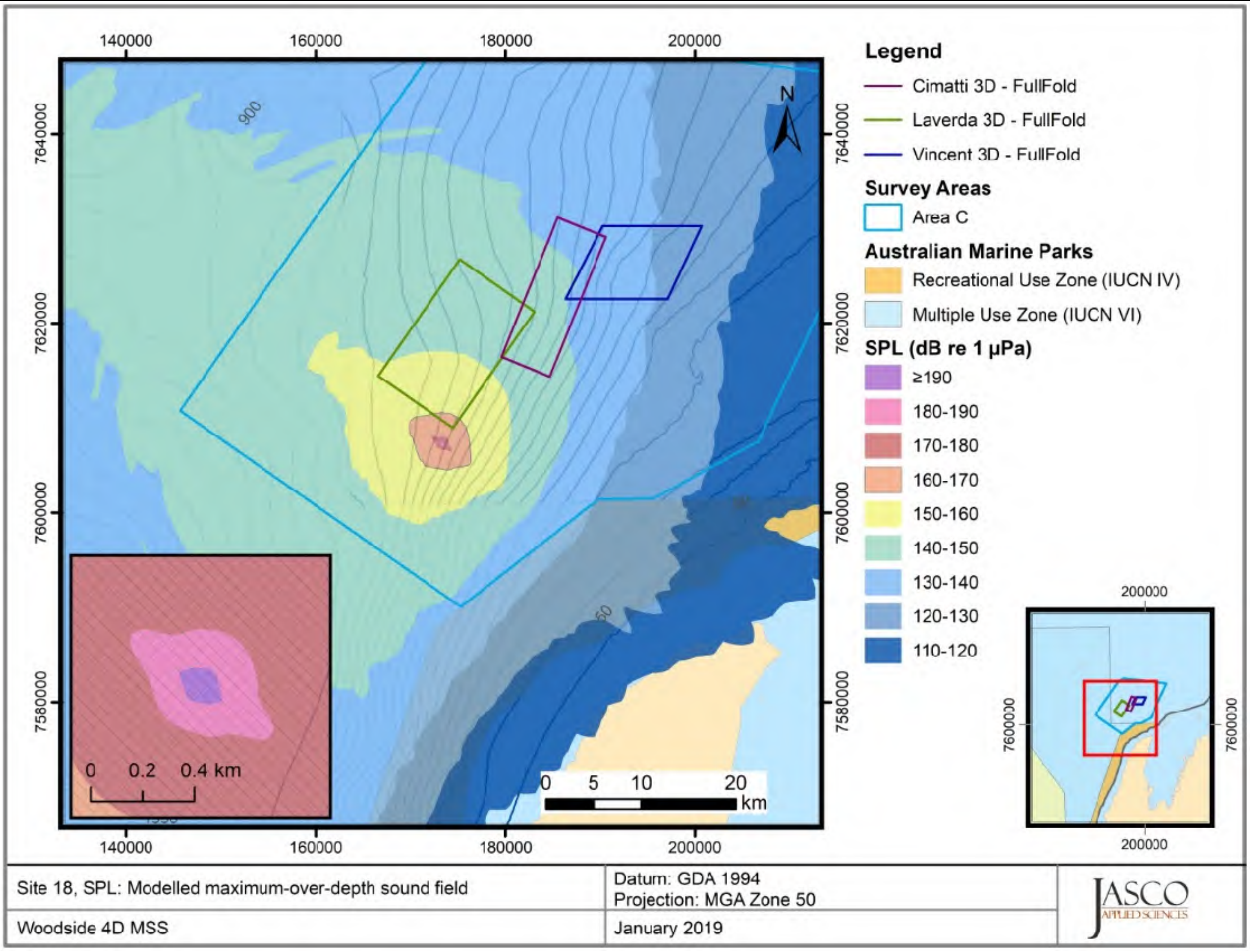

Figure 6-6: Sound level contour map for modelling Site 18, showing unweighted MOD SPL results

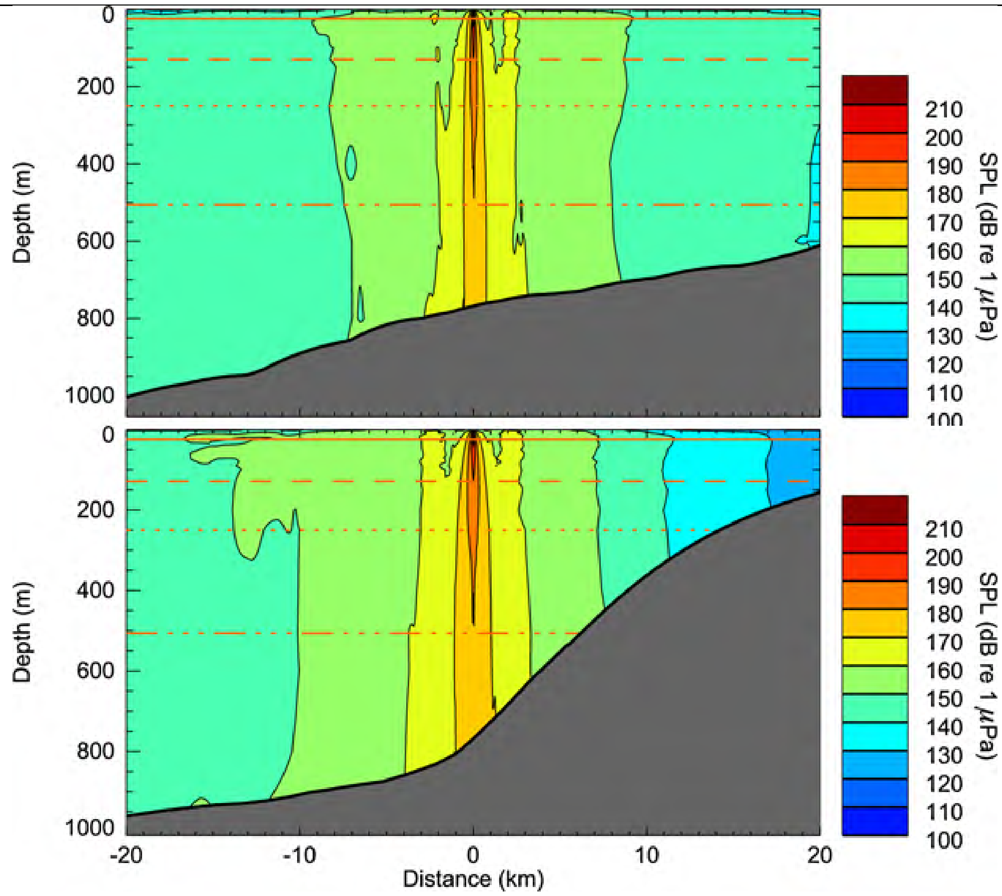

Figure 6-7: Site 18, vertical slice plot of the predicted SPL. Levels are shown along the endfire (top) and broadside (bottom) directions.

Maximum predicted received sound levels at the boundary of the Ningaloo Marine Park (State waters) and the Muiron MMA are 121.8 dB re 1 µPa (SPL) and 120.1 dB re 1 µPa (SPL), respectively (see below). Based on the sound level isopleths for modelling Site 18, received sound levels closer inshore along the outer edge of Ningaloo Reef will be in the order of 110 dB re 1 µPa (SPL), and received levels at dive sites along the western side of the Muiron Islands will be in the range of 100–110 dB re 1 µPa (SPL).

On this basis, divers and snorkellers offshore from the reef at the northern extent of Ningaloo Reef (conducting either SCUBA dives or participating in whale shark interactions), or at dive sites around the Muiron Islands, will not be exposed to sound levels anywhere close to the 145 dB re 1 µPa (SPL) threshold. If diving and snorkelling activities in these areas were to coincide with acquisition in Area C, it is highly unlikely that individuals in the water would be able to hear individual shots from the seismic source above background ambient noise levels.

Tourism and Recreation – Impact Assessment Conclusion

The potential impacts of noise emissions from the seismic source on diving and snorkelling during the Petroleum Activities Program are considered to be slight and short-term, as the activity is not likely to cause any effects to divers and snorkellers who may be in the water off Ningaloo Reef and the Muiron Islands during seismic acquisition.

Commercial Divers

There is the potential for commercial diving activity to occur in the vicinity of existing oil and gas facilities in the vicinity of Areas A, B and C. There are several facilities either within or in close proximity to Areas A and C (refer **Table 4-9)**.

Guidance note DMAC 12 issued by the UK Diving Medical Advisory Committee (DMAC) "Safe Diving Distance from Seismic Surveying Operations" (DMAC, 2019) includes the following guidance:

- Where diving and seismic activity are scheduled to occur within a distance of 45 km, it would be good practice for all parties to be made aware of the planned activity where practicable. This should include clients/operators, diving and seismic contractors.
- Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the clients/operators involved and the seismic and diving contractors in advance of any simultaneous operations.
- If the risk assessment should consider ramp-up trials as well as other risk control measures e.g. reduction in source sizes, changes to firing intervals, timeshare/prioritisation etc. Seismic operators should consider whether a source output modelling study should be undertaken to predict sound pressure levels at diving

locations. If so, these sound pressure levels should be considered together with other relevant factors in the risk assessment.

This guidance is also applicable to recreational and scientific divers.

Commercial Divers – Impact Assessment Conclusion

Based on the maximum predicted R_{max} distances to the 145 dB re 1 µPa (SPL) threshold, and on the implementation of control measures (see the Demonstration of ALARP and EPO, EPS and MC sub-sections below) that reflect the updated industry guidance, the potential impacts on commercial divers of noise emissions from the seismic source during the Petroleum Activities Program are considered to be slight and short-term.

Australian Marine Parks/Ningaloo Coast World Heritage Area

As described in **Section 4.7,** Areas A, B and C overlap or are in close proximity to a number of marine protected areas, including AMPs and the Ningaloo Coast WHA. Seismic acquisition within the Acquisition Areas for a number of the surveys has the potential to result in received sound levels that could potentially impact the designated conservation values of these AMPs or the Ningaloo Coast WHA.

Table 6-14 summarises the potential impacts of seismic noise emissions to the designated conservation values of the Montebello, Gascoyne and Ningaloo AMPs, and of the Ningaloo Coast WHA.

Table 6-16: Summary of potential impacts of seismic noise emissions to AMP conservation values

AMP	Designated values*	Sound exposure threshold	Potential impacts to AMP conservation values
Montebello Marine Park	***Natural values***		
	Ancient Coastline at 125m Depth Contour KEF	Injury: 207 dB re 1 µPa (PK) TTS: 186 dB re 1 µPa²·s (SEL_{24h}) Behavioural: Tens of metres from source	Maximum predicted distances to fish injury thresholds at seafloor are ≤130 m. Maximum predicted distances to TTS threshold at seafloor are ≤2.38 km. There is potential for recoverable injury and TTS to occur in site-attached fish communities within the KEF. Area of overlap between the KEF and the Acquisition Areas for Pluto and Harmony surveys is ~75 km², which represents less than 0.5% of the overall area of the KEF. Site-attached fish communities at 125 m depth are not likely to exhibit any behavioural responses. A recent ROV survey of an area of the KEF within the Montebello AMP indicated that benthic habitat was typically bare sand with various bedforms. No moderate or high relief features, areas of consolidated hard substrate, or sponges/soft corals were observed (i.e. no suitable habitats for site-attached fish communities were present).
	Continental Slope Demersal Fish Communities KEF#	Injury: 207 dB re 1 µPa (PK) TTS: 186 dB re 1 µPa²·s (SEL_{24h}) Behavioural: Tens of metres from source	This KEF doesn't overlap the Montebello Marine Park. Maximum predicted distances to fish injury thresholds at seafloor are ≤130 m. Water depths in the areas of the KEF overlapped by the Pluto and Harmony Acquisition Areas are >200 m. There is potential for TTS to occur in demersal fish communities within the KEF. Demersal fish communities at >200 m depth are not likely to exhibit any behavioural responses.
	Humpback whale migration BIA	Not relevant – the Petroleum Activities Program in Area A will not overlap the humpback whale migration season (June to October)	Not relevant.
	Flatback turtle 'habitat critical'	PTS: 232 dB re 1 µPa (PK) TTS: 226 dB re 1 µPa (PK) Behavioural: 166 dB re 1 µPa (SPL)	Parts of the Pluto and Harmony Acquisition Areas overlap a habitat critical area for flatback turtles. The deep, offshore waters at the outer extent of the 'habitat critical' for flatback turtles around the Montebello Islands do not represent important internesting habitat for this stock of flatback turtles. No injury (PTS) or TTS effects will occur to flatback turtles within the 'habitat critical'. In the event that any flatback turtles present within the 'habitat critical' during acquisition of the Pluto and Harmony 4D surveys do exhibit behavioural responses as a result of exposure to acoustic emissions from the seismic source (i.e. within ~ 3 km of the operating source) it is highly unlikely that they would be displaced from the 'habitat critical' area, as they would be more likely to swim inshore into shallower waters rather than offshore into deeper water depths, and would therefore be moving further away from the operating seismic source. As the Pluto and Harmony 4D surveys will be acquired in a location that is spatially on the edge of an area that is considered to provide

			biologically important habitat for turtles (i.e. the identified 'habitat critical' and internesting buffer BIA around the Montebello Islands), and as the surveys will overlap the nesting season, additional adaptive management procedures will be implemented to manage the likelihood of encountering higher numbers of turtles than expected (**Figure 6-7**).
	Flatback turtle internesting BIA	PTS: 232 dB re 1 µPa (PK) TTS: 226 dB re 1 µPa (PK) Behavioural: 166 dB re 1 µPa (SPL)	Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Sound levels will exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Most likely impact will be temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source. Waters within BIA that overlap the Acquisition Areas are deemed unsuitable for internesting flatback turtles – i.e. waters >25 m deep and >27 km from the coastline. Additional adaptive management procedures will be implemented to manage the likelihood of encountering higher numbers of turtles than expected (**Figure 6-7**).
	Green turtle internesting BIA	PTS: 232 dB re µPa (PK) TTS: 226 dB re 1 µPa (PK) Behavioural: 166 dB re 1 µPa (SPL)	There is no overlap between the Pluto and Harmony Acquisition Areas and the BIA. Maximum predicted received levels at the boundary of the BIA are 110-120 dB re 1 µPa (SPL), which is well below the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are predicted to occur to green turtles within the internesting BIA.
	Whale shark foraging BIA	Injury: 219 dB re 1 µPa^2·s (SEL_{24h}) TTS: 186 dB re 1 µPa^2·s (SEL_{24h}) Behavioural: Tens of metres from source	Injury effects will only occur within very close range of the seismic source (<60 m). TTS effects could occur out to ~2.5 km from the source. Individual whale sharks would have to remain within ~2.5 km of the operating seismic source (which is also moving) for a full 24 hour period to be exposed to sound levels that could cause TTS. There is minor temporal overlap between the presence of whale sharks in this BIA (July to November; **Table 4-5**) and acquisition of the Pluto and Harmony surveys.
	Cultural and heritage values		
	Not relevant – no cultural and heritage values of the Montebello Marine Park will be impacted by the Petroleum Activities Program.		
	Social and economic values		
	Commercial fishing	Injury, TTS and behavioural thresholds for fish, fish eggs and larvae, and plankton	Potential impacts to commercial catch rates for any fisheries overlapping the Montebello Marine Park are assessed as slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any key indicator commercial fish species.
Gascoyne Marine Park	***Natural values***		
	Continental Slope Demersal Fish Communities KEF	Injury: 207 dB re 1 µPa (PK) TTS: 186 dB re 1 µPa^2·s (SEL_{24h}) Behavioural: Tens of metres from source	Minimum water depths in areas of KEF overlapped by the Acquisition Areas are ~280 m. Maximum predicted received sound levels at, or close to, the seafloor at this water depth do not exceed the injury or TTS thresholds for all hearing groups of fishes, or for fish eggs and larvae. Behavioural responses will only occur within tens of metres of the seismic source. Therefore, any impacts to demersal fish communities at or close to the seafloor are highly unlikely to occur.
	Canyons linking Cuvier Abyssal Plain and Cape Range Peninsula KEF	Injury: 207 dB re 1 µPa (PK) TTS: 186 dB re 1 µPa^2·s (SEL_{24h}) Behavioural: Tens of metres from source	Minimum water depths in areas of KEF overlapped by the Acquisition Areas are ~360 m. Maximum predicted received sound levels at, or close to, the seafloor at this water depth do not exceed the injury or TTS thresholds for all hearing groups of fishes, or for fish eggs and larvae. Behavioural responses will only occur within tens of metres of the seismic source. Therefore, impacts to site-attached fish communities or benthic invertebrates on the seafloor will not occur. Area of overlap between the KEF and the Acquisition Areas for the Laverda, Cimatti and Vincent surveys is ~218 km², which represents ~4.0% of the overall area of the KEF.

	Commonwealth waters adjacent to Ningaloo Reef KEF	TTS: 196 dB re 1 µPa (PK) (HF-cetaceans TTS: 226 dB re 1 µPa (PK) (turtles)	There is no overlap between the Laverda, Cimatti and Vincent Acquisition Areas and the KEF. Maximum predicted received sound levels at the boundary of the KEF are ~136 dB re 1 µPa (SPL), which is below the TTS thresholds for cetaceans and turtles, and well below the behavioural thresholds for cetaceans (160 dB re 1 µPa [SPL]), or turtles (166 dB re 1 µPa [SPL]). Therefore, no impacts are predicted to occur to cetaceans, turtles or whale sharks within the KEF.	
		Behavioural: 160 dB re 1 µPa (SPL) (cetaceans) Behavioural: 166 dB re 1 µPa (SPL) (turtles)		
	Exmouth Plateau KEF	Injury: 207 dB re 1 µPa (PK)	There is no overlap between the Laverda, Cimatti and Vincent Acquisition Areas and the KEF. Maximum predicted received sound levels at the boundary of the KEF are ~130 dB re 1 µPa (SPL). Therefore, no impacts are predicted to occur to any fish or invertebrate communities in the water column or on the seafloor within the KEF.	
		TTS: 186 dB re 1 µPa²·s (SEL_{24h})		
		Behavioural: Tens of metres from source		
	Humpback whale migration BIA	Not relevant – the Petroleum Activities Program in Area C will not overlap the humpback whale migration season (June to October).	Not relevant.	
	Pygmy blue whale migration BIA	PTS: 183 dB re 1 µPa²·s (SEL_{24h})	There is potential overlap between the acquisition of the Laverda, Cimatti and Vincent surveys in Area C and the commencement of the northbound migration (April–May; **Table 4-5**). However, overlap with the peak period (May–June) will only occur for Cimatti and Vincent surveys. Injury threshold for pygmy blue whales may be exceeded out to a maximum distance of 2.14 km from the nearest seismic line, and auditory fatigue TTS threshold out to a maximum distance of 55.2 km. These impact ranges are based on the cumulative SEL_{24h} metric; therefore, PTS and TTS would only occur if individuals remained within these ranges of the operating seismic source for the full 24 hour duration, which is extremely unlikely to occur. When incorporating representative pygmy blue whale migratory animal movement and behaviour into the propagation model, the 95th percentile exposure ranges to the injury PTS threshold are reduced to 90-100 m, with an estimated 0.04-0.05 individual whales exposed within a 24 hour period. The predicted maximum distance to the NMFS (2014) marine mammal behavioural threshold is 6.5 km, across all water depths modelled (refer Table 6-8). However, with the inclusion of migratory animal movement and behaviour into the propagation model the 95th percentile exposure range to the behavioural response threshold reduces to 2.81 km, 5.19 and 4.43 km, for the three surveys (Laverda, Cimatti & Vincent), with approximately 1.05, 1.31 and 1.22 migrating animals exposed within a 24 hour period, respectively. Area of overlap between the Acquisition Areas and the BIA is ~285 km², which represents ~0.09% of the overall area of the BIA. Impacts are likely to be restricted to temporary behavioural changes (avoidance) in individuals moving through Area C and adjacent waters during the southbound or northbound migration. Given the spatial overlap with the pygmy blue whale migration BIA, and the potential temporal overlap with the southbound and northbound migration periods, additional adaptive management procedures will be implemented to manage impacts to pygmy blue whales if higher numbers than expected are encountered (**Figure 6-2**).	
		TTS: 168 dB re 1 µPa²·s (SEL_{24h})		
		Behavioural: 160 dB re 1 µPa (SPL)		
	Pygmy blue whale possible foraging BIA	PTS: 183 dB re 1 µPa²·s (SEL_{24h})	There is potential overlap between acquisition of the Laverda, Cimatti and Vincent surveys in Area C and the commencement of the northbound migration (April–May), and consequently with opportunistic foraging within the BIA. However, overlap with the peak period (May–June) will only occur for Cimatti and Vincent surveys (**Table 4-5**). Based on a maximum predicted range to injury effects, there is no potential for impact occurring to whales present within the BIA during acquisition of the Laverda, Cimatti and Vincent surveys in Area C. Based on applying the cetacean behavioural threshold, there is no	
		TTS: 168 dB re 1 µPa²·s (SEL_{24h})		
		Behavioural: 160 dB re 1 µPa (SPL)		

			potential for behavioural effects occurring to whales present within the BIA during acquisition of the surveys in Area C. Maximum predicted distance to the auditory fatigue TTS thresholds for pygmy blue whales is 47.2 km from the nearest survey line in the Cimatti Acquisition Area, based on applying the SEL_{24h} threshold. An assessment against the pygmy blue foraging BIA was also undertaken by incorporating animal movement and behaviour into the acoustic propagation model, which also confirmed that no animals will be exposed to injury or behavioural response levels within the possible foraging BIA for the three surveys within Area C). The same assessment also concluded an estimated 0.34, 0.04 and 0 individual whales potentially exposed to received levels associated with auditory fatigue, over a 24 hour period, for the Laverda, Cimatti and Vincent surveys, respectively. Based on the available evidence, marine fauna that have experienced TTS as a result of exposure to high intensity sound recover from any temporary loss of hearing sensitivity within relatively short periods of time (minutes to hours; 24 hours maximum). Given levels received within the possible foraging BIA are well below behavioural response thresholds, this short-term, transitory impact is highly unlikely to displace any pygmy blue whales from the possible foraging BIA; Accordingly, the given the lack of injury or behavioural response within the possible foraging BIA, the proposed surveys are not likely to have any significant impacts on foraging whales within this area. An overlay of the low-frequency weighted 168 dB re 1 $\mu Pa^2 \cdot s$ SEL_{24h} isopleth, which represents the possible TTS onset range for the Laverda survey, on the polygon that represents the possible foraging BIA, indicates that there is an area of overlap of approximately 130 km^2. This represents approximately 1.37% of the total area of the foraging BIA. There is no overlap between the 168 dB re 1 $\mu Pa^2 \cdot s$ SEL_{24h} isopleth for the Cimatti and Vincent surveys and the foraging BIA. Woodside will ensure that acquisition of the Laverda 4D survey does not occur during May-June. This control takes into account the spatial overlap between the TTS onset zone and a small section of the northern extent of the possible foraging area for pygmy blue whales. As described above, there is no overlap between the TTS onset zones for the Cimatti and Vincent surveys and the possible foraging area, and hence this control will not apply to these two surveys in Area C.
	Flatback turtle 'habitat critical'	PTS: 232 dB re 1 µPa (PK) TTS: 226 dB re 1 µPa (PK) Behavioural: 166 dB re 1 µPa (SPL)	The Laverda, Cimatti and Vincent 4D surveys in Area C, which will be acquired in the period March to May 2020 (**Table 4-5**), will not overlap the peak periods for breeding or nesting for flatback turtles in the region. Area C does not overlap the 'habitat critical' for flatback turtles around the Muiron Islands. The offshore, deep waters of Area C (39–1382 m water depths) are extremely unlikely to represent suitable habitat for internesting flatback turtles. Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Received sound levels at the boundary of the 'habitat critical' will not exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are likely to occur to flatback turtles within the 'habitat critical' during acquisition of the Laverda, Cimatti and Vincent surveys in Area C.
	Green and loggerhead turtle 'habitat critical'	PTS: 232 dB re 1 µPa (PK) TTS: 226 dB re 1 µPa (PK) Behavioural: 166 dB re 1 µPa (SPL)	The Laverda, Cimatti and Vincent 4D surveys in Area C, which will be acquired in the period March to May 2020 (**Table 4-5**), will not overlap the peak periods for breeding or nesting for green and loggerhead turtles in the region. There is no overlap between the Laverda and Cimatti Acquisition Areas and the 'habitat critical' for green or loggerhead turtles. At the closest points, the Laverda and Cimatti Acquisition Areas are located approximately 14 km and 13 km from the green turtle 'habitat critical', respectively. The offshore, deep waters of Area C (39–1382 m water depths) are extremely unlikely to represent suitable habitat for internesting green or loggerhead turtles.

			Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Received sound levels at the boundary of the 'habitat critical' will not exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are likely to occur to green or loggerhead turtles within the 'habitat critical' during acquisition of the Laverda, Cimatti and Vincent surveys in Area C.
	Cultural and heritage values		
	Not relevant – no cultural and heritage values of the Gascoyne Marine Park will be impacted by the Petroleum Activities Program.		
	Social and economic values		
	Commercial fishing	Injury, TTS and behavioural thresholds for fish, fish eggs and larvae, and plankton	Potential impacts to commercial catch rates for any fisheries overlapping the Gascoyne Marine Park are assessed as slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any key indicator commercial fish species.
Ningaloo Marine Park	***Natural values***		
	Continental Slope Demersal Fish Communities KEF	Injury: 207 dB re 1 µPa (PK) TTS: 186 dB re 1 µPa^2·s (SEL_{24h}) Behavioural: Tens of metres from source	Minimum water depths in areas of KEF overlapped by the Acquisition Areas are ~280 m. Maximum predicted received sound levels at, or close to, the seafloor at this water depth do not exceed the injury or TTS thresholds for all hearing groups of fishes, or for fish eggs and larvae. Behavioural responses will only occur within tens of metres of the seismic source. Therefore, any impacts to demersal fish communities at or close to the seafloor are highly unlikely to occur.
	Canyons Linking Cuvier Abyssal Plain and Cape Range Peninsula KEF	Injury: 207 dB re 1 µPa (PK) TTS: 186 dB re 1 µPa^2·s (SEL_{24h}) Behavioural: Tens of metres from source	Minimum water depths in areas of KEF overlapped by the Acquisition Areas are ~360 m. Maximum predicted received sound levels at, or close to, the seafloor at this water depth do not exceed the injury or TTS thresholds for all hearing groups of fishes, or for fish eggs and larvae. Behavioural responses will only occur within tens of metres of the seismic source. Therefore, impacts to site-attached fish communities or benthic invertebrates on the seafloor will not occur. Area of overlap between the KEF and the Acquisition Areas for the Laverda, Cimatti and Vincent surveys is ~218 km², which represents ~4.0% of the designated area of the KEF.
	Commonwealth Waters Adjacent to Ningaloo Reef KEF	TTS: 196 dB re 1 µPa (PK) – HF-cetaceans TTS: 226 dB re 1 µPa (PK) – turtles Behavioural: 160 dB re 1 µPa (SPL) – cetaceans Behavioural: 166 dB re µPa (SPL) – turtles	There is no overlap between the Laverda, Cimatti and Vincent Acquisition Areas and the KEF. Maximum predicted received sound levels at the boundary of the KEF are ~136 dB re 1 µPa (SPL), which is below the TTS thresholds for cetaceans and turtles, and well below the behavioural thresholds for cetaceans (160 dB re 1 µPa [SPL]) or turtles (166 dB re 1 µPa [SPL]). Therefore, no impacts are predicted to occur to cetaceans, turtles or whale sharks within the KEF.
	Humpback whale migration BIA	Not relevant – the Petroleum Activities Program in Area C will not overlap the humpback whale migration season (June to October).	Not relevant.
	Pygmy blue whale migration BIA	PTS: 183 dB re 1 µPa^2·s (SEL_{24h}) TTS: 168 dB re 1 µPa^2·s (SEL_{24h}) Behavioural: 160 dB re 1 µPa (SPL)	There is potential overlap between the acquisition of the Laverda, Cimatti and Vincent surveys in Area C and the commencement of the northbound migration (April–May; **Table 4-5**). However, overlap with the peak period (May–June) will only occur for Cimatti and Vincent surveys. Injury threshold for pygmy blue whales may be exceeded out to a maximum distance of 2.14 km from the nearest seismic line, and auditory fatigue TTS threshold out to a maximum distance of 55.2 km. These impact ranges are based on the cumulative SEL_{24h} metric; therefore, PTS and TTS would only occur if individuals remained within these ranges of the operating seismic source for the full 24 hour duration, which is extremely unlikely to occur. When incorporating

			representative pygmy blue whale migratory animal movement and behaviour into the propagation model, the 95th percentile exposure ranges to the injury PTS threshold are reduced to 90-100m, with an estimated 0.04-0.05 individual whales exposed within a 24 hour period. The predicted maximum distance to the NMFS (2014) marine mammal behavioural threshold is 6.5 km, across all water depths modelled (refer Table 6 5). However, with the inclusion of migratory animal movement and behaviour into the propagation model the 95th percentile exposure range to the behavioural response threshold reduces to 2.81 km, 5.19 and 4.43 km, for the three surveys (Laverda, Cimatti and Vincent), with approximately 1.05, 1.31 and 1.22 migrating animals exposed within a 24 hour period, respectively. Area of overlap between the Acquisition Areas and the BIA is ~285 km², which represents ~0.09% of the overall area of the BIA. Impacts are likely to be restricted to temporary behavioural changes (avoidance) in individuals moving through Area C and adjacent waters during the northbound migration. Given the spatial overlap with the pygmy blue whale migration BIA, and the potential temporal overlap with the southbound and northbound migration periods, additional adaptive management procedures will be implemented to manage impacts to pygmy blue whales if higher numbers than expected are encountered (**Figure 6-2**).
	Pygmy blue whale possible foraging BIA	PTS: 183 dB re 1 µPa^2·s (SEL_{24h}) TTS: 168 dB re 1 µPa^2·s (SEL_{24h}) Behavioural: 160 dB re 1 µPa (SPL)	There is potential overlap between acquisition of the Laverda, Cimatti and Vincent surveys in Area C with the commencement of the northbound migration (April–May), and consequently with opportunistic foraging within the BIA. However, overlap with the peak period (May–June) will only occur for Cimatti and Vincent surveys (**Table 4-5**). Based on a maximum predicted range to injury effects, there is no potential for impact occurring to whales present within the BIA during acquisition of the Laverda, Cimatti and Vincent surveys in Area C. Based on applying the cetacean behavioural threshold, there is no potential for behavioural effects occurring to whales present within the BIA during acquisition of the surveys in Area C. Maximum predicted distance to the auditory fatigue TTS thresholds for pygmy blue whales is 55.3 km from the nearest survey line in the Laverda Acquisition Area, based on applying the SEL_{24h} threshold. An assessment against the pygmy blue foraging BIA was also undertaken by incorporating animal movement and behaviour into the acoustic propagation model, which also confirmed that no animals will be exposed to injury or behavioural response levels within the foraging BIA for the three surveys within Area C (Table 6-8). The same assessment also concluded an estimated 0.34, 0.04 and 0 individual whales potentially exposed to received levels associated with auditory fatigue, over a 24 hour period, for the Laverda, Cimatti and Vincent surveys, respectively. Based on the available evidence, marine fauna that have experienced TTS as a result of exposure to high intensity sound recover from any temporary loss of hearing sensitivity within relatively short periods of time (minutes to hours; 24 hours maximum). Given levels received within the possible foraging BIA are well below behavioural response thresholds, this short-term, transitory impact is highly unlikely to displace any pygmy blue whales from the possible foraging BIA; Accordingly, the given the lack of injury or behavioural response within the possible foraging BIA, the proposed surveys are not likely to have any significant impacts on foraging whales within this area. An overlay of the low-frequency weighted 168 dB re 1 µPa^2·s SEL_{24h} isopleth, which represents the possible TTS onset range for the Laverda survey, on the polygon that represents the possible foraging BIA, indicates that there is an area of overlap of approximately 130 km^2. This represents approximately 1.37% of the total area of the foraging BIA. There is no overlap between the 168 dB re 1 µPa^2·s SEL_{24h} isopleth for the Cimatti and Vincent surveys and the foraging BIA. Woodside will ensure that acquisition of the Laverda 4D survey does not occur during May-June. This control takes into account the spatial overlap between the TTS onset zone and a small section of the northern extent of the possible foraging area for pygmy blue whales. As described above, there is no overlap between the TTS onset zones for the Cimatti and Vincent surveys and the possible foraging area, and hence this control will not apply to these two surveys in Area C.

	Flatback turtle 'habitat critical'	PTS: 232 dB re 1 µPa (PK) TTS: 226 dB re 1 µPa (PK) Behavioural: 166 dB re 1 µPa (SPL)	The Laverda, Cimatti and Vincent 4D surveys in Area C, which will be acquired in the period March to end May 2020 (**Table 4-5**), will not overlap the peak periods for breeding or nesting for flatback turtles in the region. Area C does not overlap the 'habitat critical' for flatback turtles around the Muiron Islands. The offshore, deep waters of Area C (39–1382 m water depths) are extremely unlikely to represent suitable habitat for internesting flatback turtles. Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Received sound levels at the boundary of the 'habitat critical' will not exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are likely to occur to flatback turtles within the 'habitat critical' during acquisition of the Laverda, Cimatti and Vincent surveys in Area C.
	Green and loggerhead turtle 'habitat critical'	PTS: 232 dB re 1 µPa (PK) TTS: 226 dB re 1 µPa (PK) Behavioural: 166 dB re 1 µPa (SPL)	The Laverda, Cimatti and Vincent 4D surveys in Area C, which will be acquired in the period March to end May 2020 (**Table 4-5**), will not overlap the peak periods for breeding or nesting for green and loggerhead turtles in the region. There is no overlap between the Laverda and Cimatti Acquisition Areas and the 'habitat critical' for green or loggerhead turtles. At the closest points, the Laverda and Cimatti Acquisition Areas are located approximately 14 km and 13 km from the green turtle 'habitat critical', respectively. The offshore, deep waters of Area C (39–1382 m water depths) are extremely unlikely to represent suitable habitat for internesting green or loggerhead turtles. Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Received sound levels at the boundary of the 'habitat critical' will not exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are likely to occur to green or loggerhead turtles within the 'habitat critical' during acquisition of the Laverda, Cimatti and Vincent surveys in Area C.
	Green turtle internesting BIA	PTS: 232 dB re µPa (PK) TTS: 226 dB re 1 µPa (PK) Behavioural: 166 dB re 1 µPa (SPL)	The Laverda, Cimatti and Vincent 4D surveys in Area C, which will be acquired in the period March to May 2020 (**Table 4-5**), will not overlap the peak periods for breeding or nesting for green turtles in the region. Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Received sound levels at the boundary of the internesting BIA will not exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are likely to occur to green turtles within the BIA during acquisition of the Laverda, Cimatti and Vincent surveys in Area C.
	Hawksbill and loggerhead turtle internesting BIA	PTS: 232 dB re 1 µPa (PK) TTS: 226 dB re 1 µPa (PK) Behavioural: 166 dB re 1 µPa (SPL)	The Laverda, Cimatti and Vincent 4D surveys in Area C will be acquired in the period March to May 2020 (**Table 4-5**). Consequently, acquisition of these surveys could overlap with the peak nesting period for loggerhead turtles in the region (Dec–Jan). Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Received sound levels at the boundary of the internesting BIA will not exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are likely to occur to hawksbill or loggerhead turtles within the BIA during acquisition of the Laverda, Cimatti and Vincent surveys in Area C.
	Whale shark foraging (high density prey) BIA	Injury: 219 dB re 1 µPa^2·s (SEL_{24h}) TTS: 186 dB re 1 µPa^2·s (SEL_{24h}) Behavioural: Tens of metres from source	It is possible that whale sharks may be present in Area C during the acquisition of the Laverda, Cimatti and Vincent surveys. Injury effects will only occur within very close range of the seismic source (<60 m). TTS effects could occur out to ~2.5 km from the source. Given the ranges to behavioural and TTS impacts, there is no likelihood of any effects occurring to whale sharks aggregating at Ningaloo Reef within the BIA at the start of the aggregation season in March.
	Cultural and heritage values		
	Not relevant – no cultural and heritage values of the Montebello Marine Park will be impacted by the Petroleum Activities Program.		

	Social and economic values		
	Tourism and recreation (fishing, diving and snorkelling)	Injury: 207 dB re 1 μPa (PK) TTS: 186 dB re μPa^2·s (SEL$_{24h}$) Behavioural: Tens of metres from source	The maximum predicted distances to PTS and TTS effects in large pelagic fishes for the Laverda, Cimatti and Vincent surveys are 110 m and 5.2 km, respectively. Billfishes and sailfishes are most likely to exhibit behavioural responses (avoidance) by moving away from an operating seismic source that approaches within a few tens of metres of them. Therefore, should acquisition of the Laverda, Cimatti or Vincent surveys coincide with billfish fishing competitions in the waters of the Ningaloo Marine Park, it is highly unlikely that any significant impacts will occur to the target species, particularly with respect to the ‘catchability’ of individual fish.
		145 dB re 1 μPa (SPL)	Maximum predicted received sound levels at the boundary of the Ningaloo Marine Park are ~136 dB re 1 μPa (SPL), which is below the 145 dB re 1 μPa (SPL) sound exposure threshold for divers and swimmers.
Ningaloo Coast World Heritage Area	***Natural values***		
	Aggregations of whale sharks and other megafauna (e.g. manta rays)	Injury: 219 dB re 1 μPa^2·s (SEL$_{24h}$)	It is possible that whale sharks may be present in Area C during acquisition of the Laverda, Cimatti and Vincent surveys (**Table 4-5**). Injury effects will only occur within very close range of the seismic source (<60 m). TTS effects could occur out to ~2.5 km from the source. Given the ranges to behavioural and TTS impacts, there is no likelihood of any effects occurring to whale sharks aggregating at Ningaloo Reef within the BIA at the start of the aggregation season in March. Similarly, there is no likelihood of any impacts on aggregations of other megafauna, such as manta rays.
		TTS: 186 dB re 1 μPa^2·s (SEL$_{24h}$)	
		Behavioural: Tens of metres from source	
	Marine mammals (e.g. cetaceans and dugong)	PTS: 183 dB re 1 μPa^2·s (SEL$_{24h}$) – LF cetaceans	The Petroleum Activities Program in Area C will not overlap the humpback whale migration season (June to October; **Table 4-5**). The sound exposure thresholds for injury (PTS) and TTS effects in LF, MF and HF cetaceans, and in dugong, will not be exceeded anywhere within the Ningaloo Coast WHA. The sound exposure thresholds for behavioural effects in LF, MF and HF cetaceans will not be exceeded anywhere within the Ningaloo Coast WHA.
		PTS: 185 dB re 1 μPa^2·s (SEL$_{24h}$) – MF cetaceans	
		PTS: 155 dB re 1 μPa^2·s (SEL$_{24h}$) – HF cetaceans	
		TTS: 187 dB re 1 μPa^2·s (SEL$_{24h}$) – dugong	
		TTS: 168 dB re 1 μPa^2·s (SEL$_{24h}$) – LF cetaceans	
		TTS: 170 dB re 1 μPa^2·s (SEL$_{24h}$) – MF cetaceans	
		TTS: 140 dB re 1 μPa^2·s (SEL$_{24h}$) – HF cetaceans	
		Behavioural: 160 dB re 1 μPa (SPL)	
	Marine reptiles (e.g. turtles and sea snakes)	PTS: 232 dB re μPa (PK)	The injury (PTS), TTS and behavioural sound exposure thresholds for marine turtles will not be exceeded anywhere within or adjacent to the Ningaloo Coast WHA. No impacts are likely to occur to any marine reptiles within the Ningaloo Coast WHA.
		TTS: 226 dB re 1 μPa (PK)	
		Behavioural: 166 dB re 1 μPa (SPL)	
	Reef fish communities	Injury: 207 dB re 1 μPa (PK)	The injury (PTS), TTS and behavioural sound exposure thresholds for all hearing groups of fishes, and for fish eggs and larvae, will not be exceeded anywhere within or adjacent to the Ningaloo Coast WHA. No impacts are likely to occur to any reef fish communities within the Ningaloo Coast WHA.
		TTS: 186 dB re 1 μPa^2·s (SEL$_{24h}$)	
		Behavioural: Tens of metres from source	
	Corals and other benthic invertebrates (e.g. sponges, crustaceans, echinoderms,	226 dB re 1 μPa (PK) – corals and sponges	Sound exposure thresholds for injury in corals and other benthic invertebrates will not be exceeded anywhere within or adjacent to the Ningaloo Coast WHA, and consequently no impacts are likely to occur to these habitats and communities.
		209 dB re 1 μPa (PK-PK) – crustaceans and bivalves	

	gastropods, etc)		
	Planktonic communities (including coral spawning)	207 dB re 1 µPa (PK) 178 dB re 1 µPa (PK-PK)	Sound exposure thresholds for injury effects to zooplankton, including fish eggs and larvae, and coral spawn and larval stages, will not be exceeded anywhere within or adjacent to the Ningaloo Coast WHA, and consequently no impacts are likely to occur to planktonic communities.
	Social and economic values		
	Areas of exceptional natural beauty (e.g. Cape Range)	Not relevant – no social and economic values of the Ningaloo Coast WHA will be impacted by the Petroleum Activities Program.	

*Notes: * As described in the North-west Marine Parks Network Management Plan 2018.*
[#] This KEF doesn't overlap the Montebello Marine Park.
[+] N/A: Not applicable.

Area A

Area A overlaps the Montebello Marine Park, all of which is designated as a Multiple Use Zone (MUZ – IUCN VI). The spatial extent of overlap between the Acquisition Areas for the Pluto and Harmony surveys and the MUZ is approximately 35 km^2, which represents approximately 1% of the Marine Park. The Montebello Marine Park supports a range of species, including species listed as Threatened, Migratory, Marine or Cetacean under the EPBC Act. BIAs within the Marine Park include breeding habitat for seabirds, internesting, foraging, mating and nesting habitat for marine turtles, a migratory pathway for humpback whales, and foraging habitat for whale sharks.

The potential impacts from acquisition of the Pluto and Harmony surveys in Area A to these designated conservation values are summarised in **Table 6-14**.

Area B

Area B is located approximately 51 km north of the Gascoyne Marine Park MUZ, and the Acquisition Area for the Scarborough survey is located approximately 67 km from the boundary of the MUZ. Therefore, no significant impacts to the identified natural values of the Gascoyne Marine Park are predicted to occur from acquisition of the Scarborough survey in Area B.

Area C

Area C overlaps the Gascoyne Marine Park MUZ, and the south-eastern boundary of the Area C is 2 km from the boundary of the Ningaloo Marine Park and the Ningaloo Coast WHA. However, the Acquisition Areas for the Laverda, Cimatti and Vincent surveys do not overlap either the Gascoyne Marine Park MUZ or any part of the Ningaloo Marine Park and the Ningaloo Coast WHA. At the closest point, the Laverda Acquisition Area is located approximately 3.5 km from the boundary of the Gascoyne Marine Park MUZ, and parts of the Operational Areas for all three surveys in Area C overlap the MUZ.

The potential impacts from acquisition of the Laverda, Cimatti and Vincent surveys in Area C to the designated conservation values of the Gascoyne and Ningaloo AMPs, and of the Ningaloo Coast WHA, are summarised in **Table 6-14**.

State Marine Reserves

As described in **Section 4.7** and shown in **Figure 4-22**, Areas A and C are located offshore from a number of WA State waters marine reserves; specifically, the Montebello Islands Marine Park (approximately 18 km south-east of Area A), the Ningaloo Marine Park (State waters) (approximately 9.5 km south-east of Area C), and the Muiron Islands MMA (approximately 12 km south-east of Area C). The acoustic modelling study considered received sound levels from the closest single shot locations in Acquisition Areas in Areas A and C at fixed receiver points along the boundaries of the Montebello Islands Marine Park, Ningaloo Marine Park (State waters) and the Muiron Islands MMA. The predicted received MOD single-pulse SPL at these receivers were:

- Montebello Islands Marine Park – 101.2 dB re 1 µPa (SPL)
- Ningaloo Marine Park (State waters) – 121.8 dB re 1 µPa (SPL) and 118.5 dB re 1 µPa (SPL)
- Muiron Islands Marine Management Area – 120.1 dB re 1 µPa (SPL).

These maximum received sound levels are well below the behavioural threshold for cetaceans of 160 dB re 1 µPa SPL (NMFS, 2014), and the behavioural response for turtles of 166 dB re 1 µPa SPL (NSF, 2011). Therefore, no impacts to cetaceans or turtles present in the waters of these State marine reserves are likely to occur as a result of seismic acquisition in Areas A and C.

AMPs/Ningaloo Coast WHA – Impact Assessment Conclusion

Based on the proposed timing and duration of the Petroleum Activities Program in Areas A, B and C (up to 148 days), and the control measures proposed (discussed in the Demonstration of ALARP and EPO, EPS and MC sub-sections below), predicted noise levels from seismic acquisition are not considered likely to cause any ecologically significant impacts to the natural or heritage values of any AMP in the region, to the Ningaloo Coast WHA, or to any State waters marine reserves located in inshore coastal waters of the Pilbara region.

Potential Cumulative Impacts

Cumulative impacts from seismic surveys can potentially occur when the activities take place concurrently in close proximity to each other, or when the timing between surveys is less than the recovery rate of any potential impacts.

Section 4.6.7 identifies other seismic surveys that have the potential to occur concurrently within approximately 100 km of the Petroleum Activities Program. The locations of the potential concurrent surveys, relative to Areas A, B and C, are shown in **Figure 4-20.** Only four other seismic surveys have the potential to occur concurrently with the Petroleum Activities Program:

- Davros Extension Multi-client 3D MSS
- Rollo Multi-client MSSs
- TGS North West Shelf Renaissance North Multi-client MSS
- Outer Exmouth Multi-client 3D MSS.

For seismic surveys that occur at the same time, the Bureau of Ocean Energy Management (2014) recommends a 40 km geographic separation distance (based on worst-case scenarios) between the sources of simultaneous seismic surveys to minimise the impacts to marine life, by providing a ‘corridor’ between vessels.

By definition, when seismic pulses of different sources combine, the largest difference between the combined and individual noise levels will be 3 dB; however, typically the combined dB is only 1–2 dB (United States Naval Academy, 2015). There is also the potential that noise from multiple surveys can combine and cancel each other out, actually reducing the peak noise levels of each survey (referred to as destructive interference). Even in this worst-case scenario where resultant sound levels for the multiple surveys are increased by 3 dB, this change is not expected to result in any significant variation to the stated maximum behavioural thresholds for marine fauna.

Woodside will engage with proponents identified as having potential concurrent MSS prior to commencing the Petroleum Activities Program and have committed to a 40 km geographic separation distance for concurrent surveys identified within 100 km of each Acquisition Area.

A review of previous seismic surveys over or near Areas A, B and C identified three 3D seismic surveys and one 2D seismic survey. The most recent survey that overlapped any of Areas A, B or C was the Exmouth SLB15 Multi-client 3D MSS, which overlapped most of Area C. The Exmouth SLB15 Multi-client 3D MSS was completed before September 2018, giving a period of over two years for recovery, before acquisition of the Laverda, Cimatti and Vincent surveys in early 2020.

Based on the acoustic modelling study and noise impact assessment conducted for the Petroleum Activities Program, the recovery periods for any impacts to sensitive receptors are predicted to be:

- immediately after completing seismic acquisition for migratory or transient species that may avoid the area, e.g. whales, whale sharks, turtles and pelagic fishes
- days or weeks after completing seismic acquisition for demersal fish species, including key indicator commercial fish species that may show avoidance or behavioural reactions during the surveys
- days to months after completing seismic acquisition for plankton, based on the CSIRO (Richardson et al., 2017) modelling study
- weeks to months after completing seismic acquisition for site-attached fish species and benthic invertebrates, as only sub-lethal effects were identified that would not reduce reproductive potential or inhibit spawning.

Based on the fishing effort reported in the annual State of the Fisheries reports (2013 to 2017) for key indicator commercial fish species, there has been no decline in the tonnages of fish caught for the allocated licences, even though seismic surveys have been conducted within this period overlapping the area of catch and effort for these fisheries. Thus, using a recovery time of 12 months, cumulative impacts to sensitive receptors in Areas A, B and C from previous seismic surveys are not predicted.

Summary of Potential Impacts to Environmental Values(s)

Given the adopted controls, the potential impacts of noise emissions from the seismic source on marine fauna during acquisition of the six 4D surveys in Areas A, B and C are considered to be slight and short-term, and restricted to temporary behavioural changes (avoidance) in any isolated individuals that may transit the area in close proximity to the operating seismic source.

Acquisition of the 4D surveys in Area C will be managed to avoid injury to any pygmy blue whale and avoid displacement of any pygmy blue whales from the possible foraging BIA during the peak of the northbound migration (May-June; **Table 4-5**). Acquisition of the surveys in Area A will be managed to avoid displacement of any flatback turtles from the identified ‘habitat critical’ around the Montebello Islands. Therefore, the Petroleum Activities Program will be conducted in a manner that is not inconsistent with the objectives and actions of the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015), and the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017).

With the control measures in place, the Petroleum Activities Program will not result in any significant impacts to any socio-economic receptors or activities taking place within or adjacent to Areas A, B and C.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures to cetaceans, as outlined below: • observation zone: 3 km+ • shut-down zone: 2 km • observation and compliance reporting: – Use of vessel crew to supplement dedicated MFOs in marine fauna observations and monitoring compliance to Policy Statement 2.1. – Records kept of marine fauna observations during all surveys. • pre start-up visual observation (30 minutes) • soft start procedure (30 minutes) • start-up delay procedure (if sighting occurs) • operations procedure • stop work procedure • night-time and low visibility procedure.	F: Yes. CS: Minimal cost. Standard.	Reduces the likelihood of individuals of cetacean, turtle or whale shark species being within proximity of the acoustic source where behavioural impact could occur.	Benefits outweigh cost/sacrifice.	Yes **C 3.1**
Good Practice				
Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures to	F: Yes.	Reduces the likelihood of individuals of cetacean, turtle or whale	Benefits outweigh cost/sacrifice.	Yes **C 3.2**

[15] Qualitative measure
[16] Measured in terms of reduction of consequence (C)

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)*[15]**	***Benefit in Impact/Risk Reduction*[16]**	***Proportionality***	***Control Adopted***
whale sharks and turtles, as outlined below: • observation and shutdown zone 500 m. During survey: • pre start-up Visual Observation (final ten minutes of the whale pre-start up observation period) • soft start observations (final ten minutes of the whale soft start period) • start-up delay procedure (applied if whale shark or turtle is sighted within the 500 m shutdown zone, recommence soft start if animal/s observed to move outside of the 500 m shut down zone or a period of ten minutes has passed since last sighting) • operations procedure (continuous observations focusing on 500 m zone) • stop work procedure (applied to whale shark and turtle sightings in 500 m shutdown zone). Observation and compliance reporting: • use of vessel crew to supplement dedicated MFOs in whale shark and turtle observations and monitoring compliance • record kept of whale shark and turtle sightings • record kept of observation effort, observation conditions, source operations and procedures implemented.	CS: Minimal cost. Standard practice.	shark species being within proximity of the acoustic source where behavioural impact could occur.		
Extension of pre start-up visual observation survey from 30 minutes to 60 minutes to avoid	F: Yes. CS: Significant cost and schedule impacts	Surveys have been planned to take place outside the humpback whale northbound and	Disproportionate. The cost/sacrifice outweighs the benefit gained.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
impacts to deep diving cetacean species.	due to delays in acquiring seismic data. Given the seismic survey vessel be in continuous transit while seismic gear is deployed, an extension to the pre-start visual survey would result in the vessel being approximately 10 km from the initial shot point at the commencement of a pre start-up visual survey. If a whale was spotted at this distance it would result in the vessel aborting the survey line and conducting a second line turn to allow for the pre start-up survey to recommence. The delays to the survey from this could be up to seven hours given the vessel speed and required distance for a line turn. Given significant impacts (i.e. injury) to cetaceans has been identified from modelling as being restricted to approximately 1, 6 and 2 km from the seismic source for Areas A, B and C, respectively, and the adopted controls for monitoring, soft starts and shut down procedures, which are effective within these distances, the potential cost implications outweigh the environmental benefits of an extended pre start-up visual survey.	southbound migratory seasons to minimise impacts. The pygmy blue whale southbound migration does have an identified short peak period of migrating individuals within the North West Shelf region at the end of November and a rapid decline in early December which is outside the proposed timing of the activity. However, there is a short period of temporal overlap of the Petroleum Activities Program at the start of the northbound pygmy blue whale migration. Given the absence of any interaction between critical habitats (i.e. feeding, breeding, calving) or a constricted migratory pathway and the Acquisition Areas, and potential impacts from delays to the survey causing its duration to be extended, no benefit is considered by implementing an extended 60 minute pre start-up survey. Given the existing controls in place the predicted impacts from seismic acquisition are not considered to be ecologically significant at a population level for pygmy blue whales or any other species of baleen or larger toothed whale that may be encountered during the Petroleum Activities Program.		
Do not discharge the seismic source outside Acquisition Areas for all six surveys, except for the purpose of run-ins, run-outs and soft starts within an approximate 4 km buffer extension along the	F: Yes. CS: Standard activity. Business as usual. No additional cost/sacrifice.	Reduces the likelihood of seismic noise emissions impacting the marine environment, outside of what is deemed acceptable in this EP.	Standard activity. Business as usual. No additional cost/sacrifice.	Yes **C 3.3**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
axes of the planned line turns of each Acquisition Areas.				
Undertake source testing within the Acquisition Area.	F: Yes. CS: Standard activity. No additional cost/sacrifice.	Reduces the likelihood of seismic noise emissions impacting the marine environment, outside of what is deemed acceptable in this EP.	Standard activity. No additional cost/sacrifice.	Yes **C 3.4**
Establish a 2 km buffer between the Petroleum Activities Program and the Ningaloo Coast WHA through reducing the Operational Areas for Laverda and Cimatti seismic surveys.	F: Yes. CS: The inshore boundaries of the Operational Areas for the Laverda and Cimatti surveys have been moved further offshore to allow for a 2 km buffer zone between the Operational Areas and the boundary of the Ningaloo Coast WHA.	Establishment of a buffer zone between the Operational Areas for the Laverda and Cimatti surveys will ensure that there is no possibility of the survey vessel or any part of the towed array inadvertently entering the Ningaloo Coast WHA during acquisition of the Area C surveys.	Some additional benefit and limited additional cost.	Yes **C 3.5**

Notify the Exmouth Game Fishing Club and Recfishwest two weeks before the seismic vessel arriving into any Operational Area. Exmouth Game Fishing Club will be provided with information that includes:
• proposed survey mobilisation date
• map of survey area and acquisition lines
• relevant contact details for communications during survey acquisition:
  – VHF radio channel
  – satellite call sign
  – vessel call signs.
If seismic acquisition in Area C unavoidably overlaps with a recreational fishing tournament, Woodside will provide the Exmouth Game Fishing Club with the following additional information:
• daily 24-hour lookahead plan of proposed acquisition
	F: Yes.
	CS: Minimal cost. Standard practice.
		Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interfering with other marine users.	Standard activity. Business as usual. Minimal additional cost/sacrifice.	Yes
				C 3.6

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[15]	***Benefit in Impact/Risk Reduction***[16]	***Proportionality***	***Control Adopted***
and vessel movements.				
Do not acquire seismic data within Area C during GAMEX tournament fishing days.	F: Yes. CS: Survey timing planned in advance to avoid disproportionate cost.	Seismic data acquisition in Area C will take place outside of the 15th to 20th of March to avoid GAMEX tournament fishing days to minimise impacts.	Survey timing planned in advance to avoid disproportionate cost.	Yes **C 3.7**
Engage with facility operators, commercial diving companies, scientific research groups, and recreational dive operators. This process will adhere to the following recommended requirements of the revised DMAC 12 guidelines: • Where diving and seismic activity are scheduled to occur within a distance of 45 km, Woodside will notify divers of the planned activity where practicable. • Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the clients/operators involved and the seismic and diving contractors in advance of any simultaneous operations. • The risk assessment should consider ramp-up trials as well as other risk control measures e.g. reduction in source sizes, changes to firing intervals, timeshare/prioritisation etc. Sound pressure levels from noise modelling studies should be considered together with other relevant factors in the risk assessment.	F: Yes. CS: Minimal cost. Standard practice.	Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interfering with other marine users.	Standard activity. Business as usual. Minimal additional cost/sacrifice.	Yes **C 3.8**
Maintain a 40 km separation distance between the Acquisition Area and any identified concurrent seismic survey.	F: Yes. CS: Minimal cost. Standard practice.	Implementing a separation distance may reduce the likelihood of cumulative impacts from concurrent surveys.	Benefits outweigh cost/sacrifice.	Yes **C 3.9**
Professional Judgement – Eliminate				
No additional controls identified.				

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
Professional Judgement – Substitute				
Vary the timing of the Petroleum Activities Program in Areas A and C to avoid the migration periods for humpback whales. Timing of acquisition of the Pluto and Harmony surveys in Area A, and the Laverda, Cimatti and Vincent surveys in Area C will avoid northbound and southbound and humpback whale migration (June to October).	F: Yes. The surveys in Areas A and C will be acquired in the period between late December 2019 and the end of May 2020 (**Table 4-5**), thus avoiding the migration seasons for humpback whales. CS: Survey timing planned in advance to avoid disproportionate cost.	Surveys will take place outside the humpback whale northbound and southbound migratory seasons to minimise impacts.	Survey timing planned in advance to avoid disproportionate cost.	Yes **C 3.10**
Vary the timing of the Petroleum Activities Program to avoid migration periods of pygmy blue whales.	F: Yes CS: Significant cost and schedule impacts due to delays in acquiring data and securing survey vessel for specific timeframes. The data acquired during the M1 and M2 4D surveys (Pluto, Harmony, Laverda, Cimatti and Vincent) will be used to calibrate subsurface models to assist in de-risking future infill targets and support optimising reservoir offtake strategies. Any delays to the seismic program will accordingly result in significant cost and operational implications for the business.	The pygmy blue whale southbound migration does have an identified short peak period of migrating individuals within the North West Shelf region at the end of November with a rapid decline in early December which is outside the proposed timing of the activity. However, there is a short period of temporal overlap of the Petroleum Activities Program at the start of the northbound pygmy blue whale migration. Given the absence of any overlap between critical habitats (i.e. feeding, breeding, calving) or a constricted migratory pathway and the Acquisition Areas, the small predicted distance from the seismic source within which PTS, TTS and behavioural impacts are expected, and the control measures proposed, the predicted impacts from seismic acquisition are not considered to be ecologically significant at a population level for pygmy blue whales or any other species of large whale that may be encountered during the	Disproportionate. The cost/sacrifice outweighs the benefit gained. The cost of not acquiring seismic data during this period will result in schedule implications for the producing fields and significant additional costs to complete the surveys at another time. More significantly there are greater cost/sacrifice implications in the value of receiving the data to optimise reservoir production and inform future production profiles. Implementing EPBC Policy Statement 2.1 Part A, and selected Part B measures will achieve an acceptable level of risk reduction during the pygmy blue whale southbound and northbound migrations.	No

Demonstration of ALARP				
Control Considered	**Control Feasibility (F) and Cost/Sacrifice (CS)[15]**	**Benefit in Impact/Risk Reduction[16]**	**Proportionality**	**Control Adopted**
		Petroleum Activities Program.		
Vary the timing of survey acquisition in Area C such that the sound footprint does not exceed TTS thresholds for low frequency cetaceans during the peak period for the northbound pygmy blue whale migration through the possible foraging BIA.	F: Yes. Acquisition of the surveys in Area C is planned for the period early March to May 2020 (**Table 4-5**). The schedule will be managed to ensure that the Laverda survey is not acquired in May without significant additional cost.	The Petroleum Activities Program will not commence until late December 2019, or the beginning of January 2020. The Pluto and Harmony surveys in Area A will be acquired first, which means that there will be no overlap with the peak period for the southbound migration of pygmy blue whales in the region (end November/early December), for surveys in either Area A or Area C. Acquisition of surveys in Area C may overlap the beginning of the northbound migration for pygmy blue whales (April/May). Acquisition of the Laverda 4D survey will not occur during May-June (**Table 4-5**). This control takes into account the spatial overlap between the TTS onset zone and a small section of the northern extent of the possible foraging area for pygmy blue whales. As described above, there is no overlap between the TTS onset zones for the Cimatti and Vincent surveys and the possible foraging area, and hence this control will not apply to these two surveys in Area C.	Survey timing planned in advance to avoid disproportionate cost.	Yes **C 3.11**
Vary the timing of survey acquisition in Areas A and C so that the behavioural response zone for pygmy blue whales is minimised within the migration BIA during peak migration seasons.	F: Yes. CS: Significant cost and schedule impacts due to delays in acquiring data and securing survey vessel for specific timeframes. It is not possible to commit to a specific period for acquisition of	The Petroleum Activities Program will not commence until late December 2019, or the beginning of January 2020. The Pluto and Harmony surveys in Area A will be acquired first, which means that there will be no overlap	Disproportionate. The cost/sacrifice outweighs the benefit gained. Implementing EPBC Policy Statement 2.1 Part A, and selected Part B measures will	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
	surveys in Area C, or the order in which they will be acquired, due to uncertainties around timing of acceptance of the EP, survey vessel availability, commencement date for the Petroleum Activities Program and other factors (e.g. weather downtime, cyclones etc.). Woodside will take all possible steps to ensure that this is unlikely to occur, but cannot commit to avoiding this temporal overlap.	with the peak period for the southbound migration of pygmy blue whales in the region (end November/early December), for surveys in either Area A or Area C. Acquisition of surveys in Area C may overlap the beginning of the northbound migration for pygmy blue whales (April/May), however, acquisition of Laverda, where will not occur during peak migration (May-June; **Table 4-5**). Based on the acoustic and ANIMAT modelling results an estimated 1.72 to 1.05 individual whales may be exposed to received levels associated with behavioural responses within the migration BIA across all five surveys in Areas A and C, without the application of control/mitigation measures. This is for a (sub) population with an estimated mean of 1110 animals. Hence, any controls to minimise temporal overlap between surveys in Areas A and C and the northbound pygmy blue whale migration would have limited benefit in terms of impact/risk reduction.	achieve an acceptable level of risk reduction during the pygmy blue whale northbound migration.	
Vary the timing of the Petroleum Activities Program to avoid turtle internesting seasons.	F: Yes. CS: Significant cost and schedule impacts due to delays in acquiring data and securing survey vessel for specific timeframes. The data acquired during the M1 and M2 4D surveys (Pluto, Harmony, Laverda, Cimatti and Vincent) will be used to calibrate subsurface models to assist in de-risking	Based on the timing and duration of the Petroleum Activities Program, the absence of suitable habitat for internesting turtles and the control measures proposed, predicted noise levels from seismic acquisition are not considered likely to cause injury effects, displace any individuals from the internesting BIA or 'habitat critical' areas, or result in any	Disproportionate. The cost/sacrifice outweighs the benefit gained. The cost of not acquiring seismic data during this period will result in schedule implications for the producing fields and significant additional costs to complete the surveys at	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
	future infill targets and support optimising reservoir offtake strategies. Any delays to the seismic program will accordingly result in significant cost and operational implications for the business.	ecologically significant impacts at a population level for any species of turtle that may be present within or adjacent to Areas A, B and C during the Petroleum Activities Program.	another time. More significantly there are greater cost/sacrifice implications in the value of receiving the data in order to optimise reservoir production and inform future production profiles. Implementing EPBC Policy Statement 2.1 Part A measures for turtles will achieve an acceptable level of risk reduction during turtle breeding and nesting seasons in the North West Shelf region.	
Vary the timing of survey acquisition in Areas A and C so that the behavioural response footprint for whale sharks is minimised within the foraging BIA during the migration season.	F: Yes. CS: Significant cost and schedule impacts due to delays in acquiring data.	The behavioural response zone for whale sharks is likely to be restricted to a few hundred metres from the seismic source. None of the Acquisition Areas for the surveys in Area C overlap the whale shark migration BIA, with a minimum separation distance of approximately 5 km between the boundary of the BIA and the closest Acquisition Area (Cimatti). The migration BIA overlaps the Pluto and Harmony Acquisition Areas. However, acquisition of these surveys will not overlap the period when whale sharks are likely to be moving through the migration BIA (July to November).	Disproportionate. The cost/sacrifice outweighs the benefit gained. EPBC Policy Statement 2.1 Part A measures for whale sharks will achieve an acceptable level of risk reduction during whale shark migration to the aggregation area off Ningaloo Reef.	No
Vary the timing of the Petroleum Activities Program	F: No CS: Significant cost and schedule impacts	Not considered – control not feasible.	Not considered – control not feasible.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
to avoid concurrent survey activities.	due to delays in acquiring data.			
Professional Judgement – Engineered Solution				
Employ two dedicated MFOs to undertake observations for EPBC Act Policy Statement 2.1, as applied in other adopted controls.	F: Yes. Additional MFO coverage required due to the proposed timing of the Petroleum Activities Program corresponding with the pygmy blue whale migration seasons, and peak periods for turtle breeding/nesting in the region. CS: Additional cost of MFOs.	Additional MFO coverage will increase the likelihood of marine fauna being spotted.	Benefits outweigh cost/sacrifice.	Yes **C 3.12**
EPBC Act Policy Statement 2.1 Part B 4 – Increased precaution zones and buffer zones as follows: • An increased shutdown zone of 2 km will be applied for whales during all six 4D surveys.	F: Yes. Increased shutdown zone of 2 km rather than 500 m for whales. CS: Additional cost of increased downtime due to shutdowns for whales in the 2 km shutdown zone.	Increased shutdown zone reduces the potential for impact to whales from noise generated from the seismic source.	Benefits outweigh cost/sacrifice.	Yes **C 3.13**
EPBC Act Policy Statement 2.1 Part B.6 – Adaptive Management measures to minimise the potential impacts to pygmy blue whales from seismic noise. The following adaptive management measures will be implemented: • If the survey is required to shutdown/power-down three or more times per day for three consecutive days as a result of sighting any blue whale then the seismic operations must not be undertaken thereafter at night time or during low visibility conditions. • Seismic operations cannot resume at night time or during low visibility conditions, until there has been a 24-hour period, which included seismic	F: Yes. CS: Minimal cost. Low numbers of pygmy blue whales are predicted to occur during the Petroleum Activities Program period.	Implementation of adaptive management procedures (**Figure 6-2**) to ensure that the potential for behavioural disturbance to pygmy blue whales is minimised within the migration BIA during the migration seasons. These procedures will apply for pygmy blue whales within the migration BIA during either southbound (Dec-Jan) or northbound (Apr-Jun) migration. These procedures reduce the potential for impacts to pygmy blue whales from noise generated from the seismic source if higher than predicted numbers are found to occur during the Petroleum Activities Program period.	Benefits outweigh cost/sacrifice.	Yes **C 3.14**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
operations during good visibility conditions, during which no shutdowns/ power-downs have occurred for blue whale sightings.				
Application of EPBC Act Policy Statement 2.1 Part B.6 – Adaptive Management Measures to minimise the potential impacts from seismic noise to turtles. EPBC Act Policy Statement 2.1 Part B.6 – Adaptive Management Measures. Turtles - within Area A during December to February. The following adaptive management measures procedures will be implemented: • If the seismic source is required to be shutdown three or more times per day for three consecutive days as a result of sighting turtles, then the seismic operations must not be undertaken thereafter at night-time or during low visibility conditions. • Seismic operations cannot resume at night-time or during low visibility conditions, until there has been a 24-hour period which included seismic operations during good visibility conditions, during which 0-2 shutdowns have occurred for turtle sightings.	F: Yes. CS: Significant cost and schedule impacts due to potential delays in acquiring data. The data acquired during the M1 and M2 4D surveys (Pluto, Harmony, Laverda, Cimatti and Vincent) will be used to calibrate subsurface models to assist in de-risking future infill targets and support optimising reservoir offtake strategies. Any delays to the seismic program could result in significant cost and operational implications.	Based on the timing and duration of the Petroleum Activities Program, the absence of suitable habitat for internesting turtles and the control measures proposed, predicted noise levels from seismic acquisition are not considered likely to cause injury effects, displace any individuals from the internesting BIA or 'habitat critical' areas, or result in any ecologically significant impacts at a population level for any species of turtle that may be present within or adjacent to Areas A, B and C during the Petroleum Activities Program. As the Pluto and Harmony 4D surveys will be acquired in a location that is spatially on the edge of an area that is considered to provide biologically important habitat for turtles (i.e. the identified 'habitat critical' and internesting buffer BIA around the Montebello Islands), and as the surveys will overlap the nesting season, additional adaptive management procedures (**Figure 6-5**) will be implemented to manage the likelihood of encountering higher numbers of turtles than expected. These procedures are based on the cessation of acquisition at night-time or periods of poor	Benefits outweigh cost/sacrifice.	Yes **C 3.15**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
		visibility if there are three consecutive days during which there have been three or more turtle-instigated shutdowns.		
EPBC Act Policy Statement 2.1 Part B.2 – Night-time/poor visibility: • limiting soft start procedures to conditions that allow visual inspection of the precaution zone • spotter vessel or aircraft searches • pre-survey research.	F: Yes. Increases potential likelihood of environmental impacts, health and safety impacts to personnel due to additional vessels and aircraft in the field. CS: Significant cost and schedule delays.	These control measures will not be implemented given the relatively low densities of cetaceans, turtles and whale sharks expected and the absence of any overlap between critical habitats (i.e. feeding, breeding, calving) or a constricted migratory pathway and the Acquisition Areas. The adoption of both Part B.6 – Adaptive management procedures for pygmy blue whales in the migration BIA (**Figure 6-2**) and Part A3.6 – Night time and low visibility procedures, are considered adequate to ensure potential impacts to whales, turtles and whale sharks are ALARP.	Disproportionate. The cost/sacrifice outweighs the benefit gained.	No
EPBC Act Policy Statement 2.1 Part B.3 – Use of spotter aircraft and vessels to detect presence of cetaceans.	F: Yes. Increases potential likelihood of environmental impacts, health and safety impacts to personnel due to additional vessels and aircraft in the field. CS: Significant cost of aircraft/vessels and personnel.	Surveys have been planned to take place outside the humpback whale northbound and southbound migratory seasons to minimise impacts. The pygmy blue whale southbound migration does have an identified short peak period of migrating individuals within the North West Shelf region at the end of November with a rapid decline in early December which is outside the proposed timing of the activity. However, there is a short period of temporal overlap of the Petroleum Activities Program at the start of the northbound pygmy blue whale migration.	Disproportionate. The cost/sacrifice outweighs the benefit gained.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
		Given the absence of any interaction between critical habitats (i.e. feeding, breeding, calving) or a constricted migratory pathway and the Acquisition Areas, no benefit is considered by implementing EPBC Policy Statement 2.1 Part B3. Given the existing controls in place the predicted impacts from seismic acquisition are not considered to be ecologically significant at a population level for pygmy blue whales or any other species of large whale that may be encountered during the Petroleum Activities Program.		
Application of EPBC Act Policy Statement 2.1 Part B.5 – PAM: • A PAM system will be installed aboard the survey vessel to detect odontocete whales (specifically sperm and beaked whales) meeting the specification requirements detailed in **Appendix I.**	F: Yes. PAM is an emerging technology that can be a useful tool. PAM is known to be effective for detecting small odontocetes (toothed whales) such as porpoise species that are known to emit regular high frequency echolocation clicks and sperm whales, which emit regular distinctive clicks during long dives (Marine Mammal Observer Association, 2014). However, it has many limitations, particularly when used to detect baleen whales such as pygmy blue whales. CS: Significant cost of PAM equipment and personnel.	PAM will be deployed aboard the survey vessel to detect foraging sperm and beaked whales, and procedures as described in the EPO, EPS and MC table, and in **Appendix I** will be implanted in the event that any sperm or beaked whales are detected.	Benefits outweigh cost/sacrifice.	Yes **C 3.16**
Establish a warning system on the survey vessel that will activate an alarm if the vessel comes within 1 km of the Operational Area boundary adjacent to the WHA (i.e. 3 km from the WHA boundary) for Laverda, Cimatti and Vincent surveys.	F: Yes. CS: Minimal cost. Vessels are already monitored 24-hours a day via AIS tracking system resulting in minimal cost to set up an alarm as part of the	Warning system will ensure compliance with legislation that states no petroleum activity should occur within the boundary of a WHA. The alarm will be activated on board the survey vessel as well as	Minimal additional cost/sacrifice.	Yes **C 3.17**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[15]***	***Benefit in Impact/Risk Reduction[16]***	***Proportionality***	***Control Adopted***
	project GIS management systems.	at Woodside headquarters as it will be linked to the 24-hour vessel AIS tracking system.		
Risk Based Analysis				
N/A.				
Company Values				
N/A.				
Societal Values				
N/A.				
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type B), Woodside considers the adopted controls appropriate to manage the impacts and risks of noise emissions generated from seismic source. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability			
Receptor	***Acceptability Criteria and Assessment***	***Acceptable Levels of Impact***	***Statement of Acceptability***
Migratory and threatened cetaceans	**Principles of ESD** The Petroleum Activities Program is consistent with the relevant principles of ESD: • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making. • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context** The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety, Environment and Quality Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** During stakeholder consultation with relevant persons, the Cape Conservation Group (CCG), Ningaloo Coast World Heritage Advisory Committee and the DNP sought information regarding the potential impacts of seismic acquisition on whales within AMPs and the Ningaloo Coast WHA, and on proposed control measures to eliminate, minimise or mitigate impacts and risks. These concerns have been considered in this EP through the implementation of a series of controls (**C 3.3**, **C 3.4**, **C 3.9**, **C 3.10**, **C 3.11**, **C 3.12**, **C 3.13**, **C 3.14** and **C 3.16**) and demonstration that impacts and risks will be managed to levels that are ALARP. **Other Requirements** The proposed control measures exceed the required standards and control measures set out in EPBC Policy Statement 2.1. Part A Standard Management Measures (DEWHA, 2008).	Seismic activities conducted as part of the Petroleum Activities Program are not inconsistent with a recovery plan or wildlife conservation plan/advice that is in force for a species of cetacean, including the: • Conservation management plan for the blue whale (Commonwealth of Australia, 2015a) • Conservation advice *Balaenoptera borealis* (sei whale) (Threatened Species Scientific Committee, 2015a) • Conservation advice *Balaenoptera physalus* (fin whale) (Threatened Species Scientific Committee, 2015b) • Conservation advice for *Megaptera novaeangliae* (humpback whale) (Threatened Species Scientific Committee, 2015c) • Conservation management plan	The predicted level of impact for migratory and threatened cetaceans is considered to be at or below the defined acceptable levels given the controls implemented will: • prevent physical injury to any cetacean species • prevent physical injury or displacement of pygmy blue whales from foraging BIAs • prevent displacement of humpback whales from BIAs during migration periods, as defined in Table 4-5. Based on an assessment against the defined acceptable levels, the impact to migratory and threatened cetaceans from seismic noise is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD • the proposed controls have considered the environmental consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advices • the predicted level of impact has been reduced to ALARP • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Consideration**

	Control measures have been identified that are not inconsistent with the requirements of the Conservation Management Plan for the Blue Whale, specifically that '*Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area*'. The impact assessment and proposed control measures are not inconsistent with the relevant conservation actions identified in the conservation advices for humpback, sei and fin whales, specifically to '*Assess and address anthropogenic noise*'. Control measures have been identified that are not inconsistent with the requirements of the Conservation Management Plan for the Humpback Whales, specifically that '*All seismic surveys must be undertaken consistently with the EPBC Act Policy statement 2.1. Should a survey be undertaken in or near a calving, resting, foraging area, or a confined migratory pathway then Part B additional management procedures must be applied*'. The impact assessment and proposed control measures are consistent with NOPSEMA Acoustic Impact Evaluation and Management Guideline (N-04750-IP1765 Rev2 Dec 2018). No significant or long-term impacts are expected to occur to key habitats of EPBC Act listed species included as values of the Montebello, Gascoyne and Ningaloo AMPs, including pygmy blue whales and other cetaceans. Marine mammals are also identified as a natural value of the Ningaloo Coast WHA. No significant impacts to any species of marine mammal are predicted and the activity will be undertaken consistent with the Australian World Heritage management principles as described in Schedule 5 of the EPBC Regulations 2000 (**Section 1.10.1.2**).	for the southern right whale (DSEWPaC, 2012b).	To manage impacts to migratory and threatened cetaceans to at or below the defined acceptable levels the following EPOs have been applied: **EPO 3.1**: Undertake seismic acquisition in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks) **EPO 3.2**: Undertake seismic acquisition in a manner that prevents displacement of pygmy blue whales within foraging BIAs **EPO 3.3**: Undertake seismic acquisition in a manner that prevents impacts to humpback whales within BIAs.
Migratory and threatened turtles	**Principles of ESD** The Petroleum Activities Program is consistent with the relevant principles of ESD: • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making. • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context**	Seismic activities conducted as part of the Petroleum Activities Program are not inconsistent with a recovery plan or wildlife conservation plan/advice that is in force for a species of marine turtles, including the:	The predicted level of impact for migratory and threatened turtles is considered to be at or below the defined acceptable levels given the controls implemented will: • prevent physical injury to marine turtle species • prevent displacement of marine turtles from habitat critical/important internesting habitat during nesting/internesting periods, as defined in Table 4-5.

	The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety, Environment and Quality Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** During stakeholder consultation with relevant persons, no specific concerns were raised regarding the potential impacts of seismic noise to marine turtles. The DNP directed Woodside to the Recovery Plan for Marine Turtles to determine where operations intercept 'habitat critical' areas for turtles and where there is temporal overlap with marine turtle nesting, internesting and hatchling emergence periods. The Recovery Plan for Marine Turtles was incorporated as part of the assessment of impacts and risks to marine turtles and additional controls, beyond those legislated, have been implemented to prevent impacts to marine turtles within these areas (**C 3.2**, **C 3.3**, **C 3.4**, **C 3.9**, **C 3.12**, **C 3.13**, and **C 3.15**). **Other Requirements** The proposed control measures are not inconsistent with the applicable objectives and actions of the Recovery Plan for Marine Turtles. Specifically, controls measures will '*manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival'* of marine turtles and '*given that the impacts of noise are unknown, a precautionary approach [will] be applied to seismic work, such that surveys planned to occur inside important internesting habitat should be scheduled outside the nesting season*'. Relevant controls adopted to ensure consistency with these actions have been adopted to ensure that received noise levels from seismic acquisition are not likely to cause injury impacts, displace any individuals from habitat critical or internesting BIAs, or result in any ecologically significant impacts at a population level for any species of marine turtle that may be present within or adjacent to Areas A and C during the Petroleum Activities Program. The impact assessment and proposed control measures are consistent with NOPSEMA Acoustic Impact Evaluation and Management Guideline (N-04750-IP1765 Rev2 Dec 2018).	• Recovery plan for marine turtles in Australia (DoEE, 2017) • Conservation advice *Dermochelys coriacea* (leatherback turtle) (Threatened Species Scientific Committee, 2008a).	Based on an assessment against the defined acceptable levels, the impact to migratory and threatened turtles from seismic noise is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD • the proposed controls have considered the environment consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation plans/advice • the predicted level of impact has been reduced to ALARP • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Consideration** To manage impacts to migratory and threatened turtles to at or below the defined acceptable levels, the following EPOs have been applied: **EPO 3.1**: Undertake seismic acquisition in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks) **EPO 3.4**: Undertake seismic acquisition in a manner that prevents displacement of marine turtles from habitat critical during nesting and internesting periods.

	Nesting and internesting marine turtle habitats are identified as a natural value of the Montebello, Gascoyne and Ningaloo AMPs. No significant impacts to internesting marine turtles are predicted and the activity will be undertaken consistent with marine park objectives. Nesting and internesting marine turtle habitats are also identified as a natural value of the Ningaloo Coast WHA. No significant impacts to internesting marine turtles are predicted and the activity will be undertaken consistent with the Australian World Heritage management principles as described in Schedule 5 of the EPBC Regulations 2000 (**Section 1.10.1.2**).		
Migratory and threatened fishes and elasmobranchs (whale sharks)	**Principles of ESD** The Petroleum Activities Program is consistent with the relevant principles of ESD: • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making. • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context** The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety, Environment and Quality Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** During stakeholder consultation with relevant persons, the CCG sought information regarding the potential impacts of seismic acquisition on whale sharks off Ningaloo Reef, and on proposed control measures to eliminate, minimise or mitigate impacts and risks. These concerns have been considered in this EP through the implementation of a series of controls (**C 3.2**, **C 3.3**, **C 3.4**, **C 3.9**, and **C 3.12**) and demonstration that impacts and risks will be managed to levels that are ALARP. **Other Requirements**	Seismic activities conducted as part of the Petroleum Activities Program are not inconsistent with a recovery plan or wildlife conservation plan/advice that is in force for whale sharks, including the: • Conservation advice (Threatened Species Scientific Committee, 2015).	The predicted level of impact for whale sharks is considered to be at or below the defined acceptable levels given the controls implemented will: • prevent physical injury to whale sharks Based on an assessment against the defined acceptable levels, the impact to migratory and threatened fishes and elasmobranchs (whale sharks) from seismic noise is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD • the proposed controls have considered the environment consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation advice • the predicted level of impact has been reduced to ALARP • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Consideration** To manage impacts to migratory and threatened fishes and elasmobranchs (whale sharks) to at or

	There are no legislative requirements applicable to managing the effects of seismic surveys in relation to whale sharks. Seismic noise has not been identified as a threat to whale sharks (or other shark species identified as possibly present in the region) in either the Approved Conservation Advice (Threatened Species Scientific Committee, 2015) or previously in force Whale Shark Recovery Plan 2005–2010 (DEH, 2005). Noise pollution is not identified as a pressure to whale sharks in the Marine Bioregional Plan for the NWMR (DSEWPaC, 2012), or in the Ningaloo Coast: World Heritage nomination report (Commonwealth of Australia, 2010). The impact assessment and proposed control measures are consistent with NOPSEMA Acoustic Impact Evaluation and Management Guideline (N-04750-IP1765 Rev2 Dec 2018).		below the defined acceptable levels, the following EPO has been applied: **EPO 3.1**: Undertake seismic acquisition in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks)
Fish spawning and commercial fisheries	**Principles of ESD** The Petroleum Activities Program is consistent with the relevant principle of ESD: • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context** The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety, Environment and Quality Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** During stakeholder consultation with relevant persons, feedback was received from DPIRD, WAFIC and commercial fisheries licence holders highlighting concerns regarding the potential impacts of seismic surveys to commercial fish spawning, stocks and catch. These concerns have been considered in this EP through review of overlap of behavioural response zone for fish and potential spawning areas, and demonstration that impacts and risks will be managed to levels that are ALARP. The potential impacts of noise emissions from	Acquisition conducted in a manner such that the level of impact to commercial fish stocks is acceptable if disturbance to spawning fishes will not result in changes to the spawning biomass or changes in recruitment that may be discernible from normal natural variation.	The predicted level of impact for fish spawning and commercial fisheries is considered to be at or below the defined acceptable levels given the controls implemented will: • not lead to a change in spawning biomass of a commercially important species • not lead to changes in recruitment of a commercially important species that may be discernible from normal natural variation. Based on an assessment against the defined acceptable levels, the impact to fish spawning and commercial fisheries from seismic noise is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD • the proposed controls have considered the environment consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted

	the seismic source on spawning of key indicator commercial fish species are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any key indicator commercial fish species that may be spawning within or adjacent to Areas A, B or C during acquisition activities. Similarly, the potential impacts on commercial catch rates are considered to be slight and short-term, as the activity is not likely to result in any ecologically significant impacts at a population level for any key indicator species targeted by commercial fisheries. **Other Requirements** There are no legislative requirements applicable to managing the effects of seismic surveys in relation to fish spawning and commercial fisheries. The proposed control measures are consistent with key mitigation strategies for seismic surveys published in the WA Department of Fisheries Guidance statement on undertaking seismic surveys in Western Australian waters (DoF, 2013) – e.g. use of soft starts; minimise the sound intensity and exposure time of surveys. Woodside has also considered DPIRD's ecological risk assessment of seismic impacts to marine finfish and invertebrates (Webster et al., 2018) during the assessment of impacts and risks to fish spawning and commercial fisheries. The impact assessment and proposed control measures are consistent with NOPSEMA Acoustic Impact Evaluation and Management Guideline (N-04750-IP1765 Rev2 Dec 2018).		• the predicted level of impact has been reduced to ALARP • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Consideration** To manage impacts to fish spawning and commercial fisheries to at or below the defined acceptable levels , the following EPO has been applied: **EPO 3.5**: Undertake seismic acquisition in a manner that prevents any change in spawning biomass of a commercially important species and does not lead to changes in recruitment that may be discernible from normal natural variation.
AMPs/ Ningaloo Coast WHA	**Principles of ESD** The Petroleum Activities Program is consistent with the relevant principles of ESD: • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making. • Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context** The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and	Seismic activities conducted as part of the Petroleum Activities Program are not inconsistent with a management plan that is in force for AMPs or any legislated management principle for WHAs.	The predicted level of impact for AMPs and the Ningaloo Coast WHA is considered to be at or below the defined acceptable levels given the controls implemented will: • prevent any impacts to the principles, values and objectives of AMPs and WHAs • prevent any seismic activity being undertaken within a WHA • not be inconsistent with conditions of the Class Approval Based on an assessment against the defined acceptable levels, the impact to AMPs and WHAs

	systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety, Environment and Quality Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** Feedback received from DNP, DBCA and the Ningaloo Coast World Heritage Advisory Committee (**Section 5.6**) around the location of the activity, potential for concurrent activities has been taken into consideration in the development of this EP. In addition to the controls referenced above relevant to protected species, the Operational Areas for Cimatti and Laverda in Area C were reduced to allow for a 2 km buffer between the WHA (**C 3.5**) and an alarm system established to ensure activities do not extend into the WHA (**C 3.17**). **Other Requirements** The proposed controls and consequence/residual risk level are consistent with: • Australian World Heritage management principles as described in Schedule 5 of the EPBC Regulations 2000 (**Section 1.10.1.2**) • Australian IUCN Reserve Management Principles and objectives of the IUCN category VI zone, as outlined in the North West Marine Park Management Plan (**Section 1.10.1.1**) • conditions of the Class Approval (**Section 1.10.1.1**) • the zone management categories outlined in the North West Marine Park Management Plan and the values of the Montebello, Gascoyne and Ningaloo AMPs **(Section 1.10.1.1** and **Section 6.6.3**).		from seismic noise is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD • the proposed controls have considered the environment consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation advices • the predicted level of impact has been reduced to ALARP • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Consideration** To manage impacts to AMPs/Ningaloo Coast WHA to at or below the defined acceptable levels, the following EPOs have been applied: **EPO 3.6**: Undertake seismic acquisition in a manner that prevents impacts to the principles, values and objectives of AMPs and WHAs **EPO 3.7**: Do not undertake seismic acquisition or other project activities within a WHA
Other environmental values (ecosystems/ habitats, species and socio-economic)	**Principles of ESD** The Petroleum Activities Program is consistent with the relevant principles of ecologically sustainable development: • The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.	Seismic activities conducted as part of the Petroleum Activities Program will not result in physical injury to any diver. Seismic activities conducted as part of the	The predicted level of impact for other environmental values is considered to be at or below the defined acceptable levels given the controls implemented will: • prevent physical injury to divers • prevent impacts to ecosystems/habitats, species and socio-economic values above Slight.

	• Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. **Internal Context** The Petroleum Activities Program is consistent with Woodside corporate policies, culture, processes, standards, structure and systems as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including: • Woodside Health, Safety, Environment and Quality Policy (**Appendix A**) • Woodside Risk Management Policy (**Appendix A**). **External Context** Impact assessment evaluated potential interaction with recreational fishing tournaments and verified/controlled seismic acquisition to avoid overlap with identified key periods. **Other Requirements** No additional legislative requirements applicable to managing the effects of seismic surveys in relation to other identified environment values have been identified.	Petroleum Activities Program will not result in any impacts to other environmental values above Slight as defined in Woodside's Risk Matrix consequence descriptions in Table 2-3.	Based on an assessment against the defined acceptable levels, the impact to other environmental values from seismic noise is considered acceptable, given that: • the activity is aligned with the relevant principles of ESD • the proposed controls have considered the environment consequence and are consistent with Woodside's internal policies, procedures and standards • feedback from stakeholders has been taken into consideration • legislative requirements/industry standards have been adopted • the activity will be managed in a manner that is consistent with management objectives for relevant WHAs, AMPs, recovery plans and conservation advices • the predicted level of impact has been reduced to ALARP • the predicted level of impact is at or below the defined acceptable levels. **Environmental Performance Consideration** To manage potential impacts to other environmental values to at or below the defined acceptable levels, the following EPOs have been applied: **EPO 3.8**: Undertake seismic acquisition in a manner that prevents injury to any diver **EPO 3.9**: Manage impacts to other environmental values from seismic noise to at or below Slight.

Environmental Performance Outcomes, Standards and Measurement Criteria			
From the assessment and demonstration of ALARP and Acceptability, including assessment against the defined acceptable levels of impact/risk, the following EPOs have been adopted for this EP to manage impacts/risks resulting from the discharge of seismic noise as part of the Petroleum Activities Program: • **EPO 3.1**: Undertake seismic acquisition in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks) • **EPO 3.2**: Undertake seismic acquisition in a manner that prevents displacement of pygmy blue whales within foraging BIAs • **EPO 3.3**: Undertake seismic acquisition in a manner that prevents impacts to humpback whales within BIAs • **EPO 3.4**: Undertake seismic acquisition in a manner that prevents displacement of marine turtles from habitat critical during nesting and internesting periods • **EPO 3.5**: Undertake seismic acquisition in a manner that prevents any change in spawning biomass of a commercially important species and does not lead to changes in recruitment that may be discernible from normal natural variation • **EPO 3.6**: Undertake seismic acquisition in a manner that prevents impacts to the principles, values and objectives of AMPs and WHAs • **EPO 3.7**: Do not undertake seismic acquisition or other project activities within a WHA • **EPO 3.8**: Undertake seismic acquisition in a manner that prevents injury to any diver • **EPO 3.9**: Manage impacts to other environmental values from seismic noise to at or below Slight.			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***

EPO 3.1
 	
EPO 3.9
	C 3.1
	Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures to cetaceans, as outlined below:
	• observation zone: 3 km+
	• shut-down zone: 2 km
	• observation and compliance reporting:
	  – Use of vessel crew to supplement dedicated MFOs in marine fauna observations and monitoring compliance to Policy Statement 2.1.
	  – Records kept of marine fauna observations during all surveys.
	• pre start-up visual observation (30 minutes)
	• soft start procedure (30 minutes)
	• start-up delay procedure (if sighting occurs)
	• operations procedure
	• stop work procedure
	• night-time and low visibility procedure.
		PS 3.1
		EPBC Policy Statement 2.1 – Part A Standard Management Procedures.
			MC 3.1.1
			Records demonstrate compliance with Policy Statement 2.1 Part A.

Environmental Performance Outcomes, Standards and Measurement Criteria			
	C 3.13 Application of EPBC Act Policy Statement 2.1 Part B.4 – Increased precaution zones and buffer zones as follows: An increased shutdown zone of 2 km will be applied for whales during all six 4D surveys.	**PS 3.13** An increased shutdown zone of 2 km to be applied during all six 4D surveys to reduce impacts to whales.	**MC 3.13.1** Records demonstrate compliance with an increased shutdown zone of 2 km for whales.
	C 3.14 Application of EPBC Act Policy Statement 2.1 Part B.6 – Adaptive management measures to minimise the potential impacts to pygmy blue whales from seismic noise. The following adaptive management measures will be implemented: • If the survey is required to shutdown/power-down three or more times per day for three consecutive days as a result of sighting any blue whale, then the seismic operations must not be undertaken thereafter at night time or during low visibility conditions. • Seismic operations cannot resume at night time or during low visibility conditions, until there has been a 24-hour period which included seismic operations during good visibility conditions, during which no shutdowns/ power-downs have occurred for blue whale sightings.	**PS 3.14** EPBC Act Policy Statement 2.1 Part B.6 – Adaptive management measures to be implemented as described to minimise the potential impacts from seismic noise to pygmy blue whales from operation of the seismic source within the Operational Areas for all six 4D surveys.	**MC 3.14.1** Records demonstrate compliance with blue whale adaptive management measures as described.

Environmental Performance Outcomes, Standards and Measurement Criteria			
	C 3.16 Application of EPBC Act Policy Statement 2.1 Part B.5 – PAM: • A PAM system will be installed aboard the survey vessel to detect odontocete whales (specifically sperm and beaked whales) meeting the specification requirements detailed in **Appendix I.**	**PS 3.16** EPBC Act Policy Statement 2.1 Part B.5 – Passive Acoustic Monitoring. • PAM observations are undertaken on a 24-hour basis by two competent and experienced PAM Operators trained in the PAM system software used. • During daylight hours, PAM detections will be validated against MFO observations and ranges to determine the error (if any) in PAM detection distances. • At night and during periods of low visibility PAM will be used to trigger: – shutdown for any sperm and beaked whales detected in the 2 km shutdown zone.	**MC 3.16.1** Records demonstrate that an operational PAM system, which meets the requirements described in **Appendix I** is aboard the survey vessel. Calibration records of PAM detections and visual observations during daylight hours. PAM Master Observation Sheet provides acoustic detection record for the surveys. Records (CV) verify the PAM Operators are competent to a standard equivalent to those in the *International Association of Geophysical Contractors (IAGC) Guidance on the Use of Towed Passive Acoustic Monitoring during Geophysical Operations (IAGC, 2014)*.
EPO 3.2	**C 3.11** Vary the timing of survey acquisition in Area C such that the sound footprint does not exceed TTS thresholds for low frequency cetaceans during the peak period for the northbound pygmy blue whale migration within the possible foraging BIA.	**PS 3.11** Acquisition of the Laverda 4D survey will not occur during May-June.	**MC 3.11.1** Records that there has been no acquisition of the Laverda 4D survey in May or June.
EPO 3.3	**C 3.10** Vary the timing of the Petroleum Activities Program in Areas A and C to avoid the migration periods for humpback whales. Time acquisition of the Pluto and Harmony surveys in Area A, and the Laverda, Cimatti and Vincent surveys in Area C, to avoid northbound and southbound and humpback whale migration (June to October).	**PS 3.10** No seismic acquisition for the Pluto and Harmony surveys in Area A, and the Laverda, Cimatti and Vincent surveys in Area C between June and October to avoid northbound and southbound and humpback whale migration.	**MC 3.10.1** Records demonstrate that the Petroleum Activities Program start and finish dates in Areas A and C did not overlap with humpback migration period (June to October).
EPO 3.1 **EPO 3.4**	**C 3.2** Application of EPBC Policy Statement 2.1 Part A Standard Management Procedures to whale sharks and turtles, as outlined below:	**PS 3.2** EPBC Policy Statement 2.1 Part A Standard Management Procedures applied to	**MC 3.2.1** Records demonstrate compliance with Policy Statement 2.1 Part A for whale sharks and turtles.

Environmental Performance Outcomes, Standards and Measurement Criteria			
	• observation and shutdown zone 500 m. During survey: • pre start-up Visual Observation (final ten minutes of the whale pre-start up observation period) • soft start observations (final ten minutes of the whale soft start period) • start-up delay procedure (applied if whale shark or turtle is sighted within the 500 m shutdown zone, recommence soft start if animal/s observed to move outside of the 500 m shut down zone or a period of ten minutes has passed since last sighting) • operations procedure (continuous observations focusing on 500 m zone) • stop work procedure (applied to whale shark and turtle sightings in 500 m shutdown zone). Observation and compliance reporting: • use of vessel crew to supplement dedicated MFOs in whale shark and turtle observations and monitoring compliance • record kept of whale shark and turtle sightings • record kept of observation effort, observation conditions, source operations and procedures implemented.	whale sharks and turtles, as outlined below: • observation and shutdown zone 500 m. During survey: • pre start-up Visual Observation (final ten minutes of the whale pre-start up observation period) • soft start observations (final ten minutes of the whale soft start period) • start-up delay procedure (applied if whale shark or turtle is sighted within the 500 m shutdown zone, recommence soft start if animal/s observed to move outside of the 500 m shut down zone or a period of ten minutes has passed since last sighting) • operations procedure (continuous observations focusing on 500 m zone) • stop work procedure (applied to whale shark and turtle sightings in 500 m shutdown zone). Observation and compliance reporting: • use of vessel crew to supplement dedicated MFOs in whale shark and turtle observations and monitoring compliance	

Environmental Performance Outcomes, Standards and Measurement Criteria			
		• record kept of whale shark and turtle sightings • record kept of observation effort, observation conditions, source operations and procedures implemented.	
	C 3.15 EPBC Act Policy Statement 2.1 Part B.6 – Adaptive Management Measures. Turtles - within Area A during December to February. The following adaptive management measures procedures will be implemented: • If the seismic source is required to be shutdown three or more times per day for three consecutive days as a result of sighting turtles, then the seismic operations must not be undertaken thereafter at night-time or during low visibility conditions. • Seismic operations cannot resume at night-time or during low visibility conditions, until there has been a 24-hour period which included seismic operations during good visibility conditions, during which 0-2 shutdowns have occurred for turtle sightings.	**PS 3.15.1** EPBC Act Policy Statement 2.1 Part B.6 – Adaptive management measures procedures to be implemented as described to minimise the potential impacts from seismic noise to flatback turtles within the 'habitat critical' around the Montebello Islands during December to February.	**MC 3.15.1** Records demonstrate compliance with turtle adaptive management measures procedures as described.
EPO 3.1 **EPO 3.4** **EPO 3.9**	**C 3.12** Employ two dedicated MFOs to undertake observations for EPBC Act Policy Statement 2.1, as applied in other adopted controls.	**PS 3.12.1** Two MFOs employed to undertake observations for EPBC Act Policy Statement 2.1, as applied in other adopted controls.	**MC 3.12.1** Records show two MFOs were present onboard survey vessel throughout Petroleum Activities Program.
		PS 3.12.2 All MFOs engaged for the Petroleum Activities Program complete relevant training detailing marine fauna identification and EPBC Act Policy Statement 2.1 requirements.	**MC 3.12.2** Records demonstrate that all MFOs engaged for the Petroleum Activities Program have received training in marine fauna identification and EPBC Act Policy Statement 2.1 requirements.
EPO 3.1 **EPO 3.2**	**C 3.3** Do not discharge the seismic source outside Acquisition Areas for all six surveys, except for the purpose of	**PS 3.3** The seismic source will not be discharged outside Acquisition Areas	**MC 3.3.1** Records demonstrate the seismic source is only discharged outside the

Environmental Performance Outcomes, Standards and Measurement Criteria			
EPO 3.4 **EPO 3.5** **EPO 3.6** **EPO 3.7** **EPO 3.8** **EPO 3.9**	run-ins, run-outs and soft starts within an approximate 4 km buffer extension along the axes of the planned line turns of each Acquisition Areas.	except for the purpose of run-ins, run-outs and soft starts within an approximate 4 km buffer extension along the axes of the planned line turns.	Acquisition Areas for the purpose of run-ins, run-outs and soft starts.
	C 3.4 Undertake source testing within Acquisition Areas	**PS 3.4** Source testing will be undertaken within Acquisition Areas	**MC 3.4.1** Records demonstrate that source testing was undertaken within Acquisition Areas
	C 3.9 Maintain a 40 km separation distance between the Petroleum Activities Program and any identified concurrent seismic survey.	**PS 3.9** No concurrent seismic surveys within 40 km of the Petroleum Activities Program.	**MC 3.9.1** Records demonstrate that Woodside have communicated with titleholders of all accepted in force Seismic EPs within 40 km of the Petroleum Activities Program to ensure no concurrent seismic surveys.
EPO 3.6 **EPO 3.7**	**C 3.5** Establish a 2 km buffer between the Petroleum Activities Program and the Ningaloo Coast WHA through reducing the Operational Areas for Laverda and Cimatti seismic surveys.	**PS 3.5** Petroleum Activities Program will be undertaken within defined Operational Areas.	**MC 3.5.1** Records demonstrate that Petroleum Activities Program was not undertaken outside defined Operational Areas.
	C 3.17 Establish a warning system on the survey vessel that will activate an alarm if the vessel comes within 1 km of the Operational Area boundary adjacent to the WHA (i.e. 3 km from the WHA boundary) for Laverda, Cimatti and Vincent surveys.	**PS 3.5** Petroleum Activities Program undertaken within defined Operational Areas.	**MC 3.5.1** Records demonstrate that Petroleum Activities Program was not undertaken outside defined Operational Areas.
EPO 3.8	**C 3.8** Engage with facility operators, commercial diving companies, scientific research groups, and recreational dive operators. This process will adhere to the following recommended requirements of the revised DMAC 12 guidelines: • Where diving and seismic activity are scheduled to occur within a distance of 45 km, Woodside will notify divers of the planned activity where practicable. • Where diving and seismic activity will occur within a distance of 30 km a joint risk assessment should be conducted, between the clients/operators involved and the seismic and diving contractors in advance of any simultaneous operations.	**PS 3.8** To ascertain if there will be any concurrent seismic acquisition and diving operations within Areas A, B and C during the Petroleum Activities Program, Woodside will engage with facility operators, commercial diving companies, scientific research groups, and recreational dive operators and develop a SIMOPS plan based on Draft Guidance from DMAC, IOGP and IMCA on managing concurrent diving and seismic surveys.	**MC 3.8.1** Records demonstrate that Woodside has engaged with relevant facility operators, commercial diving companies, scientific research groups, and recreational dive operators before commencing seismic acquisition in Area C. Records demonstrate that Woodside has implemented any relevant requirements.

Environmental Performance Outcomes, Standards and Measurement Criteria			
	• The risk assessment should consider ramp-up trials as well as other risk control measures e.g. reduction in source sizes, changes to firing intervals, timeshare/prioritisation etc. Sound pressure levels from noise modelling studies should be considered together with other relevant factors in the risk assessment.		
EPO 3.9	**C 3.6** Notify the Exmouth Game Fishing Club and Recfishwest two weeks before the seismic vessel arrives into any Operational Areas in Area C. Exmouth Game Fishing Club will be provided with information that includes: • proposed survey mobilisation date • map of survey area and acquisition lines • relevant contact details for communications during survey acquisition: – VHF radio channel – satellite call sign – vessel call signs. If seismic acquisition in Area C unavoidably overlaps with a recreational fishing tournament, Woodside will provide the Exmouth Game Fishing Club with the following additional information: • daily 24-hour lookahead plan of proposed acquisition and vessel movements.	**PS 3.6** Engagement with Exmouth Game Fishing Club two weeks before the seismic vessel arriving into any Operational Areas in Area C, and provision of specified operational information to ensure they are informed and aware, thereby reducing the likelihood of interference.	**MC 3.6.1** Records demonstrate that Woodside has communicated with the Exmouth Game Fishing Club, and has provided the necessary information both before and during seismic acquisition in Area C.
	C 3.7 Do not acquire seismic data within Area C during GAMEX tournament fishing days.	**PS 3.7** No seismic data acquisition for Area C between the 15th and 20th of March to avoid GAMEX tournament fishing days.	**MC 3.7.1** Records demonstrate that seismic data acquisition in Area C did not occur during the 15th to 20th of March.

6.6.4 Routine Atmospheric Emissions: Fuel Combustion

Context		
Project vessels – **Section 3.6.4**	Socio-economic environment – **Section 4.6**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary

Source of Impact	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	*Marine Sediments*	*Water Quality*	*Air Quality (incl. Odour)*	*Ecosystems/Habitats*	*Species*	*Socio-Economic*	*Decision Type*	*Consequence/Impact*	*Likelihood*	*Current Risk Rating*	*ALARP Tools*	*Acceptability*	*Outcome*
Internal combustion engines on seismic, supply and chase vessels and machinery engines				X				A	F	-	-	LCS GP	Broadly Acceptable	EPO 4
Power generation equipment and waste incineration				X				A	F	-	-			

Description of Source of Impact

Atmospheric emissions generated from internal combustion engines of project vessels and machinery used during the program activities will include SO_2, NO_X, ozone depleting substances, CO_2, particulates and Volatile Organic Compounds.

Impact Assessment

Atmospheric emissions from fuel combustion have the potential to result in localised air quality reduction. Potential impacts include a localised reduction in air quality, and contribution to greenhouse gas emissions.

Given the limited number of vessels operating in the Operational Area for each survey at any one time, together with the proposed short duration for each survey (ranging from 11-45 days) and offshore location of the activity away from sensitive air sheds (Exmouth is the closest population centre, located approximately 30 km away), which will lead to the rapid dispersion of the low volumes of atmospheric emissions. Hence, the potential impacts are expected to be localised with no lasting effect.

Summary of Potential Impacts to Environmental Values(s)

Given the adopted controls, it is considered that emissions from fuel combustion will not result in a potential impact greater than a minor and temporary exceedance over air quality standards.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/ Sacrifice (CS)***[17]	***Benefit in Impact/Risk Reduction***[18]	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Marine Order 97 (marine pollution prevention – air pollution).	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirements to be followed may slightly reduce the likelihood of air pollution.	Controls based on legislative requirements – must be adopted.	Yes **C 6.1**
Good Practice				
N/A.				
Professional Judgement – Eliminate				
No additional controls identified.				
Professional Judgement – Substitute				
No additional controls identified.				
Professional Judgement – Engineered Solution				
No additional controls identified.				
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of fuel combustion. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, fuel combustion emissions are unlikely to result in a potential impact greater than localised exceedance over national/international air quality standards with low impact to the environment or human health, resulting in no lasting effect. Further opportunities to reduce the impacts and risks have been investigated above. The controls adopted meet the requirements within Marine Order 97. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of the described emissions to a level that is broadly acceptable.

[17] Qualitative measure.

[18] Measured in terms of reduction of consequence (C).

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 4 Fuel combustion emissions during the Petroleum Activities Program will be in compliance with Marine Order 97 (marine pollution prevention – air pollution) requirements to restrict emissions to those necessary to perform the activity.	**C 4.1** Apply Marine Order 97 (marine pollution prevention – air pollution) which details requirements for: • International Air Pollution Prevention Certificate, required by vessel class • use of low sulphur fuel when available • Ship Energy Efficiency Management Plan, where required by vessel class • onboard incinerator complying with Marine Order 97.	**PS 4.1** Project vessels compliant with Marine Order 97 (marine pollution prevention – air pollution) to restrict emissions to those necessary to perform the activity.	**MC 4.1.1** Marine Assurance inspection records demonstrate compliance with Marine Order 97.

6.6.5 Routine Light Emissions: External Lighting on Project Vessels

Context														
Project vessels – **Section 3.6.4**	Biological environment – **Section 4.5**							Stakeholder consultation – **Section 5**						
Impacts and Risks Evaluation Summary														
	Environmental Value Potentially Impacted							***Evaluation***						
Source of Impact	***Soil and Groundwater***	***Marine Sediments***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitats***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence/Impact***	***Likelihood***	***Current Risk Rating***	***ALARP Tools***	***Acceptability***	***Outcome***
Lighting emissions from project vessels						X		A	F	-	-	LCS GP	Broadly Acceptable	N/A

Description of Source of Impact
The project vessels present in the Operational Areas will display artificial lighting to meet navigational and safety requirements under the Prevention of Collision Convention (Marine Order 30).

Impact Assessment

Light emissions can affect fauna in two main ways:

1. Behaviour: many organisms are adapted to natural levels of lighting and the natural changes associated with the day and night cycle as well as the night-time phase of the moon. Artificial lighting has the potential to create a constant level of light at night that can override these natural levels and cycles.
2. Orientation: organisms such as marine turtles and birds may also use lighting from natural sources to orient themselves in a certain direction at night. In instances where an artificial light source is brighter than a natural source, the artificial light may act to override natural cues leading to disorientation.

As the fauna associated with Areas A, B and C are predominantly pelagic species of fish, with a low abundance of transient species such as marine turtles, whale sharks and large whales transiting through the Operational Areas for each survey, significant impacts from light emissions are highly unlikely.

Light emissions reaching turtle nesting beaches are widely considered detrimental owing to interference with important nocturnal activities including choice of nesting sites and orientation/navigation to the sea by post-nesting females and hatchlings (Lutcavage et al., 1997; Pendoley, 1997; Witherington & Martin, 1996, 2003). Artificial lighting may affect the location that turtles emerge to the beach, the success of nest construction, whether nesting is abandoned, and even the seaward return of adults (Salmon et al., 1995, Salmon, 2005).

The Petroleum Activities Program is expected to overlap temporally with the peak nesting season for green, flatback and loggerhead turtles in the NWMR (see **Table 4-5** for details on seasonality). Area A overlaps spatially with the flatback turtle 'habitat critical' around the Montebello Islands (60 km internesting buffer) (**Table 4-6**; **Figure 4-14)**. Area C also overlaps partially with the 'habitat critical' for loggerhead and green turtles around Exmouth Gulf and the Ningaloo Coast (20 km nesting buffer).

Areas A and C have a small spatial overlap with the turtle 'habitat critical' internesting buffer zones (see above) and the timing of the Petroleum Activities Program is over the peak season for green, flatback and loggerhead turtle nesting (on beaches more than 20-60 km away, refer to **Section 4.5.2**). Scientific literature and expert opinion on the turtle internesting range and patterns, however, show that it is highly unlikely for significant numbers of turtles to be encountered within the offshore Areas A, B and C.

The risk associated with collision from seabirds attracted to the light is considered to be low, given slow moving speeds associated with the project vessels and there is no critical habitat for these species within Areas A, B and C.

Demersal fish communities in the Continental Slope Demersal Fish Communities KEF, which overlaps with Areas A and C (**Section 4.7.4**), are highly unlikely to be affected by vessel light. Lighting from project vessels may result in the localised aggregation of fish below the vessels. These aggregations of fish are considered localised and temporary and any long term changes to fish species composition or abundance is considered highly unlikely.

The Petroleum Activities Program will be conducted in an open ocean, offshore environment approximately 28 km from Montebello Islands for Area A, approximately 17 km from North West Cape for Area C and over 200 km from land for Area B. Given the transient nature of the surveys, the limited number of vessels operating in the Operational Area for each survey at any one time, together with the short duration for each survey (ranging from 11–45 days) and the predominantly open oceanic and offshore location of the Operational Areas, the potential impacts are expected to be localised with no lasting effect, with light spill limited to the immediate vicinity of vessels.
Summary of Potential Impacts to Environmental Values(s)
It is anticipated that light generated by vessels is highly unlikely to generate light levels sufficient to disrupt natural behavioural patterns on a long-term basis that could result in significant effects to the marine fauna populations in the region, therefore impacts are expected to be highly localised with no lasting effect.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[19]***	***Benefit in Impact/ Risk Reduction[20]***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
No options identified.				
Good Practice				
No options identified.				
Professional Judgement – Eliminate				
Substitute external lighting with ‘turtle friendly’ light sources (reduced emissions in turtle visible spectrum).	F: Yes. Replacing external lighting with turtle friendly lighting is technically feasible, although is not considered to be practicable. CS: Significant cost sacrifice. Retrofitting all external lighting on the vessels, etc., would expend considerable cost and time. Considerable logistical effort to source sufficient inventory of the range of light types onboard the vessels.	Given the potential impacts to turtles during this activity is highly localised, implementing this control would not result in a reduction in consequence.	Grossly disproportionate. Implementing the control requires considerable cost sacrifice for minimal environmental benefit. The cost/sacrifice outweighs the benefit gained.	No
Vary the timing of the Petroleum Activities Program to avoid peak turtle internesting periods (December to January).	F: No. The Operational Areas overlap with internesting BIAs. Given the low potential for internesting turtles to be present within the Operational Areas, the risk of potential impacts from vessel light emissions on adult turtles is considered to be low. CS: Significant cost and schedule impacts due to delays in securing vessels for specific timeframes.	Not considered – control not feasible.	Not considered, control not feasible.	No
Professional Judgement – Substitute				
No additional controls identified.				

[19] Qualitative measure

[20] Measured in terms of reduction of consequence (C)

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[19]	***Benefit in Impact/ Risk Reduction***[20]	***Proportionality***	***Control Adopted***
Professional Judgement – Engineered Solution				
No additional controls identified.				
ALARP Statement Lighting is not considered a key impact for this Petroleum Activities Program due to the open ocean, offshore environment. Vessel activities will be of short duration for each survey (ranging from 11-45 days), with light spill limited to the immediate vicinity of the vessels. The potential impacts to marine fauna, such as turtles, fish or seabirds, from light emissions from vessels and equipment is expected to be restricted to localised attraction (if any) and are considered to be localised and of no lasting effect. No controls have been applied for this risk as light management will be consistent with that required to provide a safe working environment for vessel personnel.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that lighting is unlikely to result in a potential impact greater than localised impact of no lasting effect to protected species. Further opportunities to reduce the impacts and risks have not been applied as light management will be consistent with that required to provide a safe working environment for vessel personnel. Woodside considers that any potential impacts and risks are considered broadly acceptable.

6.6.6 Routine Discharge: Bilge Water, Grey Water, Sewage, Putrescible Wastes and Deck Drainage Water

Context		
Project vessels – **Section 3.6.4**	Physical environment – **Section 4.4** Biological environment – **Section 4.5**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary

Source of Impact	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	***Marine Sediments***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitats***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence/ Impact***	***Likelihood***	***Current Risk Rating***	***ALARP Tools***	***Acceptability***	***Outcome***
Discharge of bilge water, grey water, sewage, putrescibles wastes and deck drainage from the project vessels to the marine environment			X		X			A	F	-	-	LCS GP	Broadly Acceptable	EPO 6

Description of Source of Impact

The project vessels routinely generate/discharge:

- Small volumes (up to 15 m³ per vessel per day) of treated sewage and putrescible wastes to the marine environment.
- Routine/periodic discharge of relatively small volumes of bilge water – Bilge tanks receive fluids from many parts of the vessel. Bilge water can contain water, oil, detergents, solvents, chemicals, particles and other liquids, solids or chemicals.
- Variable water discharge from vessel decks directly overboard or via deck drainage systems – Water sources could include rainfall events and/or from deck activities such as cleaning/wash-down of equipment/decks.

Routine discharges generated from the Petroleum Activities Program have the potential to cause temporary and localised reduction in water quality.

Environmental risk relating to the disposal/discharges above regulated levels or incorrect disposal/discharge of waste would be unplanned (non-routine/accidental) and are addressed in **Section 6.7.5**.

Impact Assessment

No significant impacts from the routine discharges described are anticipated because of the minor quantities involved, the limited duration of vessel activities during the Petroleum Activities Program, localised 200 m mixing zone and high level of dilution into the open water marine environment of the Operational Areas. This includes impacts on values and sensitivities in the Montebello AMP within Area A, Gascoyne AMP within Area C, or on benthic habitats present within the Operational Areas for each survey.

Areas A and Area B are located more than 12 nm from land, which exceeds the exclusion zones required by Marine Order 96 (marine pollution prevention – sewage) 2009 and Marine Order 95 (Marine pollution prevention – garbage) 2013. The south-east part of Area C is located less than 12 nm from land. In accordance with MARPOL Annex IV and Marine Order 96, no discharges will occur in areas less than 12 nm from land.

Therefore, impacts associated with the routine discharges are considered to be localised with no lasting effect.

Summary of Potential Impacts to Environmental Values(s)

Given the adopted controls, it is considered that routine discharges described will not result in a potential impact greater than minor and/or temporary contamination above background levels, water quality standards, or known effect concentrations.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/ Sacrifice (CS)***[21]	***Benefit in Impact/ Risk Reduction***[22]	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Comply with Marine Order 95 – pollution prevention – garbage (as appropriate to vessel class), which requires putrescible waste and food scraps be passed through a macerator so they can pass through a screen with no opening wider than 25 mm.	F: Yes. CS: Minimal cost. Standard practice.	No reduction in likelihood or consequence would result.	Controls based on legislative requirements – must be adopted.	Yes **C 7.1**
Comply with Marine Order 96 – pollution prevention – sewage (as appropriate to vessel class) specifically: • a valid International Sewage Pollution Prevention (ISPP) Certificate, as required by vessel class • an AMSA approved sewage treatment plant • sewage commuting and disinfecting system • a sewage holding tank sized appropriately to contain all generated waste (black and grey water) • discharge of sewage which is not comminuted or disinfected will only occur at a distance of more than 12 nm from the nearest land • discharge of sewage which is comminuted or disinfected using a certified approved sewage treatment plant will only occur at a distance of more than 3 nm from the nearest land • discharge of sewage will occur at a moderate rate while the vessel is proceeding (> four knots).	F: Yes. CS: Minimal cost. Standard practice.	No reduction in likelihood or consequence would result.	Controls based on legislative requirements – must be adopted.	Yes **C 7.2**
Comply with Marine Order 91 – oil (as relevant to vessel class) requirements, which include mandatory measures for processing oily water prior to discharge: • Machinery space bilge/oily water shall have International Maritime Organisation (IMO)-approved oil filtering equipment (oil/water separator) with an on-line monitoring device to measure Oil in Water (OIW) content to be less than 15 ppm prior to discharge. • IMO-approved oil filtering equipment shall also have an alarm and an automatic stopping device, or be capable of	F: Yes. CS: Minimal cost. Standard practice.	No reduction in likelihood or consequence would result.	Controls based on legislative requirements – must be adopted.	Yes **C 7.3**

[21] Qualitative measure.
[22] Measured in terms of reduction of consequence (C).

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/ Sacrifice (CS)[21]***	***Benefit in Impact/ Risk Reduction[22]***	***Proportionality***	***Control Adopted***
recirculating if OIW concentration exceeds 15 ppm. • A deck drainage system shall be capable of controlling the content of discharges for areas of high risk of fuel/oil/grease or hazardous chemical contamination. • There shall be a waste oil storage tank available, to restrict oil discharges. • If machinery space bilge and deck drainage discharges cannot meet the oil content standard of <15 ppm without dilution or be treated by an IMO-approved oil/water separator, they will be contained on-board and disposed onshore. • A valid ISPP Certificate, as required by vessel class.				
Good Practice				
No additional controls identified.				
Professional Judgement – Eliminate				
Storage, transport and treat/dispose onshore sewage, greywater, putrescible and bilge wastes.	F: No. Would present additional safety and hygiene hazards resulting from storing, loading and transporting the waste material. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Substitute				
No additional controls identified.				
Professional Judgement – Engineered Solution				
No additional controls identified.				
ALARP Statement On the basis of the environmental impact assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of planned routine and non-routine discharges from the project vessels. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement
The impact assessment has determined that, given the adopted controls, planned (routine) discharges are unlikely to result in a potential impact greater than a localised contamination above background levels, and/or national/international quality standards, and/or known biological effect concentrations outside a 200 m mixing zone. No lasting effect is expected. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet legislative requirements under Marine Orders 91, 95 and 96. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of these discharges to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 6 No impact to water quality greater than a consequence level of F from discharge of sewage, greywater, putrescible wastes, bilge and deck drainage to the marine environment during the Petroleum Activities Program.	**C 6.1** Comply with Marine Order 95 – pollution prevention – garbage (as appropriate to vessel class), which requires putrescible waste and food scraps be passed through a macerator so they can pass through a screen with no opening wider than 25 mm.	**PS 6.1** Project vessels compliant with Marine Order 95 – pollution prevention – garbage.	**MC 6.1.1** Records demonstrate project vessels comply with Marine Order 95 – pollution prevention (as appropriate to vessel class).
	C 6.2 Comply with Marine Order 96 – pollution prevention – sewage (as appropriate to vessel class) specifically: • a valid ISPP Certificate, as required by vessel class • an ASMA approved sewage treatment plant • sewage commuting and disinfecting system • a sewage holding tank sized appropriately to contain all generated waste (black and grey water) • discharge of sewage which is not comminuted or disinfected will only occur at a distance of more than 12 nm from the nearest land • discharge of sewage which is comminuted or disinfected using a certified approved sewage treatment plant will only occur at a distance of more than 3 nm from the nearest land • discharge of sewage will occur at a moderate rate while the vessel is proceeding (> four knots).	**PS 6.2** Project vessels compliant with Marine Order 96 – pollution prevention – sewage (as appropriate to vessel class).	**MC 6.2.1** Records demonstrate project vessels comply with Marine Order 96 – pollution prevention – sewage (as appropriate to vessel class).

<table>
<tr><th colspan="4">Environmental Performance Outcomes, Standards and Measurement Criteria</th></tr>
<tr><th>Outcomes</th><th>Controls</th><th>Standards</th><th>Measurement Criteria</th></tr>
<tr><td></td><td>C 6.3
Comply with Marine Order 91 – oil (as relevant to vessel class) requirements, which includes mandatory measures for processing oily water prior to discharge:
• Machinery space bilge/oily water shall have IMO-approved oil filtering equipment (oil/water separator) with an online monitoring device to measure OIW content to be less than 15 ppm prior to discharge.
• IMO-approved oil filtering equipment shall also have an alarm and an automatic stopping device, or be capable of recirculating if OIW concentration exceeds 15 ppm.
• A deck drainage system shall be capable of controlling the content of discharges for areas of high risk of fuel/oil/grease or hazardous chemical contamination.
• There shall be a waste oil storage tank available, to restrict oil discharges.
• If machinery space bilge and deck drainage discharges cannot meet the oil content standard of <15 ppm without dilution or be treated by an IMO-approved oil/water separator, they will be contained on-board and disposed onshore.
• A valid ISPP Certificate, as required by vessel class.</td><td>PS 6.3
Discharge of machinery space bilge/oily water will meet the oil content standard of <15 ppm without dilution.</td><td>MC 6.3.1
Records demonstrate discharge specification met for project vessels.</td></tr>
</table>

6.7 Unplanned Activities (Accidents, Incidents, Emergency Solutions)

6.7.1 Quantitative Spill Risk Assessment Methodology

Quantitative hydrocarbon spill modelling was performed by RPS, on behalf of Woodside, using a three-dimensional hydrocarbon spill trajectory and weathering model, SIMAP (Spill Impact Mapping and Analysis Program). The model is designed to simulate the transport, spreading and weathering of specific hydrocarbon types under different environmental conditions (both meteorological and oceanographic). Near-field subsurface discharge modelling was performed using OILMAP, which predicts the droplet sizes that are generated by the turbulence of the discharge as well as the centreline velocity, buoyancy, width and trapping depth (if any) of the rising gas and oil plumes. The OILMAP output parameters were used as input into SIMAP.

The algorithms in the SIMAP model are based on the best available scientific knowledge, and are updated when necessary in response to significant advances in knowledge. Recent improvements have been implemented to the entrainment algorithm, which have been adjusted to implement the findings of published data based on field research performed during the Macondo spill event in the Gulf of Mexico (Spaulding et al., 2017; Li et al., 2017; French McCay et al., 2018).

Stochastic modelling was conducted this study, which compiled data from hypothetical spills under different environmental conditions to determine the widest extent of possible oil dispersion. The environmental conditions for each of the hypothetical spills were selected randomly from an historic time-series of wind and current data representative of the study area. Results of the replicate simulations were then statistically analysed and mapped to define contours of percentage probability of contact at identified thresholds around the hydrocarbon release point. The simulations that show something unusual or unexpected make an important contribution to the overall outcomes and fate of the hydrocarbon.

The model simulates surface releases and uses the unique physical and chemical properties of a representative hydrocarbon type to calculate rates of evaporation and viscosity change, including the tendency to form oil-in-water emulsions. Moreover, the unique transport and dispersion of surface slicks and in-water components (entrained and dissolved) are modelled separately. Thus, the model can be used to understand the wider potential consequences of a spill, including direct contact of hydrocarbons due to surface slicks (floating hydrocarbon) and exposure of organisms to entrained and dissolved aromatic hydrocarbons in the water column. The model also calculates the accumulation of hydrocarbon mass that arrives on each section of shoreline over time, taking into account any mass that is lost to evaporation and/or subsequent removal by current and wind forces.

All hydrocarbons spill modelling assessments performed by RPS undergo initial sensitivity modelling to determine appropriate time to add to the simulation after the cessation of the spill. The amount of time following the spill is based on the time required for the modelled concentrations to practically drop below threshold concentrations anywhere in the model domain in the test cases.

6.7.1.1 Environment that May be Affected and Hydrocarbon Contact Thresholds

The outputs of the quantitative hydrocarbon spill modelling are used to assess the environmental risk, if a credible hydrocarbon spill scenario occurred, by delineating which areas of the marine environment could be exposed to hydrocarbon levels exceeding hydrocarbon threshold concentrations. The summary of all the locations where hydrocarbon thresholds could be exceeded by any of the simulations modelled is defined as the ‘environment that may be affected’. The EMBA covers a larger area than the area that is likely to be affected during any single spill event, as the model was run for a variety of weather and metocean conditions, and the EMBA represents the total extent of all the locations where hydrocarbon thresholds could be exceeded from all modelling runs. Furthermore, as the weathering of different fates of hydrocarbons (surface, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, a different EMBA is presented for each fate.

The spill modelling outputs are presented as threshold concentrations for surface, entrained and dissolved hydrocarbons for the modelled scenarios. Surface spill concentrations are expressed as grams per square metre (g/m²), with entrained and dissolved aromatic hydrocarbon concentrations expressed as parts per billion (ppb). A conservative approach adopting accepted contact thresholds that are documented to impact the marine environment are used to define the EMBA. These hydrocarbon thresholds are presented in **Table 6-15** and described in the following subsections.

Table 6-17: Summary of environmental impact thresholds applied to the quantitative hydrocarbon spill risk modelling results

Surface hydrocarbon	Entrained hydrocarbon	Dissolved aromatic hydrocarbon
10 g/m²	500 ppb	500 ppb

Surface Hydrocarbon Threshold Concentrations

The spill modelling outputs defined the EMBA for surface hydrocarbons resulting from a spill (contact on surface waters) using a threshold of ≥10 g/m² (dull metallic colours based on the relationship between film thickness and appearance (Bonn Agreement 2015)) (**Table 6-16**). This threshold concentration is geared towards informing potential oiling impacts for wildlife groups and habitats that may break through the surface slick from the water or the air (for example: emergent reefs, vegetation in the littoral zone and air-breathing marine reptiles, cetaceans, seabirds and migratory shorebirds).

Thresholds for registering biological impacts resulting from contact of surface slicks have been estimated by different researchers at approximately 10–25 g/m² (French et al., 1999; Koops et al., 2004; NOAA, 1996). Potential impacts of surface slick concentrations in this range for floating hydrocarbons may include harm to seabirds through ingestion from preening contaminated feathers, or the loss of the thermal protection of their feathers. The 10 g/m² threshold is the reported level of oiling to instigate impacts to seabirds and is also applied to other wildlife, though it is recognised that ‘unfurred’ animals, where hydrocarbon adherence is less, may be less vulnerable. ‘Oiling’ at this threshold is taken to be of a magnitude that can cause a response to the most vulnerable wildlife such as seabirds. Due to weathering processes, surface hydrocarbons will have a lower toxicity due to change in their composition over time. Potential impacts to shoreline sensitive receptors may be markedly reduced in instances where there is extended duration until contact.

Table 6-18: The Bonn Agreement oil appearance code

Appearance (following Bonn visibility descriptors)	Mass per area (g/m²)	Thickness (µm)	Volume per area (L/km²)
Discontinuous true oil colours	50 to 200	50 to 200	50,000 to 200,000
Dull metallic colours	5 to 50	5 to 50	5000 to 50,000
Rainbow sheen	0.30 to 5.00	0.30 to 5.00	300 to 5000
Silver sheen	0.04 to 0.30	0.04 to 0.30	40 to 300

Dissolved Aromatic Hydrocarbon Threshold Concentrations

The threshold concentration value for dissolved hydrocarbons has been set with reference to a review of existing results (completed by Woodside, 2013) of eco-toxicity tests for marine diesel type 2, that is considered representative of the fuel to be used by project vessels within the Operational Area for each survey.

The threshold informs the assessment of the potential for toxicity to impact sensitive marine biota. A desktop literature review was performed which focused on toxicity test results of marine species, in which procedures followed the standard practice of applying water accommodated fraction to solution to produce a range of dissolved hydrocarbon concentrations for testing marine diesel. The test results are representative of both acute and chronic toxic effects of dissolved marine diesel hydrocarbons, on six taxonomic groups and marine species at various life stages (**Table 6-17**). Where possible, the review considered Australian species. Where there were several species tests for one taxonomic group, the lowest concentration to result in a toxic effect was reported. The review process showed that the most comparable measure of acute and chronic effects, when comparing studies, were the endpoints of EC50, EL50 and LC50. Each of these measures represents an effect to 50% of the tested population. Results show a large range of effect from dissolved hydrocarbons concentrations from 1200–39,000 ppb (**Table 6-17**).

Based on the review and results presented in **Table 6-17**, at the present time, the dissolved threshold concentration of 500 ppb is considered applicable and appropriate for the risk assessment of potential acute and chronic effects to marine ecosystems. The review also highlighted the potential for impact (i.e. greater sensitivity) of some early and/or adult life stages of sensitive species (such as oysters, polychaetes) but at dissolved hydrocarbon concentrations above the adopted threshold value.

Table 6-19: Summary of dissolved hydrocarbon acute and chronic effects concentrations for key life histories of different biota based on toxicity tests for water-accommodated fractions of unweathered marine diesel type 2 (based on desktop review performed by Woodside, 2013)

Biota and life stage	Exposure duration	EC/EL/LC50 – TPH concentrations of unweathered marine diesel (ppb)	Reference
Chaetoceros calcitrans (Microalgae – growth)	96 hours	36,560–38,020 (EC50)	Bhattacharjee and Fernando (2008)
Skeletonema costatum (Saltwater diatom – growth rate)	72 hours	2200 (EL50)	Xodus (2012)
Menidia (Atlantic silverside)	96 hours	3900 (LC50)	Tsvetnenko (1998)
Palaemonetes pugio (Grass shrimp – eggs)	96 hours	>9400 (LC50)	Tsvetnenko (1998)
Palaemonetes pugio (Grass shrimp – juvenile)	96 hours	1200–3500 (LC50)	Tsvetnenko (1998)
Lygia exotica (Supralittoral isopod)	96 hours	>4530 (LC50)	Tsvetnenko (1998)
Elasmopus pectenicrus (Amphipod)	96 hours	3380 (LC50)	Tsvetnenko (1998)
Crassostrea virginica (American oyster)	96 hours	1900 (LC50)	Tsvetnenko (1998)
Capitella capitata (polychaete)	96 hours	2300 (LC50)	Tsvetnenko (1998)
Capitella capitata (polychaete – juvenile)	96 hours	8700 (LC50)	Tsvetnenko (1998)

Entrained Hydrocarbon Threshold Concentrations

The spill modelling outputs are used to define the EMBA by defining the spatial variability of entrained hydrocarbons above a set concentration threshold contacting sensitive receptors (expressed in ppb).

Entrained hydrocarbons present a number of possible mechanisms for toxic exposure to marine organisms. The entrained hydrocarbon droplets may contain soluble compounds, hence have the potential for generating elevated concentrations of dissolved aromatic hydrocarbons (e.g. if mixed by breaking waves against a shoreline). Physical and chemical effects of the entrained hydrocarbon droplets have also been demonstrated through direct contact with organisms; for example, through physical coating of gills and body surfaces, and accidental ingestion (National Research Council, 2005).

The threshold concentration of entrained hydrocarbons that could result in a biological impact cannot be determined directly using available ecotoxicity data for water-accommodated fractions of oil hydrocarbons (**Table 6-17**). However, it is likely this data specific to dissolved oil hydrocarbon represents a worst-case scenario. This is because entrained oil hydrocarbons are less biologically available to organisms through absorption into their tissues than dissolved hydrocarbons. It is therefore expected that the entrained threshold concentration of 500 ppb will represent a potential impact substantially lower than the no-observed-effect concentrations presented in **Table 6-17**.

6.7.1.2 Accumulated Hydrocarbon Threshold Concentrations

Owens and Sergy (1994) define accumulated hydrocarbon <100 g/m² to have an appearance of a stain on shorelines. French-McCay (2009) defines accumulated hydrocarbons ≥100 g/m² to be the threshold that could impact the survival and reproductive capacity of benthic epifaunal invertebrates living in intertidal habitat.

6.7.2 Accidental Hydrocarbon Release: Vessel Collision

Context														
Project vessels – **Section 3.6.4**	Physical environment – **Section 4.4** Biological environment – **Section 4.5** Socio-economic environment – **Section 4.6** Values and sensitivities – **Section 4.7**							Stakeholder consultation – **Section 3**						
Risks Evaluation Summary														
Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	***Marine Sediments***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitats***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence***	***Likelihood***	***Current Risk Rating***	***ALARP Tools***	***Acceptability***	***Outcome***
Hydrocarbon release to the marine environment due to a vessel collision (between project vessels or a third party)			X		X	X	X	A	C	0	M	LCS	Acceptable	EPO 7
Description of Source of Risk														

A seismic vessel can have a fuel capacity in excess of 1000 m³ that is distributed through a number of isolated tanks. Typical seismic vessel fuel storage is distributed through multiple isolated tanks, typically located mid-ship; individual tanks can range in size of 22–190 m³.

There will be at least one support vessel used throughout the Petroleum Activities Program. This temporary presence in the area will result in a navigational hazard for commercial shipping within the immediate area (as discussed in **Section 6.6.1**). The marine diesel storage capacity of a support vessel can also be in the order of 1000 m³ total, distributed through multiple isolated tanks, typically located mid-ship, and can range in typical size of 22–105 m³.

Industry Experience

Registered vessels or foreign flag vessels in Australian waters are required to report events to the Australian Transport Safety Bureau (ATSB), AMSA or Australian Search and Rescue.

From a review of the ATSB marine safety and investigation reports, one vessel collision occurred in 2011–12 that spilled 25–30 L of oil into the marine environment resulting from a collision between a tug and support vessel off Barrow Island. Two other vessel collisions occurred in 2010, one in the port of Dampier, where a support vessel collided with a barge being towed. Minor damage was reported and no significant injury to personnel or pollution occurred. The second 2010 vessel collision involved a vessel under pilot control in port connecting with a vessel alongside a wharf, causing it to sink. No reported pollution resulted from the sunken vessel. These incidents demonstrate the likelihood of only minor volumes of hydrocarbons being released during the highly unlikely event of a vessel collision.

From 2010 to 2011, the ATSB's annual publication (ATSB, 2011) defines the individual safety action factors identified in marine accidents and incidents: 42% related to navigation action; of that, 15% related to poor communication and 42% related to poor monitoring, checking and documentation. Most of these related to the grounding instances. Given the offshore location of the Petroleum Activities Program, vessel grounding is not considered a credible risk.

Credible Spill Scenarios

For a vessel collision to result in the worst-case scenario of a hydrocarbon spill potentially impacting an environmentally sensitive area, several factors must align. The sequence of events is as follows:

- The identified causes of vessel interaction must result in a collision.
- The collision must have enough force to penetrate the vessel hull.
- The collision must be in the exact location of the fuel tank.
- The fuel tank must be full, or at least of a volume which is higher than the point of penetration.

The probability of this chain of events aligning to result in a breach of fuel tanks resulting in a spill that could potentially affect the marine environment is considered remote.

The environmental risk analysis and evaluation identified and assessed a range of potential scenarios that could result in a loss of vessel structural integrity, resulting in damage to fuel storage tank(s) and a loss of marine diesel to the marine environment (**Table 6-18**).The scenarios considered damage to single and multiple fuel storage tanks in the project vessels due to various combinations of vessel-to-vessel collisions.

The scenario considered was a collision of the support vessel and the seismic vessel with each other or with a third party vessel (i.e. commercial shipping, other petroleum related vessels and commercial fishing vessels). The likelihood was assessed as being remote, given standard vessel operations and equipment in place to prevent collision at sea, the standby role of a support vessel (low vessel speed) and its operation in close proximity to the seismic vessel (exclusion area), and the construction and placement of storage tanks. This scenario was assessed on the worst case scenario that there is an instantaneous loss of 190 m³ from a diesel tank.

Table 6-20: Operational Area credible scenarios for hydrocarbon spill as a result of loss of vessel structural integrity

Scenario	Marine diesel volumes	Preventative and mitigation controls	Credibility	Max. possible volume loss (m³)
Breach of support vessel fuel tanks due to collision with seismic vessel	Support vessel has multiple tanks typically ranging between 22–105 m³ each.	Typically double wall, tanks which are located midship (not bow or stern) Vessels are not anchored and steam at low speeds when relocating within an Operational Area or providing stand-by cover. Normal maritime procedures would apply during such vessel movements	**Credible** Collision of support vessel with seismic vessel could potentially result in the release from a fuel tank	105 m³
Breach of seismic vessel fuel tanks due to collision with support vessel	Seismic vessel has multiple tanks typically ranging between 50–190 m³.	Typically double wall, tanks which are located midship (not bow or stern) Vessels are not anchored and steam at low speeds when relocating within an Operational Area or providing stand-by cover. Normal maritime procedures would apply during such vessel movements	**Credible** Collision of seismic vessel with support vessel could potentially result in the release from a fuel tank	190 m³
Breach of fuel tanks due to project vessel collision with other vessel (including commercial shipping/ fisheries)	Support vessel has multiple tanks typically ranging between 22–105 m³ each. Seismic vessel has multiple tanks typically ranging between 50–190 m³.	Typically double wall, tanks which are located midship (not bow or stern) Vessels operating in the vicinity of the SNA will be tracked on radar and alerted to the presence of the survey vessel operations through Notice to Mariners and AUSCOAST warnings	**Credible** Collision of project vessel with other vessel could potentially result in the release from a fuel tank	190 m³

Quantitative Hydrocarbon Risk Assessment – Area A

Woodside's hydrocarbon spill modelling database was reviewed and indicated that a marine diesel spill of 190 m³ within Area A had previously been modelled. The 190 m³ diesel spill scenario was modelled by RPS to assess the extent of a marine diesel spill during any season, using an historic sample of wind and current data for the region. A total of 400 simulations were modelled, with each simulation tracked for 14 days.

Hydrocarbon Characteristics

Marine diesel is a mixture of both volatile and persistent hydrocarbons. Predicted weathering of marine diesel, based on typical conditions in the region, indicates that approximately 40% by mass would be expected to evaporate over the first day or two (**Figure 6-5**). After this time, most of the remaining hydrocarbon is entrained into the upper water column. In calm conditions entrained hydrocarbons are likely to resurface. Up to 95% of the spill volume is expected to evaporate over time. The remaining 5% is persistent and will reduce in concentration through degradation and dissolution.

Given the environmental conditions experienced in Area A, marine diesel is expected to undergo rapid spreading and this, together with evaporative loss, will result in a rapid dissipation of the spill. Marine diesel distillates tend not to form emulsions at the temperatures found in the region. Therefore, there is no potential for the spill to extend beyond a localised area around the release site. The characteristics of the marine diesel used in the modelling are given in **Table 6-19.**

Table 6-21: Characteristics of the marine diesel used in the modelling

Hydrocarbon type	Initial density (g/cm³) at 25˚C	Viscosity (cP @ 25˚C)	Component BP (ºC)	Volatiles %<180	Semi-volatiles % 180–265	Low volatility (%) 265-380	Residual (%) >380
				Non-Persistent			Persistent
MDO (surrogate for marine gas oil)	0.829	4.0	% of total	6	34.6	54.4	5

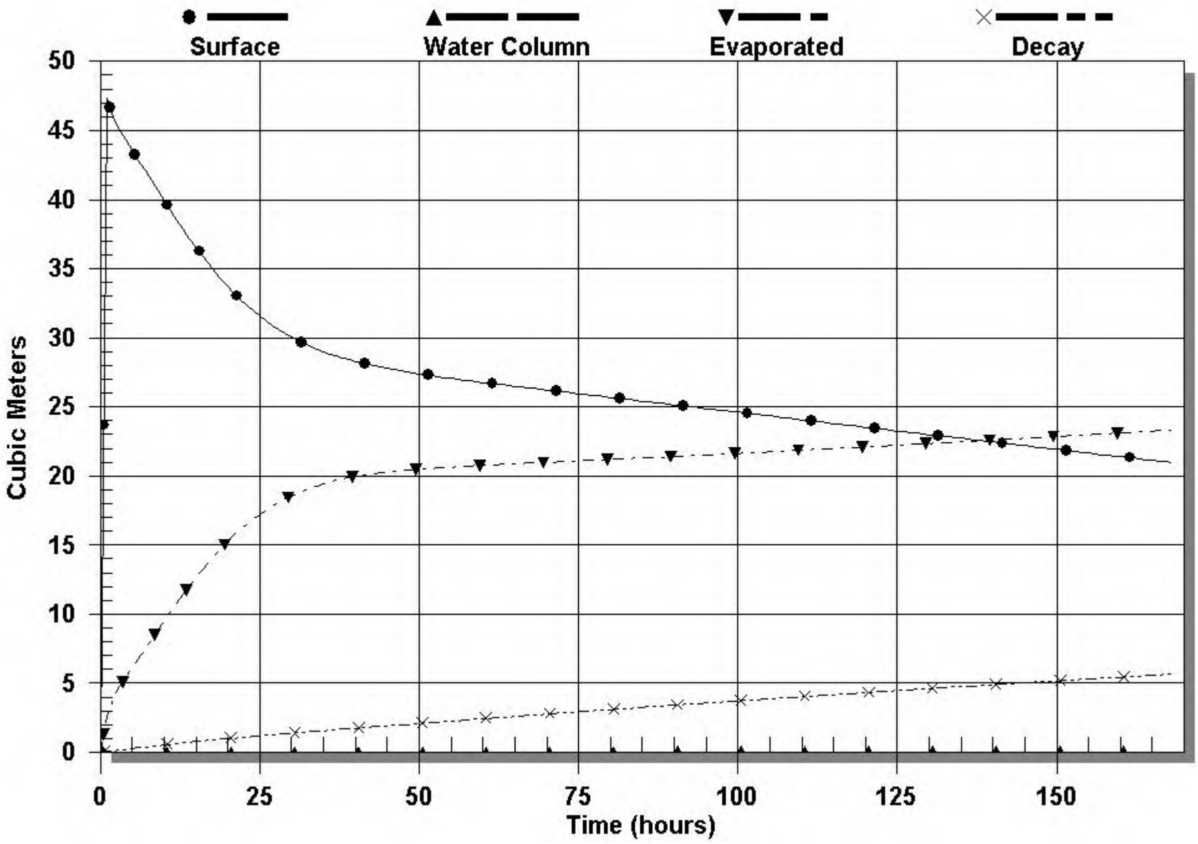

Figure 6-2: Proportional mass balance plot representing weathering of a surface spill of marine diesel

Quantitative Hydrocarbon Risk Assessment – Area C

Woodside commissioned RPS to conduct a further modelling study for a 190 m³ marine diesel spill from a vessel operating in Area C, during any season. The release location is along the eastern boundary of Area C, approximately 27 km west of the Muiron Islands.

The main objectives of the study were to quantify the movement and fate of spilled hydrocarbons that would result from an accidental, uncontrolled surface release of 190 m³ of MDO, and to investigate the risk to sensitive receptors (emergent features, submerged features and shorelines) posed by the releases. Tabulated results showing risk estimates for the nearest receptors were produced for the surface oil, entrained oil and dissolved aromatic hydrocarbon threshold concentrations defined in **Section 6.7.1**.

Qualitative Hydrocarbon Risk Assessment – Area B

No quantitative assessment of a release of marine diesel resulting from a vessel collision has been conducted for Area B as part of this EP. At the closest point, Area B is located >215 km from the nearest emergent land (west coast of Barrow Island). Given the offshore, deep water, remote location of Area B, it is highly unlikely that there would be any contact between surface, entrained or dissolved aromatic hydrocarbons with any sensitive receptors associated with inshore waters or coastlines of the NWS, at the exposure thresholds defined for the quantitative hydrocarbon risk assessments (**Table 6-15**). The EMBA for a 190 m³ release of marine diesel in Area B is expected to be reasonably similar in extent to the EMBA for a 190 m³ diesel spill in Area A, notwithstanding minor differences in metocean conditions between these two areas.

Consequence Assessment

EMBA – Area A

Surface hydrocarbons: Modelling results predict that, if this vessel collision scenario occurred, a surface hydrocarbon slick would form down-current of the release location, with the trajectory dependent on prevailing wind and current conditions at the time. The modelling indicates locations within reach of surface hydrocarbon EMBA are restricted to offshore areas, showing concentrations occurring up to approximately 40 km away, with the main drift direction either towards the north-east or south-west.

Entrained hydrocarbons: Quantitative hydrocarbon spill modelling results (190 m³) for entrained hydrocarbons released at Area A predict a plume of entrained hydrocarbons would form down-current of the release location, with the trajectory dependent on prevailing current conditions at the time. The modelling indicates locations within reach of entrained hydrocarbon EMBA are restricted to offshore areas up to approximately 40 km from the release site, with the main drift direction either towards the north-east or south-west.

Dissolved hydrocarbons: Dissolved hydrocarbons above threshold concentrations (>500 ppb) were not predicted by the modelling (190 m³ scenario) to occur at any location. Therefore, no contact with any sensitive receptors is predicted, and an EMBA figure is not presented.

Accumulated hydrocarbons: Accumulated hydrocarbons above threshold concentrations (>100 g/m²) were not predicted by the modelling (190 m³ scenario) to occur at any location.

Summary of Potential Impacts

In the unlikely event of a 190 m³ spill of marine diesel resulting from vessel collision in Area A, the EMBA will remain small and localised, restricted to the open ocean only (Commonwealth waters). Consequently, an EMBA summary table is not presented.

EMBA – Area C

Surface hydrocarbons: Quantitative hydrocarbon spill modelling results (190 m³) for surface hydrocarbons released at the boundary of Area C predict a surface hydrocarbon slick would form down-current of the release location, with the trajectory dependent on prevailing wind and current conditions at the time. During the surface release, the volatile fractions of the oil (40.6%) are likely to evaporate within 24 hours of exposure to the atmosphere. The low-volatility fraction of the oil (54.4%) will take longer, in the order of days to weeks, to evaporate, and the remaining fraction (5.0%) is expected to persist for an extended period of time as residual oil. The probability contour figures for floating oil indicate concentrations equal to or greater than the 10 g/m², 50 g/m² and 100 g/m² thresholds could potentially be found, in the form of slicks, up to 74 km, 27 km and 22 km from the spill site, respectively.

The Ningaloo Coast North WHA shoreline receptor is predicted to be contacted by floating oil concentrations at the 10 g/m², 50 g/m² and 100 g/m² thresholds, with probabilities of 22%, 16.5% and 11.5%, respectively, within one hour of the release (for films) (**Table 6-20**). The potential for oil to accumulate on shorelines is predicted to be moderate, with a maximum accumulated volume of 40 m³ and a maximum local accumulated concentration on shorelines of 2.6 kg/m² forecast at the Ningaloo Coast North and Ningaloo Coast North WHA receptors (**Table 6-20**).

Table 6-22: Summary of annualised exposure predictions for floating oil at sensitive receptors for an instantaneous 190 m³ spill of marine diesel onto the sea surface within Area C

Receptors	Probability (%) of films arriving at receptors at ≥10 g/m²	Minimum time to receptor (hours) for films at ≥10 g/m²	Maximum local accumulated concentration (g/m²) averaged over all replicate spills	Maximum local accumulated concentration (g/m²) in the worst replicate spill
Muiron Islands MMA WHA	<0.5	NC	<0.1	1.6
Ningaloo Coast Middle	<0.5	NC	0.2	24
Ningaloo Coast Middle WHA	<0.5	NC	0.2	24
Ningaloo Coast North	1	14	13	2,594
Ningaloo Coast North WHA	22	1	13	2,594
Ningaloo Marine Park Recreational Use Zone (RUZ)*	22	1	NA	NA
Exmouth Gulf West	<0.5	NC	NC	NC
Carnarvon Canyon Marine Park	<0.5	NC	NA	NA
Gascoyne Marine Park	0.5	6	NA	NA
WA Coastline	0.5	34	13	2594

NC: No contact to receptor predicted for specified threshold.

** Floating oil will not accumulate on submerged features and at open ocean locations.*
NA: Not applicable.

Entrained hydrocarbons: Entrained oil at concentrations equal to or greater than the 500 ppb threshold is predicted to be found up to approximately 133 km from the spill site. Contact by entrained oil at concentrations equal to or greater than 500 ppb is predicted at Ningaloo Coast RUZ and Ningaloo Coast North WHA (38.5%). The maximum entrained oil concentration forecast for any receptor is predicted as 30.2 ppm at Ningaloo Coast RUZ and Ningaloo Coast North WHA (**Table 6-21**).

Table 6-23: Summary of annualised exposure predictions for entrained oil at sensitive receptors for an instantaneous 190 m³ spill of marine diesel onto the sea surface within Area C

Receptors	Probability (%) of entrained hydrocarbon concentration contact ≥500 ppb	Minimum time to receptor waters (hours) at ≥500 ppb	Maximum entrained hydrocarbon concentration (ppb) averaged over all replicate simulations	Maximum entrained hydrocarbon concentration (ppb), at any depth, in the worst replicate
Muiron Islands MMA WHA	<0.5	NC	2	85
Ningaloo Coast Middle	1.5	48	19	1085
Ningaloo Coast Middle WHA	1.5	44	19	1085
Ningaloo Coast North	4	16	57	3751
Ningaloo Coast North WHA	38.5	1	1997	30,215
Ningaloo Marine Park RUZ *	38.5	1	1997	30,215
Exmouth Gulf West	<0.5	NC	<1	70
Carnarvon Canyon Marine Park	<0.5	NC	<1	77
Gascoyne Marine Park	12	6	201	4677
WA Coastline	3	18	46	3398

*NC: No contact to receptor predicted for specified threshold. * Probabilities and maximum concentrations at depth of submerged feature.*

Dissolved hydrocarbons: No receptors are predicted to be contacted by dissolved aromatic hydrocarbon concentrations at the 500 ppb threshold, and an EMBA figure is not presented. The maximum dissolved aromatic hydrocarbon concentration forecast for any receptor is predicted as 280 ppb at Ningaloo Coast RUZ and Ningaloo Coast North WHA.

Accumulated hydrocarbons: Accumulated hydrocarbons above threshold concentrations (>100 g/m²) were predicted by the modelling (190 m³ scenario) to occur at three locations: Ningaloo Coast North, Ningaloo Coast North WHA and WA Coastline (**Table 6-20**).

<u>Summary of Potential Impacts</u>

In the unlikely event of a 190 m³ spill of marine diesel resulting from a vessel collision in Area C, the EMBA will remain moderate and localised, restricted largely to the open ocean only (Commonwealth waters) with some contact with inshore waters and coastlines in the immediate vicinity. EMBA summary results are presented in **Table 6-22.**

Table 6-24: EMBA – Key receptor locations and sensitivities with the summary hydrocarbon spill contact for an instantaneous release of marine diesel

Environmental setting	Location/name	Environmental, Social, Cultural, Heritage and Economic Aspects presented as per the Environmental Risk Definitions																													Hydrocarbon contact and fate (≥1% probability)			
		Physical		Biological																						Socio-economic and Cultural								
		Water Quality	Sediment Quality	*Marine Primary Producers*			*Other Communities/Habitats*								*Protected Species*										*Other Species*									
		Open water – pristine	Marine sediment – pristine	Coral reef	Seagrass beds/macroalgae	Mangroves	Spawning/nursery areas	Open water – productivity/upwelling	Non biogenic coral reefs	Offshore filter feeders and/or deepwater benthic communities	Nearshore filter feeders	Sandy shores	Estuaries/tributaries/creeks/lagoons (including mudflats)	Rocky shores	Cetaceans – migratory whales	Cetaceans – dolphins and porpoises	Dugongs	Pinnipeds (sea lions and fur seals)	Marine turtles (including foraging and internesting areas and significant nesting	Sea snakes	Whale sharks	Sharks and rays	Sea birds and/or migratory shorebirds	Pelagic fish populations	Resident demersal fish	Fisheries – commercial	Fisheries – traditional	Tourism and recreation	Protected areas/heritage – European and indigenous/shipwrecks	Offshore oil & gas infrastructure (topside and subsea)	Surface hydrocarbon (≥10 g/m²)	Entrained hydrocarbon (≥500 ppb)	Dissolved aromatic hydrocarbon (≥500 ppb)	Accumulated hydrocarbons (>100 g/m²)
Inshore	Ningaloo Coast North	✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓		✓
Inshore	Ningaloo Coast North WHA	✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓		✓	✓		✓
Mainland (nearshore waters)	WA Coastline		✓	✓	✓	✓	✓					✓	✓	✓					✓	✓			✓			✓		✓	✓		✓	✓		✓

Summary of Potential Impacts to Environmental Values(s)
Details of impacts specific to a spill of marine diesel are provided below. It is noted that the toxic components in marine diesel include alkylated naphthalenes which can be rapidly accumulated by marine biota, including invertebrates such as marine oysters, clams, shrimp and a range of vertebrates such as finfish. Marine diesel also contains additives that contribute to its toxicity. ***Protected Species*** As identified (**Section 4.5.2**), protected species may be encountered within and adjacent to Areas A, B and C and therefore could be impacted by a marine diesel spill. No critical habitats or aggregation areas (feeding, breeding, resting) have been identified within the EMBA for a 190 m³ diesel spill within Area A. It is therefore considered that protected species that are present will be in low numbers and temporary as they traverse the area. The EMBA for a 190 m³ diesel spill within Area C and Area A overlaps with the 'habitat critical' for flatback turtles that extends for a 60 km radius from Barrow Island, the Montebello Islands, and coastal Islands from Cape Preston to Locker Island. As detailed in **Table 4-6**, this is an internesting buffer. Scientific literature and expert opinion on the turtle internesting range and patterns, however, show that it is highly unlikely for significant numbers of turtles to be encountered within Area C or Area A. <u>Cetaceans</u> Marine mammals are highly mobile and a number of field and experimental observations indicate whales and dolphins may be able to detect and avoid surface slicks. However, instances have been observed where animals have swum directly into oiled areas without seeming to detect the slicks or because the slicks could not be avoided. Cetaceans may exhibit avoidance behaviour and move away from the spill-affected area. Marine mammals that have direct physical contact with surface slicks and entrained hydrocarbons may suffer surface fouling or ingest hydrocarbons and inhale toxic vapours. This may irritate sensitive membranes such as the eyes, mouth, digestive and respiratory tracts and organs, impair the immune system or cause neurological damage (Etkins, 1997; International Petroleum Industry Environmental Conservation Association (IPIECA), 1995). For example, fouling of baleen whales (e.g. humpback and pygmy blue whales) may disrupt feeding by decreasing the ability to intake prey. If prey (fish and plankton) is also contaminated, this can result in the absorption of toxic components of the hydrocarbons (polycyclic aromatic hydrocarbons). Feeding appears to be rare during humpback whale migration so the potential for impacts associated with ingesting hydrocarbons may be low for this particular species. Toothed whales (including dolphins) are 'gulp-feeders' targeting specific prey at depth in the water column away from any potential surface slick, and are likely to be less susceptible to the ingestion of hydrocarbons. Furthermore, given cetaceans are smooth skinned and hydrocarbons would not tend to adhere to body surfaces, the likely biological consequences of physical contact with surface hydrocarbons is likely to be in the form of irritation and sublethal stress. The Petroleum Activities Program in Areas A and C are scheduled to commence in March 2019 and anticipated to end in May 2020. This is outside of the main migratory season for humpback whales but coincides with the pygmy blue whale northbound migration through the NWMR (**Table 4-5**). The migration corridor for pygmy blue whales has been identified as a BIA for the species. During the northbound migration there is potential for spatial overlap with Areas A and C. In the unlikely event of a hydrocarbon release, it is considered that contact will be low and temporary in nature due to the relatively small EMBAs and the rapid dispersion of marine diesel, with no consequence at a population level. <u>Marine Turtles</u> Adult sea turtles exhibit no avoidance behaviour when they encounter hydrocarbon slicks (Odell and MacMurray, 1986). Contact with surface slicks, or entrained hydrocarbons, can therefore result in hydrocarbon adhering to body surfaces (Gagnon and Rawson, 2010) causing irritation of mucous membranes in the nose, throat and eyes leading to inflammation and infection (NOAA, 2010). Oiling can also irritate and injure skin, which is most evident on pliable areas such as the neck and flippers (Lutcavage et al., 1995). A stress response associated with this exposure pathway includes an increase in the production of white blood cells, and even a short exposure to hydrocarbons, such as crude oil, may affect the functioning of their salt gland (Lutcavage et al., 1995). Hydrocarbons in surface waters may also impact turtles when they surface to breathe and inhale toxic vapours. Their breathing pattern, involving large 'tidal' volumes and rapid inhalation before diving, results in direct exposure to petroleum vapours which are the most toxic component of the hydrocarbon spill (Milton and Lutz, 2002). This can lead to lung damage and congestion, interstitial emphysema, inhalant pneumonia and neurological impairment (Etkins, 1997; IPIECA, 1995). Due to the absence of potential nesting habitat (i.e. no emergent islands) and the water depths (from 60 m to 1300 m), Areas A and C are highly unlikely to represent important habitat for marine turtles. The Petroleum Activities Program will overlap temporally with the peak nesting season for green, flatback and loggerhead turtles in the NWMR (**Table 4-5**). Areas A and C overlap spatially with the flatback turtle 'habitat critical' 60 km internesting buffer (**Table 4-6** and **Figure 4-14**). Area C also overlaps partially with the 'habitat critical' for loggerhead and green turtles around Exmouth Gulf and the Ningaloo Coast (20 km nesting buffer). Areas A and C have a small spatial overlap with the turtle 'habitat critical' internesting buffer zones (see above). The timing of the Petroleum Activities Program is over the peak season for green, flatback and loggerhead turtle nesting (on beaches more than 20-60 km away, refer to **Section 4.5.2**). The marine turtle internesting range (20 km for green, loggerhead and hawksbill turtles) and preference for shallow, coastal waters for the flatback turtle (though the

internesting buffer is 60 km) indicates that any potential impacts will be low and temporary in nature, and of no consequence at a population level.

For Area A, the 190 m³ diesel release scenario indicates a relatively small EMBA and a rapid dispersion and evaporation of marine diesel that will be confined to offshore waters.

As described in **Section 4.5.2**, there are a number of significant nesting beaches for loggerhead and green turtles along shorelines in the Ningaloo Coast North, North West Cape and Muiron Islands areas. For Area C, there is no overlap between the ≥10 g/m² surface oil EMBA and any shorelines in the Ningaloo Coast WHA. However, in the unlikely event of a large diesel spill occurring within Area C, nearshore waters adjacent to nesting beaches along Ningaloo Coast North may be exposed to entrained hydrocarbons exceeding the 500 ppb threshold concentration, and accumulated hydrocarbon concentrations above up to 2.6 kg/m² (**Table 6-20** and **Table 6-21**).

Hydrocarbon exposure can impact turtles during the breeding season at nesting beaches. Contact with gravid adult females or hatchlings may occur on nesting beaches (accumulated hydrocarbons) or in nearshore waters (entrained hydrocarbons) where hydrocarbons are predicted to contact the shoreline. If accumulated hydrocarbons or entrained hydrocarbons reach the shoreline or internesting coastal waters, there is the potential for impacts to turtles using the affected area. Animals that lay eggs have been shown to pass metabolised oil-related compounds into their offspring which has the potential to be toxic to the developing embryos. Similarly, adult female turtles can pass metabolised oil and related products to their eggs, thereby potentially exposing developing embryos and impairing the development and survival of embryos (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016).

During the breeding season, turtle aggregations near nesting beaches within the entrained oil EMBA are most vulnerable due to greater turtle densities. Potential impacts could occur at the population level but is not expected to impact on overall population viability.

Sea snakes

Impacts to sea snakes from direct contact with surface hydrocarbons are likely to result in similar physical effects to those recorded for marine turtles. Effects may include potential damage to the dermis and irritation to mucous membranes of the eyes, nose and throat (International Tanker Owners Pollution Federation (ITOPF), 2011). They may also be impacted when they return to the surface to breathe and inhale the toxic vapours associated with the hydrocarbons, damaging their respiratory system.

In general, sea snakes frequent the waters of the continental shelf area, around offshore islands and potentially submerged shoals (water depths <100 m). While individuals may be present in Areas A and C, their abundance is not expected to be high, given the deep water and offshore location of the activity. Therefore, a hydrocarbon spill may have a minor disruption to a portion of the population; however, there is no threat to overall population viability.

Sharks (including Whale Sharks) and Rays

Hydrocarbon contact may affect whale sharks through direct physical coating (surface slicks) and ingestion (surface slicks and entrained/dissolved hydrocarbons), particularly if feeding. Whale sharks located in open offshore waters are most likely transiting. Areas A and C partially overlap the whale shark foraging BIA that extends north from North West Cape across the NWS (**Figure 4-15**). Surveys acquired at the end of the Petroleum Activities Program in Areas A and C may also overlap temporally with the peak of annual whale shark aggregation at Ningaloo Reef (**Table 4-5**). Therefore, if individuals are present in Areas A and C, their abundance is not expected to be high. Individuals that have direct contact with hydrocarbons within the spill affected area may be impacted, but the consequences to migratory whale shark populations will be minor.

Whale sharks and manta rays are vulnerable to surface, entrained and dissolved aromatic hydrocarbon spill impacts, with both taxa having similar modes of feeding. Whale sharks are versatile feeders, filtering large amounts of water over their gills, catching planktonic and nektonic organisms (Jarman and Wilson, 2004). Whale sharks at Ningaloo Reef have been observed using two different feeding strategies: passive sub-surface ram-feeding and active surface feeding (Taylor, 2007). Passive feeding involves swimming slowly at the surface with the mouth wide open. During active feeding sharks swim high in the water, with the upper part of the body above the surface and the mouth partially open (Taylor, 2007). These feeding methods would result in the potential for individuals that are present in worse affected spill areas to ingest potentially toxic amounts of surface, entrained or dissolved aromatic hydrocarbons into their body. Large amounts of ingested hydrocarbons may affect their endocrine and immune system in the longer term. The presence of hydrocarbons may displace whale sharks from the area where they normally feed and rest, and potentially disrupt migration and aggregations to these areas in subsequent seasons. Whale sharks may also be affected indirectly by surface, entrained or dissolved aromatic hydrocarbons through the contamination of their prey. The preferred food of whale sharks are fish eggs and phytoplankton which are abundant in the coastal waters of Ningaloo Reef in late summer/autumn, driving the annual arrival and aggregation of whale sharks in this area. If the spill were to occur during the spawning season, this important food supply (in worse spill affected areas of the reef) may be diminished or contaminated. The contamination of their food supply and the subsequent ingestion of this prey by the whale shark may also result in long term impacts as a result of bioaccumulation.

Seabirds and/or Migratory Shorebirds

In the unlikely event of a large diesel spill, there is the potential for seabirds, and resident and non-breeding overwintering shorebirds that use the nearshore waters for foraging and resting, to be exposed to surface, entrained and dissolved hydrocarbons. This could result in lethal or sublethal effects. Although breeding oceanic seabird species can travel long distances to forage in offshore waters, most breeding seabirds tend to forage in nearshore waters near their breeding colony. This results in intensive feeding by higher seabird densities in these areas during the breeding season and making these areas particularly sensitive in the event of a spill.

Seabirds are vulnerable to contacting surface slicks during feeding or resting on the sea surface, particularly as they do not generally exhibit avoidance behaviour to floating hydrocarbons. Physical contact of seabirds with surface slicks is by several exposure pathways, primarily immersion, ingestion and inhalation. Such contact with hydrocarbons may result in plumage fouling and hypothermia (loss of thermoregulation), decreased buoyancy and potential to drown, inability to fly or feed, anaemia, pneumonia and irritation of eyes, skin, nasal cavities and mouths (AMSA, 2012; IPIECA, 2004) and result in mortality due to oiling of feathers or ingestion of hydrocarbons. Longer term exposure effects that may potentially impact seabird populations include a loss of reproductive success (loss of breeding adults) and malformation of eggs or chicks (AMSA, 2012).

Important areas for foraging seabirds and migratory shorebirds are identified in **Section 4.5.2**. Suitable habitat or seabirds and shorebirds are broadly distributed along the Ningaloo Coast. Therefore, a diesel spill may impact key feeding habitat and disrupt a significant portion of the habitat; however, this is not expected to result in a threat to the overall population viability of seabirds or shorebirds.

Habitats

<u>Corals</u>

The quantitative spill risk assessment and EMBA for Area C indicate there would be potential for entrained hydrocarbons (≥500 ppb threshold concentration) to contact shallow nearshore waters, and therefore expose subtidal corals associated with the fringing along the Ningaloo Coast. Areas that may be contacted by entrained hydrocarbons (≥500 ppb threshold concentration) include the Ningaloo Coast Middle, Ningaloo Coast North and WA Coastline receptors (**Table 6-21**). There is the potential for reefs in these areas to be exposed to entrained hydrocarbons concentrations that are considered to induce toxicity effects, particularly for reproductive and juvenile stages of invertebrate and fish species.

Exposure to entrained hydrocarbons (≥500 ppb) has the potential to result in lethal or sublethal toxic effects to corals and other sensitive sessile benthos within the upper water column, including upper reef slopes (subtidal corals), reef flat (intertidal corals) and lagoonal (back reef) coral communities (with reference to Ningaloo Coast). Mortality in a number of coral species is possible and would reduce coral cover and change the composition of coral communities. Sublethal effects to corals may include polyp retraction, changes in feeding, bleaching (loss of zooxanthellae), increased mucous production resulting in reduced growth rates and impaired reproduction (Negri and Heyward, 2000). This could impact the shallow water fringing coral communities/reefs of the offshore islands (e.g. Barrow/Montebello/Lowendal Islands) and also the mainland coast (e.g. Ningaloo Coast). With reference to Ningaloo Reef, wave-induced water circulation flushes the lagoon and may promote removal of entrained hydrocarbons from this particular reef habitat. Under typical conditions, breaking waves on the reef crest induce a rise in water level in the lagoon, creating a pressure gradient that drives water in a strong outward flow through channels. These reef incises are across as much as 15% of the length of Ningaloo Reef (Taylor and Pearce, 1999).

In the unlikely event of a spill occurring at the time of coral spawning at potentially affected coral locations or in the general peak period of biological productivity, there is potential for a significant reduction in successful fertilisation and coral larval survival due to the sensitivity of coral early life stages to hydrocarbons (Negri and Heyward, 2000). Such impacts are likely to result in the failure of recruitment and settlement of new population cohorts. In addition, some non-coral species may be affected via direct contact with entrained and dissolved aromatic hydrocarbons, resulting in sub-lethal impacts and in some cases mortality. This is with particular reference to the early life-stages of coral reef animals (reef attached fishes and reef invertebrates), which can be relatively sensitive to hydrocarbon exposure. Coral reef fish are site-attached, have small home ranges and, as reef residents, they are at higher risk from hydrocarbon exposure than non-resident, more wide-ranging fish species. The exact impact on resident coral communities (which may include fringing reefs of the offshore islands and/or the Ningaloo Reef system) will be entirely dependent on actual hydrocarbon concentration, duration of exposure and water depth of the affected communities.

Over the worst affected sections of reef habitat, coral community live cover, structure and composition is predicted to reduce, manifested by loss of corals and associated sessile biota. Recovery of these impacted reef areas relies on coral larvae from neighbouring coral communities that have either not been affected or only partially impacted. For example, there is evidence that Ningaloo Reef corals and fish are partly self-seeding (Underwood, 2009), with larvae supplied from locations within Ningaloo Reef critically important to the healthy maintenance of the coral communities. Recovery at other coral reef areas, including Scott Reef, may not be aided by a large supply of larvae from other reefs, with levels of recruits after a disturbance event only returning to previous levels after the numbers of reproductive corals had also recovered (Gilmour et al., 2013).

<u>Seagrass Beds/Macroalgae and Mangroves</u>

Modelling of a 190 m³ diesel spill in Area C has predicted that entrained hydrocarbons ≥500 ppb have the potential to contact a number of shoreline sensitive receptors along the Ningaloo Coast, such as those supporting biologically diverse, shallow subtidal and intertidal communities. The variety of habitat and community types, from the upper subtidal to the intertidal zones, support a high diversity of marine life and are used as important foraging and nursery grounds by a range of invertebrate and vertebrate species. Depending on the trajectory of the entrained plume, macroalgal/seagrass communities along the Ningaloo Coast (patchy and low cover associated with the shallow limestone lagoonal platforms) have the potential to be exposed.

Seagrass and macroalgal beds occurring in the intertidal and subtidal zone may be susceptible to impacts from entrained hydrocarbons. Toxicity effects can also occur due to absorption of soluble fractions of hydrocarbons into tissues (Runcie et al., 2010). The potential for toxicity effects of entrained hydrocarbons may be reduced by weathering processes that should serve to lower the content of soluble aromatic components before contact occurs. Exposure to entrained aromatic hydrocarbons may result in mortality, depending on actual entrained aromatic hydrocarbon concentration received and duration of exposure. Physical contact with entrained hydrocarbon droplets could cause sub-lethal stress, reducing growth rates and tolerance to other stress factors (Zieman et al., 1984). Impacts on seagrass and macroalgal communities are likely to occur in areas where hydrocarbon threshold concentrations are exceeded.

Mangrove habitat and associated mud flats and salt marsh along the Ningaloo Coast (small habitat areas) have the potential to be exposed to entrained hydrocarbons above the ≥500 ppb threshold concentration. Mangroves can be impacted by entrained aromatic hydrocarbons that may adhere to the sediment particles. In low energy environments such as in mangroves, deposited sediment-bound hydrocarbons are unlikely to be removed naturally by wave action and may be deposited in layers by successive tides (NOAA, 2014). Recovery of mangroves from oil spills can take 20–30 years (NOAA, 2014) therefore recovery from any impacts would be long-term (>10 years).

Entrained hydrocarbon impacts may include sub-lethal stress and mortality to certain sensitive biota in these habitats, including infauna and epifauna. Larval and juvenile fish, and invertebrates that depend on these shallow subtidal and intertidal habitats as nursery areas, may be directly impacted due to the loss of habitats and/or lethal and sublethal in-water toxic effects. This may result in mortality or impairment of growth, survival and reproduction (Heintz et al., 2000). In addition, there is the potential for secondary impacts on shorebirds, fish, sea turtles, rays and crustaceans that use these intertidal habitat areas for breeding, feeding and nursery habitat purposes.

Spawning/Nursery Areas

Fish (and other commercially targeted taxa) in their early life stages (eggs, larvae and juveniles) are at their most vulnerable to lethal and sub-lethal impacts from exposure to hydrocarbons, particularly if a spill coincides with spawning seasons or if a spill reaches nursery areas close to the shore (e.g. seagrass and mangroves) (ITOPF, 2011). Fish spawning (including for commercially targeted species such as snapper and mackerel) occurs in nearshore waters at certain times of the year. Nearshore waters are also inhabited by higher numbers of juvenile fishes than offshore waters.

Modelling indicated that in the unlikely event of a large diesel spill within Area C, there is potential for entrained hydrocarbons to occur in the surface water layers above threshold concentrations in nearshore waters of the Ningaloo Coast. This has the potential to result in lethal and sub-lethal impacts to a certain portion of fish larvae in affected areas, depending on concentration and duration of exposure and the inherent toxicity of the hydrocarbon. Although there is the potential for spawning/nursery habitat to be impacted (e.g. mangroves and seagrass beds, discussed above), losses of fish larvae in worst affected areas are unlikely to be of consequence to fish stocks compared with significantly larger losses through natural predation, and the likelihood that most nearshore areas would be exposed is low (i.e. not all areas in the region would be affected). Any impacts to spawning and nursery areas are expected to be minor and short-term, as would flow-on effects to adult fish stocks into which larvae are recruited.

Submerged Shoals

The submerged shoal features of Rankin Bank (approximately 15 km east of Area A) are not expected to have contact with hydrocarbons in a diesel spill. These permanently submerged seabed habitats, which represent sensitive open water benthic community receptors, extend from deep depths to as shallow as approximately 18 m. Due to the nature of any diesel release that may reach Rankin Bank, resulting in surface and entrained hydrocarbons within the upper water layers, this would preclude contact with benthic biota (such as coral communities and resident fish populations).

Air breathing reptiles, such as sea snakes and turtles which may be resident (sea snakes, only) or frequent the shoals to forage periodically, would be vulnerable to potential impacts from surface and entrained hydrocarbons in the upper water layers. Turtles that experience direct contact with surface slicks or entrained hydrocarbons would result in hydrocarbon adherence to body surfaces (Gagnon and Rawson, 2010), irritating mucous membranes in the nose, throat and eyes leading to inflammation and infection (NOAA, 2010). Sea snakes that experience direct contact with surface hydrocarbons would experience similar physical effects to those recorded for marine turtles and would include potential damage to the dermis and irritation to mucous membranes of the eyes, nose and throat (ITOPF, 2011).

Sandy Shores/Estuaries/Tributaries/Creeks

Shoreline exposure for the upper and lower areas differ; the upper shore has the potential to be exposed to surface slicks, while the lower shore is subjected to dissolved or entrained hydrocarbons. Shoreline contact by surface hydrocarbons above threshold concentrations are not expected; however, potential impacts may occur due to isolated shoreline accumulation above threshold concentrations at the Ningaloo Coast North, Ningaloo Coast WHA, WA Coastline (refer **Table 6-20**), and entrained hydrocarbon contact with shallow, subtidal and intertidal zones of the Ningaloo Coast Middle, Ningaloo Coast North and WA Coastline receptors (refer **Table 6-21**). In-water toxicity of the entrained hydrocarbons reaching these shores will determine impacts to the marine organisms, such as sessile barnacle species, and/or mobile gastropods and crustaceans, such as amphipods. Lethal and sub-lethal impacts may be expected where the entrained hydrocarbon concentration threshold is >500 ppb. Impacts may result in localised changes to the community structure of these shoreline habitats, which would be expected to recover in the medium term (two to five years).

Other Sensitive Receptors

Plankton and Fish Communities

Within Areas A, B and C there is the potential for plankton communities to be impacted by a marine diesel spill where entrained hydrocarbon threshold concentrations are exceeded; however, communities are expected to recover quickly (weeks/months) due to high population turnover (ITOPF, 2011). With the relatively small to moderate EMBAs and the fast population turn-over of open water plankton populations, it is considered that any potential impacts will be low and temporary in nature.

Fish populations in the open water offshore environment of Areas A, B and C are highly mobile and can move away from a marine diesel spill. The spill-affected area will likely be confined to the upper surface layers. It is therefore unlikely that fish populations would be exposed to hydrocarbon contamination. Fish populations are likely to be distributed over a wide geographical area so impacts on populations or species level are considered to be negligible. Combined with these factors and the relatively small to moderate EMBAs and the rapid dispersion of marine diesel, it is considered that any potential impacts will be negligible.

Water Quality

It is likely water quality will be reduced at the location of the spill to contamination levels above background levels and/or national/international quality standards; however, such impacts to water quality would be temporary and highly localised in nature due to the relatively small to moderate EMBAs and the rapid dispersion of marine diesel. The potential impact is therefore considered low.

Protected Areas

Area A: There is no overlap between the 190 m³ diesel spill EMBA and the Montebello AMP; therefore surface, entrained and dissolved hydrocarbons (at or exceeding the identified thresholds) are not predicted to contact the Montebello AMP.

Area C – Gascoyne Marine Park: There is no overlap between the ≥10 g/m² surface oil EMBA and the Gascoyne Marine Park MUZ. There is overlap between the 190 m³ diesel spill EMBA (based on entrained oil ≥500 ppb) and the Gascoyne Marine Park MUZ. The environmental values of the Gascoyne Marine Park are detailed in **Section 4.7.2**, and include foraging habitats for migratory seabirds, whale sharks and marine turtles, and a migratory pathway for humpback whales. Potential impacts to protected species that may be present in the offshore waters of the Gascoyne Marine Park are described above. Potential impacts to plankton and fish populations and water quality as relevant to the Gascoyne Marine Park are also described above.

The benthic habitats of the Gascoyne Marine Park are not expected to be impacted by a 190 m³ surface release of marine diesel resulting from a vessel collision, as hydrocarbon spill modelling indicates entrained hydrocarbons would be restricted to the upper water column.

Therefore, impacts to the conservation values of the Gascoyne Marine Park would be temporary and highly localised in nature due to the relatively moderate EMBA and the rapid dispersion of marine diesel. The potential impact is therefore considered low.

Area C – Ningaloo Marine Park, Ningaloo Coast WHA: There is overlap between the ≥10 g/m² surface oil EMBA, the ≥500 ppb entrained oil EMBA and the Ningaloo Marine Park RUZ. The environmental values of the Ningaloo Marine Park and of the Ningaloo Coast WHA are detailed in **Section 4.7.2**, and include whale sharks, marine mammals, marine reptiles, reef fish communities, corals and other benthic invertebrates, and planktonic communities, as well as significant tourism and recreational activities. Potential impacts to cetaceans, marine turtles, sea snakes and whale sharks that may be present in the waters of the Ningaloo Marine Park and Ningaloo Coast WHA are described above. Potential impacts to plankton and fish populations and water quality as relevant to the Ningaloo Marine Park and Ningaloo Coast WHA are also described above.

Objectives in the Ningaloo Marine Park (Commonwealth Waters) Management Plan and the Management Plan for the Ningaloo Marine Park and Muiron Islands MMA require consideration of a number of physical, ecological and social values identified in these areas (refer **Section 4.7.2**). Impact on the values of this protected area is discussed in the relevant sections above for ecological and physical (water quality) values and below for social (socio-economic) values.

In the unlikely event of a large diesel spill occurring in Area C, the nearshore waters of the Ningaloo Coast could be reached by entrained hydrocarbons ≥500 ppb, depending on prevailing wind and current conditions. Shoreline accumulation above threshold concentrations is also predicted for the Ningaloo Coast. These locations offer a number of amenities, such as fishing and swimming, and utilisation of beaches and surrounds have a recreational value for local residents and visitors (regional, national and international). If a major spill resulted in hydrocarbon contact, there could be restricted access to beaches for a period of days to weeks, until natural weathering or tides and currents remove the hydrocarbons. In a major spill, tourists and recreational users may also avoid areas due to perceived impacts, including after the hydrocarbon spill has dispersed.

There is potential for stakeholders to perceive that this remote environment will be contaminated over a large area and for the longer term, resulting in a prolonged period of tourism decline. Oxford Economics (2010) assessed the duration of hydrocarbon spill related tourism impacts and found that on average, it took 12 to 28 months to return to baseline visitor spending. There is likely to be significant impacts to the tourism industry, wider service industry (hotels, restaurants and their supply chain) and local communities in terms of economic loss as a result of spill impacts to

tourism. Recovery and return of tourism to pre-spill levels will depend on the size of the spill, effectiveness of the spill clean-up and change in any public misconceptions about the spill (Oxford Economics, 2010). Additionally, impacts of this nature may alter stakeholder understanding and/or perception of the protected marine environment, given these represent areas largely unaffected by anthropogenic influences and contain biologically diverse environments. Commercial Fisheries A marine diesel spill is considered unlikely to cause significant direct impacts on the target species fished by the Northwest Slope Trawl Fishery and the Pilbara Trawl, Trap and Line fisheries. The target species for these fisheries (demersal finfish and crustaceans) inhabit water depths in the range of >60–200 m and any in-water hydrocarbons are likely to be confined to the upper surface layers. The tuna fisheries (Western Tuna and Billfish, Skipjack Tuna, Southern Bluefin Tuna), for which limited fishing activity has occurred in this area in recent years and the Mackerel Managed Fishery, target pelagic fish species. Adult pelagic fish species are highly mobile and can move away from the spill-affected area or avoid surface waters. The relatively small spill-affected area and temporary nature of the predicted marine diesel spill would infer that it is unlikely the hydrocarbon concentrations in the upper surface layers would lead to potential exposure of pelagic fish to contamination. Given these pelagic species are distributed over a wide geographical area, the impacts at the population or species level are considered very minor in the unlikely event of a marine diesel spill. However, there is potential that a fishing exclusion zone would be applied in the area of the spill, which would put a temporary ban on fishing activities and therefore potentially lead to subsequent minor short-term economic impacts to commercial fishing operators if they were planning to fish within the area of the spill.
Summary of Potential Impacts to Environmental Values(s)
In the unlikely event of a large diesel spill due to vessel collision in Area C, the EMBA includes the sensitive marine environments and associated receptors of the Ningaloo Coast Middle, Ningaloo Coast Middle WHA, Ningaloo Coast North WHA, Ningaloo Marine Park RUZ and WA Coastline. In summary, short to medium term impacts may occur at sensitive nearshore and shoreline habitats, particularly areas of the Ningaloo Coast, as a result of a marine diesel spill from a vessel collision incident occurring in Area C during the Petroleum Activities Program.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[23]	***Benefit in Impact/Risk Reduction***[24]	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Comply with Marine Order 30 (prevention of collisions) 2016, including: • adherence to steering and sailing rules including maintaining look-outs (e.g. visual, hearing, radar, etc), proceeding at safe speeds, assessing risk of collision and taking action to avoid collision (monitoring radar) • adherence to navigation light display requirements, including visibility, light position/shape appropriate to activity • adherence to navigation noise signals as required.	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirements to be followed reduce the likelihood of interference with other marine users resulting in a collision.	Controls based on legislative requirements – must be adopted.	Yes **C 8.1**

[23] Qualitative measure

[24] Measured in terms of reduction of likelihood (L), consequence (C) and current risk rating (CRR)

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[23]	***Benefit in Impact/Risk Reduction***[24]	***Proportionality***	***Control Adopted***
Comply with Marine Order 21 (safety of navigation and emergency procedures) 2016, including: • adherence to minimum safe manning levels • maintenance of navigation equipment in efficient working order (compass/radar) • navigational systems and equipment are as specified in Regulation 19 of Chapter V of Safety of Life at Sea (SOLAS) • AIS that provides other users with information about the vessel's identity, type, position, course, speed, navigational status and other safety-related data.	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirements to be followed reduce the likelihood of interference with other marine users resulting in a collision.	Controls based on legislative requirements – must be adopted.	Yes **C 8.2**
Good Practice				
Notify Australian Hydrographic Service (AHS) will be notified of activities and movements no less than 4 working weeks prior to scheduled activity commencement date.	F: Yes. CS: Minimal cost. Standard practice.	Notifying AHS of activities and movements enables them to generate navigation warnings (MSIN and NTM (including AUSCOAST warnings where relevant)).	Benefits outweigh cost/sacrifice. Control is also Standard Practice.	Yes Refer to **C 1.1**
Notify AMSA Joint Rescue Coordination Centre (JRCC) of activities and movements 24-48 hours before operations commence.	F: Yes. CS: Minimal cost. Standard practice.	Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interfering with other marine users.	Benefits outweigh cost/sacrifice. Control is also Standard Practice.	Yes Refer to **C 1.2**
Establish and maintain a 500 m radius SNA around the seismic vessel and towed array.	F: Yes CS: Minimal cost. Standard practice.	SNA will reduce the likelihood of a collision with a third party vessel.	Benefits outweigh cost/sacrifice.	Yes Refer to **C 1.4**

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[23]	***Benefit in Impact/Risk Reduction***[24]	***Proportionality***	***Control Adopted***
A communications protocol in place between the project vessels other users (known commercial fishing vessels within the survey Operational Areas and existing oil and gas facilities or drill rigs). The communications protocol will include the aspects of: • communications • work programming • hazard management • emergency response.	F: Yes. CS: Minimal cost. Standard practice.	Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interfering with other marine users.	Benefits outweigh cost/sacrifice.	Yes Refer to **C 1.5**
At least one dedicated chase vessel to assist seismic and support vessels.	F: Yes. CS: Minimal cost. Standard practice.	Given the legislative controls in place, use of a chase vessel will provide a small reduction in likelihood of a collision with a third party vessel.	Benefits outweigh cost/sacrifice.	Yes Refer to **C 1.6**
Woodside will engage with proponents identified as having potential concurrent MSS or drilling activities within 50 km of the Petroleum Activities Program prior to commencing the Petroleum Activities Program and develop a concurrent operations plan for any concurrent surveys identified. The concurrent operations plan will include the aspects of: • communications • work programming • hazard management • emergency response.	F: Yes. CS: Minimal cost. Standard practice.	Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of interfering with other marine users.	Standard activity; business as usual. No additional cost/sacrifice.	Yes **C 1.7**
Mitigation: Oil spill response.	Refer to **Appendix D**.			
Professional Judgement – Eliminate				
Eliminate use of vessels.	F: No. The use of vessels is required to conduct the Petroleum Activities Program. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Substitute				
No additional controls identified.				
Professional Judgement – Engineered Solution				
No additional controls identified.				

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[23]	***Benefit in Impact/Risk Reduction***[24]	***Proportionality***	***Control Adopted***
Risk Based Analysis				
A quantitative spill risk assessment was undertaken (see detail above).				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the communications protocol that will be in place between the project vessels (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of an unplanned loss of hydrocarbon resulting from vessel collision. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability

Other Requirements (includes Laws, Policies,Standards and Conventions)

The Petroleum Activities Program is consistent with laws, policies, standards and conventions, including:

- Marine Order 30 (prevention of collisions) and Marine Order 21 (safety of navigation and emergency procedures) 2016.

In the event of a vessel collision the objectives in the Ningaloo management plans (Management Plan for Ningaloo Marine Park and Muiron Islands Marine Management Areas,); will be considered including for water quality, coral, shoreline and intertidal, macroalgal, seagrass, mangroves, seabirds and social and economic values .

Principles of Ecologically Sustainable Development

The proposed activity has been assessed and considered in accordance with Australian IUCN Reserve Management Principles, conditions of the class approval (**Section 1.10.1.1**), objectives of the IUCN category VI zone (**Section 1.10.1.1**), the North West Marine Park Management Plan and the values of the Montebello and Gascoyne Marine Parks **(Section 6.6.3**). The impact assessment has determined that an unplanned loss of hydrocarbon as a result of a vessel collision represents a moderate current risk rating that may result in a moderate, medium term impact on ecosystems, species, habitat or physical or biological attributes.

Internal Context

The Petroleum Activities Program is consistent with Woodside corporate policies, standards, procedures, processes and training requirements as outlined in the Demonstration of ALARP and Environmental Performance Outcomes, including:

- Woodside Health, Safety, Environment and Quality Policy (Appendix A)
- Woodside Risk Management Policy (Appendix A)

Woodside corporate values include working sustainably, with respect to the environment and communities in which we operate, listening to internal and external stakeholders and considering Health, Safety, Environment and Quality (HSEQ) when making decisions. Stakeholder consultation, outlined below, has been undertaken prior to the Petroleum Activities Program.

External Context

Woodside recognises that its licence to operate from a regulator and societal perspective is based on historical performance, complying with appropriate policies, standards and procedures, and understanding the expectations of external stakeholders. External stakeholder consultation, outlined below, has been undertaken prior to the Petroleum Activities Program:

- Consultation with other relevant stakeholders (**Section 5** and incorporation of stakeholder feedback (**Appendix F**) into this EP where appropriate.

By responding to stakeholder feedback and implementing control measures that are commensurate with the risk rating, location and sensitivity of the receiving environment (including social and aesthetic values), Woodside believes this addresses societal concerns to an acceptable level.

Acceptability Statement

The impact assessment has determined that an unplanned loss of hydrocarbon as a result of a vessel collision represents a moderate current risk rating that may result in a moderate, medium term impact on ecosystems, species, habitat or physical or biological attributes.

As per **Section 2.7.2** Woodside considers 'high order impacts' (Impact Moderate or above) as acceptable if ALARP is demonstrated using good industry practice, consideration of company and societal values and risk based analysis, if legislative requirements are met and societal concerns are accounted for, and the alternative control measures are grossly disproportionate to the benefit gained.

Further opportunities to reduce the impacts and risks have been investigated (refer ALARP discussion). The adopted controls are consistent with the most relevant regulatory guidelines, good oil-field practice/industry best practice, and meet legislative requirements of Marine Orders 30 and 21. Both internal and external context have been considered. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of a vessel collision level that is acceptable if ALARP.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 7 No release of hydrocarbons to the marine environment due to a vessel collision associated with the activity.	**C 7.1** Comply with Marine Order 30 (prevention of collisions) 2016, including: • adherence to steering and sailing rules including maintaining look-outs (e.g. visual, hearing, radar, etc.), proceeding at safe speeds, assessing risk of collision and taking action to avoid collision (monitoring radar) • adherence to navigation light display requirements, including visibility, light position/shape appropriate to activity • adherence to navigation noise signals as required.	**PS 7.1** Project vessels compliant with Marine Order 30 (prevention of collisions) 2016 (which requires vessels to be visible at all times) to prevent unplanned interaction with marine users.	**MC 7.1.1** Marine Assurance Inspection records demonstrate compliance with maritime safety procedures (Marine Orders 21 and 30).
	C 7.2 Comply with Marine Order 21 (safety of navigation and emergency procedures) 2016, including: • adherence to minimum safe manning levels • maintenance of navigation equipment in efficient working order (compass/radar) • navigational systems and equipment required are those specified in Regulation 19 of Chapter V of SOLAS • AIS that provides other users with information about the vessel's identity, type, position, course, speed, navigational status and other safety-related data.	**PS 7.2** Project vessels compliant with Marine Order 21 (safety of navigation and emergency procedures) 2016 to prevent unplanned interaction with marine users.	
	C 1.1 Notify Australian Hydrographic Service (AHS) of activities and movements will be notified no less than 4 working weeks prior to scheduled activity commencement date.	**PS 1.1** Notifying AHS of activities and movements enables them to generate navigation warnings (MSIN and NTM (including AUSCOAST warnings where relevant)).	**MC 1.1.1** Consultation records demonstrate that AHS has been notified before the activity commences to allow generation of navigation warnings (MSIN and NTM (including AUSCOAST warnings where relevant)), which communicate safety

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
			exclusion zones to marine users.
	C 1.2 Notify AMSA JRCC of activities and movements of the activity 24-48 hours before operations commence.	**PS 1.2**	**MC 1.2.1** Consultation records demonstrate that AMSA JRCC has been notified before commencing the activity within required timeframes.
	C 1.4 Establish and maintain a 500 m radius SNA around the seismic vessel and towed array.	**PS 1.4** No entry of unauthorised vessels within the 500 m SNA during the Petroleum Activities Program.	**MC 1.4.1** Records demonstrate breaches by unauthorised vessels within the SNA are recorded.
	C 1.5 A communications protocol will be in place between the project vessels and other users (known commercial fishing vessels and existing oil and gas facilities or drill rigs), within the survey operational areas. The communications protocol will include the aspects of: • communications • work programming • hazard management • emergency response.	**PS 1.5** Communications protocol developed for the project vessels and known commercial fishing vessels to actively manage concurrent activities.	**MC 1.5.1** Records demonstrate the Communications Protocol is implemented throughout the Petroleum Activities Program. **MC 1.5.2** Records demonstrate that the communications protocol has been developed and distributed to known commercial fishing stakeholders prior to survey mobilisation.
	C 1.6 At least one dedicated chase vessel will be employed to assist seismic and support vessels	**PS 1.6** One dedicated chase vessel to assist the seismic and support vessels to mitigate collision associated with concurrent seismic and third party vessel operations.	**MC 1.6.1** Records demonstrate that a dedicated chase vessel is employed for the Petroleum Activities Program.
	C 1.7 Woodside will engage with proponents identified as having potential concurrent MSS or drilling activities within 50 km of the Petroleum Activities Program prior to commencing the Petroleum Activities Program and develop a concurrent operations plan for any concurrent surveys identified. The concurrent operations plan will include the aspects of: • communications	**PS 1.7** Communicating the Petroleum Activities Program to other marine users ensures they are informed and aware, thereby reducing the likelihood of collision with other marine users.	**MC 1.7.1** Records demonstrate that the Concurrent Operations Plan has been developed and implemented.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	• work programming • hazard management • emergency response.		
Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the Petroleum Activities Program are present in **Appendix D**.			

6.7.3 Accidental Hydrocarbon Release: Bunkering

Context		
Project vessels – **Section 3.6.4**	Physical environment – **Section 4.4** Biological environment – **Section 4.5** Socio-economic environment – **Section 4.6** Values and sensitivities – **Section 4.7**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary

	Environmental Value Potentially Impacted							*Evaluation*						
Source of Risk	***Soil and Groundwater***	***Marine Sediments***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitats***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence/ Impact***	***Likelihood***	***Current Risk Rating***	***ALARP Tools***	***Acceptability***	***Outcome***
Loss of hydrocarbons to marine environment from bunkering/refuelling of seismic vessel			X		X	X	X	A	E	1	**L**	LCS GP	Broadly Acceptable	EPO 8

Description of Source of Risk

Bunkering of marine diesel between the support vessel(s) and the seismic vessel may occur within the Operational Areas for each survey. Bunkering of the seismic vessel is expected to be required approximately every five to six weeks during the Petroleum Activities Program.

Two credible scenarios for the loss of containment of marine diesel during bunkering operations were identified:

- Partial or total failure of a bulk transfer hose or fittings during bunkering, due to operational stress or other integrity issues could spill marine diesel to the deck and/or into the marine environment. This would be in the order of less than 200 L, based on the likely volume of a bulk transfer hose (assuming a failure of the dry break coupling and complete loss of hose volume).
- Partial or total failure of a bulk transfer hose or fittings during bunkering, combined with a failure in procedure to shut off fuel pumps, for a period of up to five minutes, resulting in approximately 8 m³ marine diesel loss to the deck and/or into the marine environment.

Quantitative Spill Risk Assessment

Woodside has commissioned RPS to model several small marine diesel spills, including surface spill volumes of 8 m³ in the offshore waters of the NWS. The results of these models have indicated that exposure to surface hydrocarbons above the 10 g/m² threshold is limited to the immediate vicinity of the release site, with little potential to extend beyond 1 km. Therefore, it is considered that exposure to threshold concentrations from an 8 m³ surface spill from bunkering activities would be well within the EMBAs for the vessel collision scenarios in Areas A and C detailed in **Section 6.7.2**. Given this, the offshore locations of the Operational Areas for each survey, and the fact that the same hydrocarbon type is involved for both scenarios, specific modelling for an 8 m³ marine diesel release was not conducted for this Petroleum Activities Program.

Hydrocarbon Characteristics

Refer to **Section 6.7.2** for a description of the characteristics of marine diesel, including detail on the predicted fate and weathering of a spill to the marine environment.

Consequence Assessment
Previous modelling studies for 8 m³ marine diesel releases, spilled at the surface as a result of bunkering activities, indicated that the potential for exposure to surface hydrocarbons exceeding 10 g/m² was confined to within the immediate vicinity (approximately 1 km) of the release site. Based on the previous modelling studies and the modelling presented in **Section 6.7.2**, it is considered that there is no potential for contact with sensitive receptor locations above surface (10 g/m²), entrained (500 ppb) or dissolved (500 ppb) threshold concentrations from an 8 m³ spill of marine diesel within the Operational Area for each survey. The modelling presented in **Section 6.7.2** for much larger volume diesel spills (190 m^3) predicted the diesel spill to be restricted to open offshore waters, with a low probability of contacting any protected areas.
Summary of Potential Impacts to Environmental Values(s)
The potential biological and ecological impacts associated with much larger hydrocarbon spills are presented in **Section 6.7.2**, further detail on impacts specific to a spill of marine diesel from a bunkering loss are provided below. The biological consequences of such a small volume spill on identified open water sensitive receptors relate to the potential for minor impacts to megafauna, plankton and fish populations (surface and water column biota) that are within the spill-affected area. No impacts to commercial fisheries are expected. Refer to **Section 6.7.2** (potential impacts of unplanned hydrocarbon release to the marine environment from vessel collision) for the detailed potential impacts; however, the extent of the EMBA associated with a marine diesel spill from loss during bunkering will be much reduced in terms of spatial and temporal scales, and hence, potential impacts from bunkering are considered slight and short-term.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[25]	***Benefit in Impact/Risk Reduction***[26]	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Marine Order 91 (marine pollution prevention – oil) 2014 which requires a Ship Oil Pollution Emergency Plan (SOPEP)/ Spill Monitoring Programme Execution Plan (SMPEP) (as appropriate to vessel class).	F: Yes. CS: Minimal cost. Standard practice.	Reduces the likelihood of a spill entering the marine environment. Although no significant reduction in consequence could result, the overall risk is reduced.	Controls based on legislative requirements – must be adopted.	Yes **C 9.1**
Good Practice				
Bunkering equipment controls: • All bulk transfer hoses shall be tested for integrity before use. • There shall be dry-break couplings and flotation on fuel hoses. • There shall be an adequate number of appropriately stocked, located and maintained spill kits.	F: Yes. CS: Minimal cost. Standard practice.	Reduces the likelihood of a spill occurring. Although no significant reduction in consequence could result, the overall risk is reduced.	Benefits outweigh cost/sacrifice.	Yes **C 9.2**
Contractor procedures include requirements to be implemented during bunkering/refuelling operations, including:	F: Yes. CS: Minimal cost. Standard practice.	Reduces the likelihood of a spill occurring. Although no significant reduction in consequence could result, the overall risk is reduced.	Benefits outweigh cost/sacrifice.	Yes **C 9.3**

[25] Qualitative measure
[26] Measured in terms of reduction of likelihood (L), consequence (C) and current risk rating (CRR)

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[25]***	***Benefit in Impact/Risk Reduction[26]***	***Proportionality***	***Control Adopted***
• A completed Permit to Work and/or Job Safety Assessment (JSA) shall be implemented for the hydrocarbon bunkering/ refuelling operation. • Gauges, hoses, fittings and the sea surface shall be visually monitored during the operation. • Hoses shall be checked prior to commencement. • Bunkering/refuelling will commence in daylight hours. If the transfer is to continue into darkness, the JSA risk assessment must consider lighting and the ability to determine if a spill has occurred. • Hydrocarbons shall not be transferred in marginal weather conditions.				
No bunkering / refuelling operations undertaken within an AMP boundary (unless under emergency conditions).	F: Yes. CS: Minimal cost. Standard practice.	By avoiding the AMP boundaries, the likelihood of a spill entering the AMP is reduced.	Benefits outweigh cost/sacrifice.	Yes **C 9.4**
Mitigation: Oil spill response.	Refer to **Appendix D**.			
Professional Judgement – Eliminate				
Vessels brought into port to refuel.	F: No. Eliminates the hydrocarbon spill risk from the Operational Areas, but transfers it to the coastal region. Introduces Invasive Marine Species (IMS) management risks. It is not operationally practical to transit project vessels back to port for refuelling based on distance from the nearest port. CS: Significant due to schedule delay and	Eliminates the risk in the Operational Areas. However, moves risk to another location. Therefore, no overall benefit.	Disproportionate. The cost/sacrifice outweighs the benefit gained.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[25]***	***Benefit in Impact/Risk Reduction[26]***	***Proportionality***	***Control Adopted***
	vessel transit costs and day rates.			
Professional Judgement – Substitute				
No additional controls identified.				
Professional Judgement – Engineered Solution				
No additional controls identified.				
Risk Based Analysis				
A quantitative spill risk assessment was undertaken (see detail above).				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of a bunkering spill. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement Loss of hydrocarbons to the marine environment during bunkering has been evaluated as having a low risk rating with a potential impact no greater than minor impacts to megafauna, plankton and fish populations (surface and water column biota) that are within the spill-affected area, and no impacts to commercial fisheries. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of the described emissions to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 8 No unplanned loss of hydrocarbons to the marine environment from bunkering greater than a consequence level of F during the Petroleum Activities Program.	**C 8.1** Marine Order 91 (marine pollution prevention – oil) 2014 which requires SOPEP/SMPEP (as appropriate to vessel class).	**PS 8.1** Appropriate initial responses prearranged and drilled in case of a hydrocarbon spill, as appropriate to vessel class.	**MC 8.1.1** Marine Assurance inspection records demonstrate compliance with Marine Order 91.
	C 8.2 Bunkering equipment controls: • All bulk transfer hoses shall be tested for integrity before use. • There shall be dry-break couplings and flotation on fuel hoses. • There shall be an adequate number of appropriately stocked, located and maintained spill kits.	**PS 8.2.1** Damaged equipment is replaced prior to failure.	**MC 8.2.1** Records confirm the vessel bunkering equipment is subject to systematic integrity checks.
		PS 8.2.2 Minimised inventory loss in the event of a failure.	**MC 8.2.2** Records confirm presence of dry break of couplings and flotation on fuel hoses.
		PS 8.2.3 Adequate resources available to allow implementation of SOPEP.	**MC 8.2.3** Records confirm presence of spill kits.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	C 8.3 Ensure Contractor procedures include requirements to be implemented during bunkering/refuelling operations, including: • A completed Permit to Work and/or JSA shall be implemented for the hydrocarbon bunkering/refuelling operation. • Gauges, hoses, fittings and the sea surface shall be visually monitored during the operation. • Hoses shall be checked prior to commencement. • Bunkering/refuelling will commence in daylight hours. If the transfer is to continue into darkness, the JSA risk assessment must consider lighting and the ability to determine if a spill has occurred. • Hydrocarbons shall not be transferred in marginal weather conditions.	**PS 8.3** Compliance with Contractor procedures for managing bunkering/refuelling operations.	**MC 8.3.1** Records demonstrate bunkering/refuelling undertaken in accordance with contractor bunkering procedures.
	C 8.4 No bunkering / refuelling operations undertaken within an AMP boundary (unless under emergency conditions).	**PS 8.4** To minimise potential for hydrocarbons to enter AMP boundaries.	**MC 8.4.1** Records demonstrate no bunkering / refuelling operations undertaken within an AMP boundary (unless under emergency conditions).
Detailed oil spill preparedness and response performance outcomes, standards and measurement criteria for the Petroleum Activities Program are presented in **Appendix D**.			

6.7.4 Unplanned Discharge: Deck Spills

Context		
Project vessels – **Section 3.6.4**	Physical environment – **Section 4.4** Biological environment – **Section 4.5**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary														
Source of Risk	***Environmental Value Potentially Impacted***							***Evaluation***						
	Soil and Groundwater	***Marine Sediments***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitats***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence/ Impact***	***Likelihood***	***Current Risk Rating***	***ALARP Tools***	***Acceptability***	***Outcome***
Accidental discharge of other hydrocarbons/ chemicals from survey or support vessel deck activities and equipment (e.g. cranes and winches)						X		A	F	2	**L**	LCS GP	Broadly Acceptable	EPO 9

Description of Source of Risk
Spills on deck can occur from accidental spills from stored hydrocarbons/harmful chemicals or equipment present on the deck. Project vessels require storage of small quantities of lubricating oils, hydraulic fluid, streamer fluid or other harmful chemicals on the vessel. Hydraulic fluid is also contained in hoses and lines and on hydraulic equipment, such as cranes or winches. Storage areas are typically set up with primary and secondary containment. Releases from equipment, if they do occur, are predominantly from the failure of hydraulic hoses, which can either be located within bunded areas or outside of bunded or deck areas (e.g. over water on cranes). Data from previous Woodside activities demonstrates that spills are most likely to originate from hydraulic hoses and are typically less than 10 L.
Consequence Assessment
No significant impacts from the accidental discharges described are anticipated in the deep water offshore/open water locations of the Operational Areas, because of the minor quantities involved (<10 L), the limited duration of vessel activities during the Petroleum Activities Program, and high level of dilution into the open water marine environment of the Operational Areas. The biological consequences of such a small volume spill on identified open water sensitive receptors relate to a minor potential for toxicity impacts to plankton and fish populations (surface and water column biota) and localised reduction in water quality within a small spill affected area.
Summary of Potential Impacts to Environmental Values(s)
Given the adopted controls, it is considered that minor hydrocarbon/harmful chemical spills to the marine environment will not result in a potential impact to water quality greater than localised contamination above background levels, quality standards or known effect concentrations, and will not result in a potential impact greater than localised and temporary disruption to a small proportion of the population with no impact on critical habitat or activity.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[27]	***Benefit in Impact/Risk Reduction***[28]	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Marine Order 91 (marine pollution prevention – oil) 2014 which requires SOPEP/SMPEP (as appropriate to vessel class).	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirements to be followed reduce the likelihood of an unplanned release. The consequence is unchanged.	Controls based on legislative requirements – must be adopted.	Yes **Refer to C 9.1**
Good Practice				
Liquid chemical and fuel storage areas are bunded or secondarily contained when they are not being handled/moved temporarily.	F: Yes. CS: Minimal cost. Standard practice.	Requirements for liquid chemical and fuel storage areas are bunded or secondarily contained when they are not being handled/ moved temporarily would reduce the likelihood of contaminated deck drainage water being discharged to the marine environment.	Benefits outweigh cost/sacrifice.	Yes **C 10.1**
Spill kits are maintained and located in close proximity to hydrocarbon storage areas and deck areas for use to contain and recover deck spills	F: Yes. CS: Minimal cost. Standard practice.	Spill kits would reduce the likelihood of a deck spill from entering the marine environment. The consequence is unchanged.	Benefits outweigh cost/sacrifice.	Yes **C 10.2**
Professional Judgement – Eliminate				
No additional controls identified.				
Professional Judgement – Substitute				
No additional controls identified.				
Professional Judgement – Engineered Solution				
Store below-deck all hydrocarbons and harmful chemicals.	F: No. During operations there is a need to keep small volumes near activities and within equipment requiring use of hydrocarbons and harmful chemicals, and can increase the risk of leaks from transfers via hose or smaller containers. CS: Not considered – control not feasible.	Not considered – control not feasible.	Not considered – control not feasible.	No

[27] Qualitative measure.

[28] Measured in terms of reduction of likelihood (L), consequence (C) and current risk rating (CRR).

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[27]	***Benefit in Impact/Risk Reduction***[28]	***Proportionality***	***Control Adopted***
Reduce the volumes of chemicals and hydrocarbons stored onboard the vessel.	F: Yes. Increases the risks associated with transportation and lifting operations. CS: Project delays if required chemicals not on board. Increases the risks associated with transportation and lifting operations.	No reduction in likelihood or consequence since chemicals will still be required to enable drilling activities to occur.	Disproportionate. The cost/ sacrifice outweighs the benefit gained.	No
No additional controls identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of the potential spills described above. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement Loss of hydrocarbons/harmful chemicals to the marine environment due to deck spills has been evaluated as having a low residual risk that is unlikely to result in potential impact greater than temporary exceedance over national/international water quality standards, with low impact to the marine environment. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet legislative requirements under Marine Order 91. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of the described discharges to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 9 No unplanned spills to the marine environment from deck activities greater than a consequence level of F during the Petroleum Activities Program.	**C 8.1** Marine Order 91 (marine pollution prevention – oil) 2014 which requires SOPEP/SMPEP (as appropriate to vessel class).	**PS 8.1** Appropriate initial responses pre-arranged and drilled in case of a hydrocarbon spill, as appropriate to vessel class.	**MC 8.1.1** Marine Assurance inspection records demonstrate compliance with Marine Order 91.
	C 9.1 Liquid chemical and fuel storage areas are bunded or secondarily contained when they are not being handled/moved temporarily.	**PS 9.1** Failure of primary containment in storage areas does not result in loss to the marine environment.	**MC 9.1.1** Records confirm all liquid chemicals and fuel are stored in bunded/ secondarily contained areas when not being handled/moved temporarily.
	C 9.2 Maintain and locate spill kits in close proximity to hydrocarbon storage areas and deck areas for use to contain and recover deck spills.	**PS 9.2** Spill kits to be available for use to clean up deck spills.	**MC 9.2.1** Records confirm spill kits are present, maintained, and suitably stocked.

6.7.5 Unplanned Discharge: Loss of Solid Hazardous and Non-hazardous Wastes/Equipment

Context		
Project vessels – **Section 3.6.4**	Physical environment – **Section 4.4** Biological environment – **Section 4.5**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary														
	Environmental Value Potentially Impacted							***Evaluation***						
Source of Risk	***Soil and Groundwater***	***Marine Sediments***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitats***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence***	***Likelihood***	***Current Risk Rating***	***ALARP Tools***	***Acceptability***	***Outcome***
Accidental loss of hazardous or non-hazardous wastes/ equipment to the marine environment (excludes sewage, grey water, putrescible waste and bilge water).			X		X	X		A	F	1	**L**	LCS GP	Broadly Acceptable	EPO 10

Description of Source of Risk
The project vessels will generate a variety of solid wastes including packaging and domestic wastes such as aluminium cans, bottles, paper and cardboard. Hence, there is the potential for solid wastes to be lost overboard to the marine environment. Wastes that have been recorded as being lost (primarily windblown or dropped overboard) during previous Woodside activities have included a wooden crate lid. These have occurred during backloading activities, periods of adverse weather and incorrect waste storage. Please note that unplanned waste does not include operational equipment associated with streamers that has the potential to be lost during operations, such as SRD release caps, fins or other streamer positioning equipment. If SRDs are activated, their plastic end caps will be deployed to the marine environment and cannot be recovered.
Consequence Assessment
The potential impacts of solid wastes accidentally discharged to the marine environment include direct pollution and contamination of the environment and secondary impacts relating to potential contact of marine fauna with wastes, resulting in entanglement or ingestion and leading to injury and death of individual animals. The temporary or permanent loss of waste materials into the marine environment is not likely to have a significant environmental impact, based on the location of the Operational Areas (deep/offshore waters), the types, size and frequency of wastes that could occur and species present.
Summary of Potential Impacts to Environmental Values(s)
Given the adopted controls, it is considered that the unplanned discharge of solid waste described will not result in a potential impact greater than localised contamination above background levels, water quality standards, or known effect concentrations and will not result in a potential impact greater than temporary disruption to a small proportion of the population with no lasting effect on critical habitat or activity.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/ Sacrifice (CS)[29]***	***Benefit in Impact/ Risk Reduction[30]***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Marine Order 95 – pollution prevention – garbage (as appropriate to vessel class), which requires putrescible waste and food scraps are passed through a macerator so it can pass through a screen with no opening wider than 25 mm.	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirements to be followed reduce the likelihood of an unplanned release. The consequence is unchanged.	Controls based on legislative requirements – must be adopted.	Yes **C 11.1**
Good Practice				
Vessel Waste Management Plan, which requires: • dedicated waste segregation bins • records of all waste to be disposed, treated or recycled • waste streams to be handled and managed according to their hazard and recyclability class.	F: Yes. CS: Minimal cost. Standard practice.	Controls outlined in the management plan will reduce the likelihood of an unplanned release. The consequence is unchanged.	Benefits outweigh cost/sacrifice.	Yes **C 11.2**
Professional Judgement – Eliminate				
No additional controls identified.				
Professional Judgement – Substitute				
No additional controls identified.				
Professional Judgement – Engineered Solution				
No additional controls identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of accidental discharges of solid waste. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, unplanned discharge of solid waste represents a low residual risk that may result in a potential impact greater than localised contamination above background levels and/or national/international quality standards and/or known biological effect concentrations outside a 200 m mixing zone. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet legislative requirements (Marine Order 95). The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of these discharges to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 10	**C 10.1**	**PS 10.1**	**MC 10.1.1**

[29] Qualitative measure.

[30] Measured in terms of reduction of likelihood (L), consequence (C) and current risk rating (CRR).

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
No unplanned releases of solid hazardous or non-hazardous waste to the marine environment greater than a consequence level of F during the Petroleum Activities Program.	Marine Order 95 – pollution prevention – garbage (as appropriate to vessel class), which requires putrescible waste and food scraps are passed through a macerator so it can pass through a screen with no opening wider than 25 mm.	Project vessels compliant with Marine Order 95 – pollution prevention – garbage.	Records demonstrate project vessels comply with Marine Order 95 – pollution prevention (as appropriate to vessel class).
	C 10.2 Vessel Waste Management Plan, which requires: • dedicated waste segregation bins • records of all waste to be disposed, treated or recycled • waste streams to be handled and managed according to their hazard and recyclability class.	**PS 10.2** Hazardous and non-hazardous waste will be managed in accordance with the Vessel Waste Management Plan.	**MC 10.2.1** Records demonstrate compliance against Drilling and Completions Waste Management Plan.

6.7.6 Physical Presence: Vessel Collision with Marine Fauna

Context		
Project vessels – **Section 3.6.4**	Biological environment – **Section 4.5**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary

Source of Risk	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	***Marine Sediments***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitats***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence/ Impact***	***Likelihood***	***Current Risk Rating***	***ALARP Tools***	***Acceptability***	***Outcome***
Accidental collision between project vessels and threatened and migratory fauna						X		A	E	1	**L**	LCS PJ	Broadly Acceptable	EPO 11

Description of Source of Risk

The project vessels operating in the Operational Areas for each survey during the Petroleum Activities Program, may present a potential hazard to cetaceans and other protected marine fauna such as whale sharks and marine turtles. Vessel movements can result in collisions between the vessel (hull, propellers and streamer array) and marine fauna, potentially resulting in superficial injury, serious injury that may affect life functions (e.g. movement and reproduction) and mortality. The factors that contribute to the frequency and severity of impacts due to collisions vary greatly due to vessel type, vessel operation (specific activity, speed), physical environment (e.g. water depth) and the type of animal potentially present and their behaviours.

Consequence Assessment

The likelihood of vessel/whale collision being lethal is influenced by vessel speed; the greater the speed at impact, the greater the risk of mortality (Laist et al., 2001, Jensen and Silber 2004). Vanderlaan and Taggart (2007) found that the chance of lethal injury to a large whale as a result of a vessel strike increases from about 20% at 8.6 knots to 80% at 15 knots and less than 10% at a speed of four knots.

Project vessels operating within the Operational Areas for each survey are likely to be travelling less than eight knots, therefore the chance of a vessel collision with protected species resulting in a lethal outcome is reduced.

Areas A, B and C are located in water depths ranging from approximately 60 m to 1300 m. The fauna associated with these areas will be predominantly pelagic species of fish with the potential for the transient presence of other megafauna species encounters such as turtles, whale sharks and large whales passing through the areas (**Section 4.5.2**). Surveys acquired at the end of the Petroleum Activities Program may overlap temporally with the start of the northbound migration of pygmy blue whales through the region. Areas A and C overlap spatially with the pygmy blue whale migration BIA, however, there is no overlap between Area B and the migration BIA (**Figure 4-11**). Additionally, Area C has a very small overlap with the “Possible Foraging BIA” adjacent to Ningaloo Reef/North West Cape (**Figure 4-11**).

Area C partially overlaps the humpback whale migration BIA in the area north of North West Cape and Exmouth Gulf (**Figure 4-12**). However, the surveys that will take place outside the humpback whale northbound and southbound migratory seasons (**Table 4-5**).

The Petroleum Activities Program will overlap temporally with the peak nesting season for green, flatback and loggerhead turtles in the NWMR (see **Table 4-5** for details on seasonality). Areas A and C overlap spatially with the flatback turtle ‘habitat critical’ (60 km internesting buffer) (**Table 4-6**;**Figure 4-14**). Area C also overlaps partially with the ‘habitat critical’ for loggerhead and green turtles around Exmouth Gulf and the Ningaloo Coast (20 km nesting buffer). Areas A and C have a small spatial overlap with the turtle ‘habitat critical’ internesting buffer zones (see above) and the timing of the Petroleum Activities Program is over the peak season for green, flatback and loggerhead turtle nesting (on beaches more than 20-60 km away, refer to **Section 4.5.2**). Scientific literature and expert opinion on the turtle internesting range and patterns, however, show that it is highly unlikely for significant numbers of turtles to be encountered within the offshore Areas A, B and C.

Areas A and C partially overlap the whale shark foraging BIA that extends north from North West Cape across the NWS (**Figure 4-15**). Surveys acquired at the end of the Petroleum Activities Program may also overlap temporally with the peak of annual whale shark aggregation at Ningaloo Reef (**Table 4-5**). Whale sharks are at risk from vessel strikes

when feeding at the surface or in shallow waters (where there is limited option to dive). Whale sharks may traverse offshore NWS waters including the Areas A and C during their migrations to and from Ningaloo Reef. Although a BIA for foraging whale sharks intersects with Areas A, it is expected that whale shark presence in Area A would not comprise significant numbers given the main aggregations are recorded in coastal waters, (MPRA, 2005; Sleeman et al., 2009) and their presence would be transitory and of a short duration. However, due to proximity to Ningaloo Reef (approximately 16 km south-east), Area C is expected to be more frequently visited by whale sharks to feed from March to November. It is unlikely, that vessel movement associated with the Petroleum Activities Program will have a significant impact on marine fauna populations given (1) the low presence of transiting individuals, (2) avoidance behaviour commonly displayed by whales, whale sharks and turtles and (3) low operating speed of the project vessels (generally less than eight knots or stationary, unless operating in an emergency).
Summary of Potential Impacts to environmental values(s)
Given the adopted controls, it is considered that a collision, were it to occur, will not result in a potential impact greater than slight and short-term disruption to a small proportion of the population and no impact on critical habitat or activity.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[31]***	***Benefit in Impact/Risk Reduction[32]***	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Apply EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans, including the following measures[33]: • Project vessels will not travel greater than six knots within 300 m of a cetacean or turtle (caution zone) and not approach closer than 100 m from a whale. • Project vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow riding). • If the cetacean or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than six knots. • Vessels will not travel greater than	F: Yes. CS: Minimal cost. Standard practice.	Implementing these controls will reduce the likelihood of a collision between a cetacean, whale shark or turtle occurring. The consequence of a collision is unchanged.	Control based on legislative requirements – must be adopted.	Yes Refer to **C 2.1**

[31] Qualitative measure

[32] Measured in terms of reduction of likelihood (L), consequence (C) and current risk rating (CRR)

[33] For safety reasons, the distance requirements below are not applied for a vessel holding station or with limited manoeuvrability e.g. anchor handling, loading, back-loading, bunkering, close standby cover for overside working and emergency situations.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[31]***	***Benefit in Impact/Risk Reduction[32]***	***Proportionality***	***Control Adopted***
eight knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark.				
Good Practice				
Fit streamer tail buoys with appropriate turtle guards, or use a design that does not represent an entanglement risk for turtles.	F: Yes. CS: Minimal cost. Standard practice.	Implementing this controls will reduce the likelihood of turtle entanglement.	Control based on legislative requirements – must be adopted.	Yes **C 12.1**
Professional Judgement – Eliminate				
Remove support and chase vessel for the Petroleum Activities Program.	F: No. Support and chase vessel required. CS: Introduces unacceptable safety risk.	Not considered – control not feasible.	Not considered – control not feasible.	No
Professional Judgement – Substitute				
Vary the timing of the Petroleum Activities Program in Areas A and C to avoid the migration periods for humpback whales. Time acquisition of the Pluto and Harmony surveys in Area A, and the Laverda, Cimatti and Vincent surveys in Area C to avoid northbound and southbound and humpback whale migration (June to October).	F: Yes. The surveys will commence in late December 2019 and be completed by July 2020, to avoid the migration seasons for humpback whales. CS: Survey timing planned in advance to avoid disproportionate cost.	Surveys will take place outside the humpback whale northbound and southbound migratory seasons to minimise impacts.	Survey timing planned in advance to avoid disproportionate cost.	Yes **C 3.4**
Vary the timing of the Petroleum Activities Program to avoid migration periods of pygmy blue whales.	F: Yes. CS: Significant cost and schedule impacts due to delays in acquiring data and securing seismic vessel for specific timeframes. The data acquired during the 4D seismic surveys will be used to calibrate subsurface models to assist in de-risking future infill targets and support optimising reservoir offtake strategies.	The pygmy blue whale southbound and northbound migrations have identified short peak periods of migrating individuals within the NWMR. There are short periods of temporal overlap with the Petroleum Activities Program and the potential to encounter northbound pygmy blue whales. With the absence of critical habitats within Areas A, B and C (i.e. feeding, breeding, calving) or a constricted migratory pathway, the extremely small predicted distance from vessel or mechanical	Disproportionate. The cost/sacrifice outweighs the benefit gained. The cost of not acquiring seismic data during this period will result in schedule implications for future production from these fields, and significant additional costs to complete the surveys. More significantly there are greater cost/ sacrifice implications in receiving the data in order to optimise reservoir	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[31]	***Benefit in Impact/Risk Reduction***[32]	***Proportionality***	***Control Adopted***
		equipment noise sources within which behavioural impacts are expected and the control measures proposed, such noise sources are not considered to be ecologically significant at a population level for pygmy blue whales or any other species of large whale that may be encountered during the Petroleum Activities Program.	first production for the Brunello, Laverda and Cimatti fields and to inform profiles over the next few years. Furthermore, it is believed that the adoption of EPBC Regulations 2000 Part 8 Division 8.1 (Regulation 8.05 and 8.06 – Interacting with cetaceans) will achieve an acceptable level of risk reduction in the short period when whales may be present.	
Vary the timing of the Petroleum Activities Program to avoid turtle internesting seasons.	F: Yes. CS: Significant cost and schedule impacts due to delays in acquiring data and securing the seismic vessel for specific timeframes. The data acquired during the 4D seismic surveys will be used to calibrate subsurface models to assist in de-risking future infill targets and support optimising reservoir offtake strategies.	Peak turtle internesting periods at the Montebello/Barrow/ Lowendal Islands, Muiron Islands, North West Cape and Ningaloo Coast extends from spring through to autumn, and to plan the surveys to avoid turtle internesting would mean potentially completing the activities during the humpback whale migration seasons. There is overlap of turtle ‘habitat critical’ in Area A and C. There is no overlap between any ‘habitat critical’ or turtle BIAs with Area B. It is highly unlikely for significant numbers of turtles to be encountered within the offshore Areas A, B and C. Additionally, with the extremely small predicted distance from vessel or mechanical equipment noise sources within which behavioural impacts are expected and the	Disproportionate. The cost/sacrifice outweighs the benefit gained. The cost of not acquiring seismic data during this period will result in schedule implications for future production from these fields, and significant additional costs to complete the surveys. More significantly there are greater cost/ sacrifice implications in receiving the data in order to optimise reservoir first production for the Brunello, Laverda and Cimatti fields and to inform profiles over the next few years.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[31]***	***Benefit in Impact/Risk Reduction[32]***	***Proportionality***	***Control Adopted***
		control measures proposed, such noise sources are not considered to be ecologically significant at a population level for any species of marine turtle that may be encountered during the Petroleum Activities Program.		
Professional Judgement – Engineered Solution				
No additional controls identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks of potential vessel collision with protected marine fauna. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, potential vessel collision with protected marine fauna represents a low residual risk that is unlikely to result in a potential impact greater than a slight and short-term disruption to a small proportion of the population and no impact on critical habitat or activity. Further opportunities to reduce impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meet the requirements of Part 8 (Division 8.1) of the EPBC Regulations 2000. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of potential vessel collision with protected marine fauna to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 11 No vessel strikes with protected marine fauna (whales, whale sharks, turtles) during the Petroleum Activities Program.	**C 2.1** Apply EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans, including the following measures[34]: • Project vessels will not travel greater than six knots within 300 m of a cetacean	**PS 2.1** Compliance with EPBC Regulations 2000 Part 8 Division 8.1 (Regulation 8.05 and 8.06) Interacting with cetaceans to minimise potential for vessel strike.	**MC 2.1.1** Records demonstrate no breaches with EPBC Regulations 2000 Part 8 Division 8.1 Interacting with cetaceans.

[34] For safety reasons, the distance requirements below are not applied for a vessel holding station or with limited manoeuvrability, e.g. anchor handling, loading, back-loading, bunkering, close standby cover for overside working and emergency situations.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
	or turtle (caution zone) and not approach closer than 100 m from a whale. • Project vessels will not approach closer than 50 m for a dolphin or turtle and/or 100 m for a whale (with the exception of animals bow riding). • If the cetacean or turtle shows signs of being disturbed, project vessels will immediately withdraw from the caution zone at a constant speed of less than six knots. • Vessels will not travel greater than eight knots within 250 m of a whale shark and not allow the vessel to approach closer than 30 m of a whale shark.	**PS 11.1** All vessel strike incidents with cetaceans will be reported in the National Ship Strike Database (as outlined in the Conservation Management Plan for the Blue Whale – A Recovery Plan under the EPBC Act 1999, Commonwealth of Australia, 2015).	**MC 11.1.1** Records demonstrate reporting cetacean ship strike incidents to the National Ship Strike Database.
	C 11.1 Fit streamer tail buoys with appropriate turtle guards, or use a design that does not represent an entanglement risk for turtles.	**PS 11.2** Streamer tail-buoys to have appropriate turtle guards, or will be of a design that does not represent an entanglement risk for turtles.	**MC 11.2.1** Pre-Mobilisation Inspection report confirms turtle guards have been fitted appropriately (or are not necessary by design).
	C 3.4 Vary the timing of the Petroleum Activities Program in Areas A and C to avoid the migration periods for humpback whales. Time acquisition of the Pluto and Harmony surveys in Area A, and the Laverda, Cimatti and Vincent surveys in Area C to avoid northbound and southbound and humpback whale migration (June to October).	**PS 3.4** No seismic acquisition for the Pluto and Harmony surveys in Area A, and the Laverda, Cimatti and Vincent surveys in Area C between June and October to avoid northbound and southbound and humpback whale migration.	**MC 3.4.1** Records demonstrate that the Petroleum Activities Program start and finish dates in Areas A and C did not overlap with humpback migration period (June to October).

6.7.7 Physical Presence: Loss or Grounding of Equipment

Context		
Project vessels – **Section 3.6.4**	Biological environment – **Section 4.5** Socio-economic environment – **Section 4.6**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary

Source of Risk	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	***Marine Sediments***	***Water Quality***	***Air Quality (incl. Odour)***	***Ecosystems/Habitats***	***Species***	***Socio-Economic***	***Decision Type***	***Consequence/ Impact***	***Likelihood***	***Current Risk Rating***	***ALARP Tools***	***Acceptability***	***Outcome***
Physical loss or grounding of seismic streamers and/or acoustic source					X		X	A	F	1	**L**	LCS GP	Broadly Acceptable	EPO 12

Description of Source of Risk

The Petroleum Activities Program will include using a seismic vessel to tow 12 hydrophone streamers for most of the surveys, with less hydrophone streamers for the Laverda M1, Cimatti M1 and Vincent 4D M2 surveys. Streamer lengths range between 5 km and 8 km. The streamer(s) will be towed at a depth of approximately 15–18 m (±1 m). Loss of this equipment has the potential to cause minor physical damage to benthic habitats and potentially subsea infrastructure if cables and associated equipment drop to the seabed.

Consequence Assessment

In the unlikely event of damage or loss of seismic streamers and/or acoustic source equipment, potential environmental effects would be limited to physical impacts on benthic communities arising from the cables and associated equipment potentially sinking and being dragged along the seabed. However, the depth range of streamers during tow, and the application of depth control built into the design and planning of the Petroleum Activities Program (including SRDs, **Section 3.6.3**) means the likelihood of direct impact on benthic communities during normal seismic operations is highly unlikely.

The Ancient Coastline at 125 m Depth Contour KEF occurs within Areas A and C. Parts of the ancient coastline, represented as rocky escarpment, are considered to provide biologically important habitat in an area predominantly made up of soft sediment (**Section 4.7.4**).

Areas A, B and C are expected to consist primarily of soft, fine unconsolidated sediments, which are typical of the broader NWMR. As such physical impacts to the seabed are expected to be highly localised, non-significant disturbance to deep water soft sediments. Due to the presence of soft sediments and lack of hard substrate, the seabed is likely to be inhabited by a low abundance of patchy distributions of filter feeders and other epifauna, including mobile epibenthos (e.g. sea cucumbers, ophiuroids, echinoderms, polychaetes and sea-pens) characteristic of the wider NWMR (Brewer et al., 2007).

Impacts to benthic habitats such as shelf and slope habitats, pinnacle and terrace seabed features and the Ancient Coastline KEF are not expected. Any potential impacts as a result of loss or damage to streamers and/or acoustic source equipment would be short term disturbance and are expected to be minimal, as the disturbed areas will be relatively very small and will physically recover. Therefore, anticipated impacts are expected to be low.

Summary of Potential Impacts to Environmental Values(s)

Given the adopted controls, it is considered that a loss of seismic streamers and/or acoustic source equipment to the seabed will not result in a potential impact greater than localised disruption to a small area of the seabed, a small proportion of the benthic population and no impact on critical habitat or activity.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[35]	***Benefit in Impact/Risk Reduction***[36]	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Marine Order 21 (safety of navigation and emergency procedures) 2016, including: • adherence to minimum safe manning levels • maintenance of navigation equipment in efficient working order (compass/radar) • navigational systems and equipment required are those specified in Regulation 19 of Chapter V of SOLAS • AIS that provides other users with information about the vessel's identity, type, position, course, speed, navigational status and other safety-related data.	F: Yes. CS: Minimal cost. Standard practice.	Legislative requirements to be followed may slightly reduce the likelihood of equipment loss or grounding.	Controls based on legislative requirements – must be adopted.	Yes Refer to **C 8.2**
Good Practice				
Deploy, retrieve and operate streamers as per predetermined procedures, including: • Streamer deployment will not occur in water closer than 12 nm to shore, or in waters less than 50 m deep. • Streamers will only be deployed in suitable sea state in accordance with contractor's Matrix of Permitted Operations (MOPO).	F: Yes. CS: Minimal cost. Standard practice.	Implementing these controls will reduce the likelihood of equipment grounding or loss. The consequence is unchanged.	Benefits outweigh cost/sacrifice.	Yes **C 13.1**
Recover and relocate lost towed equipment where safe and practicable to do so.	F: May not always be possible. Assessed case by case.	No reduction in likelihood or consequence would result.	Benefits outweigh cost/sacrifice.	Yes **C 13.2**

[35] Qualitative measure

[36] Measured in terms of reduction of likelihood (L), consequence (C) and current risk rating (CRR)

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)[35]***	***Benefit in Impact/Risk Reduction[36]***	***Proportionality***	***Control Adopted***
	CS: Minimal cost Standard practice.			
Install steerable fins on streamers.	F: Yes. CS: Minimal cost. Standard practice.	Implementing this control will reduce the likelihood of equipment grounding or loss. The consequence is unchanged.	Benefits outweigh cost/sacrifice.	Yes **C 13.3**
Equip streamers with real time monitoring equipment.	F: Yes. CS: Minimal cost. Standard practice.	Implementing this control will reduce the likelihood of equipment grounding or loss. The consequence is unchanged.	Benefits outweigh cost/sacrifice.	Yes **C 13.4**
Activate pressure-activated SRDs within streamers in the event of loss, to bring the equipment to the surface.	F: Yes. CS: Minimal cost. Standard practice.	Implementing this control will reduce the likelihood of equipment grounding or loss. The consequence is unchanged.	Benefits outweigh cost/sacrifice.	Yes **C 13.5**
Professional Judgement – Eliminate				
No additional controls identified.				
Professional Judgement – Substitute				
Use modified short marine towed streamers (approximately 1.5–3 km in length).	F: No. CS: Shorter streamers result in a significant loss of data, especially in deeper waters.	Not considered – control not feasible.	Not considered – control not feasible.	No
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type (i.e. Decision Type A), Woodside considers the adopted controls appropriate to manage the impacts and risks to benthic communities from losing seismic streamers and/or acoustic source equipment to the seabed. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without grossly disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement The impact assessment has determined that, given the adopted controls, potential loss of seismic streamers and/or acoustic source equipment to the seabed represents a low residual risk that may result in a potential localised disruption to a small area of the seabed, a small proportion of the benthic population and no impact on critical habitat or activity. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice and meets legislative requirements under Marine Order 21. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks to marine sediment from dropped objects to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 12 No loss or groundings of	**C 7.2** Marine Order 21 (safety of navigation and emergency procedures) 2016, including:	**PS 7.2** Project vessels compliant with Marine	**MC 7.2.1** Pre-Mobilisation Inspection Report

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
streamers within the Operational Areas for each survey, for the duration of the Petroleum Activities Program.	• adherence to minimum safe manning levels • maintenance of navigation equipment in efficient working order (compass/radar) • navigational systems and equipment required are those specified in Regulation 19 of Chapter V of SOLAS • AIS that provides other users with information about the vessel's identity, type, position, course, speed, navigational status and other safety-related data.	Order 21 (safety of navigation and emergency procedures) 2016 to prevent unplanned interaction with marine users.	confirms maintenance of navigation equipment in working order and AIS installed as required by vessel class in accordance with SOLAS Chapter V (Regulation 19).
	C 12.1 Deploy, retrieve and operate streamers as per predetermined procedures, including: • Streamer deployment will not occur in water closer than 12 nm to shore, or in waters less than 50 m deep. • Streamers will only be deployed in suitable sea state in accordance with contractors Matrix of Permitted Operations (MOPO).	**PS 12.1** To avoid potential for streamer loss or grounding, survey vessels compliant with predetermined procedures on deployment, retrieval, and operation of streamers.	**MC 12.1.1** Records confirm that seismic survey vessel holds procedures for towed equipment.
			MC 12.1.2 A copy of Vessel Masters' signed declaration that they will obey exclusion zones.
			MC 12.1.3 Daily report demonstrates that streamers were deployed in accordance with contractor's MOPO.
	C 12.2 Relocate and recover lost towed equipment recovered where safe and practicable to do so.	**PS 12.2** Lost streamers do not present an entanglement or grounding risk.	**MC 12.2.1** Woodside Event Report form documents last known location of streamers in the event of grounding.
	C 12.3 Install steerable fins on streamers.	**PS 12.3** Ability to control streamer depth.	**MC 12.3.1** Records confirm streamers are fitted with steerable fins.
	C 12.4 Equip streamers with real-time monitoring equipment.	**PS 12.4** Streamer location in relation to the seabed is known at all times.	**MC 12.4.1** Records confirm streamers will be equipped with real-time monitoring equipment.
	C 12.5 Activate pressure-activated SRDs within streamers in the event of loss, to bring the equipment to the surface.	**PS 12.5** Use of SRDs.	**MC 12.5.1** Records confirm streamers are equipped with pressure-activated SRDs.

6.7.8 Physical Presence: Accidental Introduction and Establishment of Invasive Marine Species

Context		
Project vessels – **Section 3.6.4**	Physical environment – **Section 4.4** Biological environment – **Section 4.5**	Stakeholder consultation – **Section 5**

Impacts and Risks Evaluation Summary

Source of Risk	*Environmental Value Potentially Impacted*							*Evaluation*						
	Soil and Groundwater	*Marine Sediments*	*Water Quality*	*Air Quality (incl. Odour)*	*Ecosystems/Habitats*	*Species*	*Socio-Economic*	*Decision Type*	*Consequence/ Impact*	*Likelihood*	*Current Risk Rating*	*ALARP Tools*	*Acceptability*	*Outcome*
Introduction of invasive marine species (IMS)					X	X	X	A	D	0	**L**	**LCS GP**	Broadly Acceptable	EPO 13

Description of Source of Risk

IMS are a subset of Non-indigenous Marine Species (NIMS) that have been introduced into a region beyond their natural biogeographic range, resulting in impacts to social/cultural, human health, economic and/or environmental values. NIMS are species that have the ability to survive, reproduce and establish founder populations. However, not all NIMS introduced into an area will thrive or cause demonstrable impacts. The majority of NIMS around the world are relatively benign and few have spread widely beyond sheltered ports and harbours.

During the Petroleum Activities Program, vessels will be transiting to and from the Operational Areas, potentially including traffic mobilising from beyond Australian waters. There is therefore the potential for project vessels to transfer IMS from either international waters or Australian waters into the Operational Area.

All vessels are subject to some level of marine fouling. Organisms attach to the vessel hull, particularly in areas where organisms can find a good attachment surface (e.g. seams, strainers and unpainted surfaces) or where turbulence is lowest (e.g. niches, sea chests, etc.). Commercial vessels typically maintain anti-fouling coatings to reduce the build-up of fouling organisms. Organisms can also be drawn into ballast tanks during onboarding of ballast water required to maintain safe operating conditions.

During the Petroleum Activities Program, project vessels have the potential to introduce IMS to the Operational Area through biofouling (containing IMS) on vessels, as well as ballast water exchange (as described above). Cross-contamination between vessels can also occur (e.g. IMS translocated between project vessels).

Consequence Assessment

IMS are marine plants or animals that have been introduced into a region beyond their natural range and have the ability to survive, reproduce and establish founder populations. IMS have been introduced and translocated around Australia by a variety of natural and human means including biofouling. Species of concern are those that are not native to the region, are likely to survive and establish in the region, and are able to spread by human mediated or natural means. Species of concern vary from one region to another depending on various environmental factors such as water temperature, salinity, nutrient levels and habitat type. These factors dictate their survival and invasive capabilities.

If successfully established, IMS may result in:

- competition, predation or displacement of native species
- alteration of natural ecological processes
- introduction of pathogens with the potential to impact ecological health.

If established, eradicating IMS populations is difficult, with management options limited to ongoing control or impact minimisation. For this reason, increased management requirements have been implemented in recent years by Commonwealth and State regulatory agencies.

In general, the offshore open waters of the NWS are not conducive to IMS settling and establishing; however, species of concern, if they become established, have the potential to alter the community structure of benthic habitats and have potential for biofouling existing oil and gas infrastructure within the vicinity of the Operational Areas.

Vessels operating in offshore environments are less likely to accumulate or translocate IMS than vessels that spend prolonged periods in shallow port or coastal waters (Commonwealth of Australia, 2009; Wells et al., 2009). Therefore, highly disturbed, shallow water environments such as ports and marinas are more susceptible to colonisation than open-water environments, such as the Operational Areas, where the rate of dilution and the degree of dispersal are high (Williamson and Fitter, 1996). Given the water depths of Areas A, B and C (60 m to 1300 m) and the distance from landfall (>16 km from Area C at the closest point), the introduction and establishment of IMS within Areas A, B and C as a result of survey activities is considered highly unlikely.

Summary of Potential Impacts to Environmental Value(s)

In support of Woodside's assessment of the impacts and risks of IMS introduction associated with the Petroleum Activities Program, Woodside evaluated risks and impacts of the different aspects of a marine pest's translocation. The results of this assessment are presented in **Table 6-23**

As a result of this assessment, Woodside has presented the highest potential consequence as a C and likelihood as Remote (0), resulting in an overall Moderate risk after the identified controls are implemented.

Table 6-25: Evaluation of risks and impacts from marine pest translocation

IMS Introduction Location	Credibility of Introduction	Consequence of Introduction	Likelihood
Introduced to Operational Areas and establish on the seafloor.	**Not Credible** The deep offshore open waters of the Operational Areas are located away from shorelines and/or critical habitat, more than 17 km from a shore and in waters 73–1185 m deep; they are therefore not conducive to the settlement and establishment of IMS.		
Introduced to operational areas and establish on project vessels.	**Credible** There is potential to transfer marine pests between project vessels within the Operational Areas.	**Environment – Not Credible** Translocation of IMS from a colonised project vessel to shallower environments via natural dispersion is not considered credible, given the distances of the Operational Areas from nearshore environments (i.e. greater than 17 km/70 m water depth). There is therefore no credible environmental risk and the assessment is limited to Woodside's reputation and brand. If IMS were to establish on a project vessel, this could potentially impact the vessel operationally by fouling intakes, resulting in translocation of an IMS into the Operational Areas and, depending on the species, potentially transfer of an IMS to other support vessels which would likely result in the vessel being quarantined until eradication could occur (by cleaning and treating infected areas), which would be costly to perform. Such introduction would be expected to have minor impact to Woodside's reputation, particularly with Woodside's contractors, and would likely have a reputational impact on future proposals.	**Remote (0)** Interactions between project vessels will be limited during the Petroleum Activities Program, with a 500 m SNA around the seismic vessel, and interactions limited to short periods of time alongside (i.e. during bunkering activities). There is also no direct contact (i.e. they are not tied up alongside) during these activities. Spread of marine pests via ballast water in these open ocean environments is also considered remote due to the lack of suitable habitat for settlement and establishment.

Transfer between project vessels and by extension from project vessels to other marine environments beyond the Operational Areas (i.e. transfer of IMS from seismic vessel to a support or chase vessel and then to another environment).	**Not Credible** This risk is considered so remote that it is not credible for the purposes of the activity. Transfer of a marine pest between project vessels was already considered remote, given the offshore open ocean environment (i.e. transfer pathway discussed above). For a marine pest to then establish into a mature spawning population on the new project vessel (which would have been through Woodside's IMS process) and then transfer to another environment is considered not credible (i.e. beyond the Woodside risk matrix). Project vessels will be in an offshore, open ocean, deep environment, where IMS survival is implausible. Also, this marine pest, once transferred, would need to survive on a new vessel that has good hygiene (i.e. has been through Woodside's risk assessment process), and survive the transport back from the Operational Area to shore. If it was to survive this trip, it would then need to establish a viable population in nearshore waters.

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[37]	***Benefit in Impact/Risk Reduction***[38]	***Proportionality***	***Control Adopted***
Legislation, Codes and Standards				
Manage project vessels' ballast water using one of the approved ballast water management options, as specified in the Australian Ballast Water Management Requirements.	F: Yes. CS: Minimal cost. Standard practice.	Using an approved ballast water management option will reduce the likelihood of transfer of marine pests between project vessels within the operational area. No change in consequence would occur.	Controls based on legislative requirements under the *Biosecurity Act 2015* – must be adopted.	Yes **C 14.1**
Good Practice				
Apply IMS risk assessment process to project vessels which enter the Operational Areas. Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS inspections or cleaning) will be implemented to minimise the likelihood of introducing IMS.	F: Yes. CS: Minimal cost. Good practice implemented across all Woodside Operations.	The IMS risk assessment process will identify potential risks and additional controls implemented accordingly. In doing so, the likelihood of transfer of marine pests between project vessels within the Operational Areas is reduced. No change in consequence would occur.	Benefits outweigh cost/sacrifice.	Yes **C 14.2**

[37] Qualitative measure.

[38] Measured in terms of reduction of likelihood (L), consequence (C) and current risk rating (CRR).

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[37]	***Benefit in Impact/Risk Reduction***[38]	***Proportionality***	***Control Adopted***
Professional Judgement – Eliminate				
Do not discharge ballast water during the Petroleum Activities Program.	F: No. Ballast water discharges are critical for maintaining vessel stability. Given the nature of the Petroleum Activities Program, using ballast (including the potential discharge of ballast water) is considered to be a safety-critical requirement. CS: Not assessed, control not feasible.	Not assessed, control not feasible.	Not assessed, control not feasible.	No
Eliminate use of vessels.	F: No. Because vessels must be used to implement the project, there is no feasible means to eliminate the source of risk. CS: Loss of the project.	Not assessed, control not feasible.	Not assessed, control not feasible.	No
Professional Judgement – Substitute				
Source project vessels based in Australia only.	F: Potentially. Limiting activities to only use local project vessels could potentially pose a significant risk in terms of time and duration of sourcing a vessel, as well as the ability of the local vessels to perform the required tasks. While the project will attempt to source support vessels locally, it is not always possible. Availability cannot always be guaranteed when considered competing oil and gas activities in the region. Sourcing Australian based vessels only will also cause increases in cost due to pressures of vessel availability. CS: Significant cost and schedule impacts due to restrictions of vessel hire opportunities.	Sourcing vessels from within Australia will reduce the likelihood of IMS from outside Australian waters; however, it does not reduce the likelihood of introducing species native to Australia but alien to the Operational Areas and NWMR, or of IMS that have established elsewhere in Australia. The consequence is unchanged.	Disproportionate. Sourcing vessels from Australian waters may reduce the likelihood of IMS being introduced to the Operational Areas; however, the potential cost of implementing this control is disproportionate to the minor environmental gain (or reducing an already remote likelihood of IMS introduction) potentially achieved by using only Australian based vessels. Consequently, this risk is considered not reasonably practicable.	No
Inspection all vessels for IMS.	F: Yes. Approach to inspect vessels could be a feasible option. CS: Significant cost and schedule impacts. In addition, Woodside's IMS risk assessment process (C 14.2) is seen to be more cost-effective as this	Inspecting all vessels for IMS would reduce the likelihood of IMS being introduced to the Operational Areas. However, this reduction is unlikely to be significant given the other control measures implemented.	Disproportionate. The cost/sacrifice outweighs the benefit gained, as other controls to be implemented achieve an ALARP position.	No

Demonstration of ALARP				
Control Considered	***Control Feasibility (F) and Cost/Sacrifice (CS)***[37]	***Benefit in Impact/Risk Reduction***[38]	***Proportionality***	***Control Adopted***
	control allows Woodside to manage the introduction of marine pests through biofouling, while targeting its efforts and resources to areas of greatest concern.	No change in consequence would occur.		
Professional Judgement – Engineered Solution				
No additional controls identified.				
ALARP Statement On the basis of the environmental risk assessment outcomes and use of the relevant tools appropriate to the decision type, Woodside considers the adopted controls appropriate to manage the impacts and risks of introduced IMS. As no reasonable additional/alternative controls were identified that would further reduce the impacts and risks without disproportionate sacrifice, the impacts and risks are considered ALARP.				

Demonstration of Acceptability
Acceptability Statement
The impact assessment has determined that, given the adopted controls, introduction of IMS to the Operational Areas through ballast water or biofouling on vessels or in-water equipment represents a low residual risk that has a remote likelihood of resulting in a potential impact greater than minor and short term (one to two years) to a small proportion of the benthic community and existing oil and gas activities. Further opportunities to reduce the impacts and risks have been investigated above. The adopted controls are considered good oil-field practice/industry best practice. The potential impacts and risks are considered broadly acceptable if the adopted controls are implemented. Therefore, Woodside considers the adopted controls appropriate to manage the impacts and risks of introducing IMS to the Operational Areas to a level that is broadly acceptable.

Environmental Performance Outcomes, Standards and Measurement Criteria			
Outcomes	***Controls***	***Standards***	***Measurement Criteria***
EPO 13 No introduction and establishment of invasive marine species into the Operational Area as a result of the Petroleum Activities Program.	**C13.1** Manage project vessels' ballast water using one of the approved ballast water management options, as specified in the Australian Ballast Water Management Requirements.	**PS 13.1** Translocating IMS within the vessel's ballast water from high risk locations to the Operational Area is prevented.	**MC 13.1.1** Ballast Water Records System maintained by vessels which verifies compliance against Australian Ballast Water Management Requirements.
	C 13.2 Apply IMS risk assessment process to project vessels which enter the Operational Areas. Based on the outcomes of each IMS risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS inspections or cleaning) will be implemented to minimise the likelihood of introducing IMS.	**PS 13.2** The likelihood of translocating IMS within a vessel's biofouling is minimised.	**MC 13.2.1** Records of IMS Risk Assessments maintained for all project vessels conducting the Petroleum Activities Program.
			MC 13.2.2 Records of management measures which have been implemented where identified through the IMS Vessel Risk Assessment process maintained.

7. IMPLEMENTATION STRATEGY

7.1 Overview

Regulation 14 of the Environment Regulations requires an EP to contain an implementation strategy for the activity. The Implementation Strategy for the Petroleum Activities Program confirms fit-for-purpose systems, practices and procedures are in place to direct, review and manage the activities so environmental risks and impacts are continually being reduced to ALARP and are Acceptable, and that environmental performance outcomes and standards outlined in this EP are achieved.

Woodside, as nominated titleholder, is responsible for ensuring the Petroleum Activities Program is managed in accordance with this Implementation Strategy and the WMS (see **Section 1.9**).

7.2 Systems, Practice and Procedures

All operational activities are planned and performed in accordance with relevant legislation, standards and management measures identified in this EP, and internal environment standards and procedures.

Processes are implemented to verify that:

- controls to manage environmental impacts and risks to ALARP and acceptable are effective
- environmental performance outcomes are met
- standards defined in this EP are complied with.

The systems, practices and procedures that will be implemented are listed in the Performance Standards (PS) contained in this EP. Document names and reference numbers may be subject to change during the statutory duration of this EP and is managed through a changes register and update process.

7.3 Roles and Responsibilities

Key roles and responsibilities for Woodside and Contractor personnel relating to implementing, managing and reviewing this EP are described in **Table 7-1**. Roles and responsibilities for oil spill preparation and response are outlined in **Appendix D** and the Woodside Oil Pollution Emergency Arrangements (Australia).

Table 7-1: Roles and responsibilities

Title (role)	Environmental Responsibilities
Office-based Personnel	
Woodside Project Manager	• Ensure seismic operations are conducted as per this EP and approval conditions. • Ensure sufficient resources are available to implement the management measures in this EP. • Ensure vessel personnel are given an environmental induction as per **Section 7.4.2** of this EP at the start of the survey. • Ensure controls, as detailed in the Performance Standards in this EP are actioned, as required, before the seismic operations commence. • Ensure changes to the survey are communicated to the Woodside Environmental Adviser. • Ensure environmental incident reporting meets regulatory requirements (as outlined in this EP) and Woodside's internal event recording, investigation and learning requirements. • Ensure corrective actions raised from environmental audits/inspections are tracked and closed out.
Woodside Environmental Adviser	• Prepare the environmental component of the relevant Induction package. • Assist with reviewing, investigating and reporting environmental incidents. • Ensure environmental monitoring and inspections/audits are conducted as per the requirements of this EP. • Liaise with relevant regulatory authorities as required. • Assist in preparing external regulatory reports required, in line with environmental approval requirements and Woodside external regulatory reporting obligations. • Monitor and close out corrective actions (Environmental Commitments and Actions Register (eCAR)) identified during environmental monitoring or audits/inspections. • Verify that relevant Environmental Approvals for the activities exist before commencing the activity. • Track compliance with performance outcomes and performance standards as per the requirements of this EP. • Provide advice to relevant Woodside personnel and Contractors to help them understand their environment responsibilities.
Woodside Corporate Affairs Adviser	• Prepare and implement the Stakeholder Consultation Plan for the Petroleum Activities Program. • Report on stakeholder consultation. • Undertake ongoing liaison and notification as required, as per **Section 5.7**.
Woodside Marine Assurance	• Conduct relevant audits, inspections or risk assessments to confirm vessels comply with relevant Marine Orders and Woodside Marine Charters Instructions requirements to meet safety, navigation and emergency response requirements.
Woodside Corporate Incident Coordination Centre (CICC) Duty Manager	• Establish and take control as requested by Contractors during an emergency. • Act as Emergency Response Duty Manager. • Assess the situation, identify risks and actions to minimise the risk, and communicate impact, risk and progress to the Crisis Management Team and stakeholders. • Develop the incident action plan (IAP) including setting priorities for action. • Approve, implement and manage the IAP. • Communicate within and beyond the incident management structure. • Establish procedures to permit control to be exercised. • Manage and review safety of responders. • Address the broader public safety considerations. • Conclude and review activities.

Title (role)	Environmental Responsibilities
Vessel-based Personnel	
Vessel Master	• Ensure the vessel management system and procedures are implemented. • Ensure personnel commencing work on the vessel receive an environmental induction that meets the relevant requirements specified in this EP. • Ensure personnel are competent to perform the work they have been assigned. • Verify SOPEP drills are conducted as per the vessel's schedule. • Ensure the vessel Emergency Response Team has been given sufficient training to implement the SOPEP. • Ensure any environmental incidents or breaches of relevant environmental performance outcomes or performance standards, detailed in this EP, are reported immediately to the Party Chief and Woodside Site Representative.
Party Chief	• Understand and manage environmental aspects of the seismic operations per this EP and approval conditions. • Provide copies of documents, records, reports and certifications (as requested by Woodside) in a timely manner to assist in compliance reporting. • Ensure any environmental incidents or breaches of environmental performance outcomes, performance standards or measurement criteria outlined in this EP, are reported immediately to the Woodside Site Representative and Woodside HSE Adviser.
Woodside Site Representative	• Ensure project personnel adhere to the requirements of this EP so the environmental performance outcomes are met, and the performance standards detailed in this EP are implemented during seismic operations. • Ensure environmental incidents or breaches of outcomes or standards are reported as per the Woodside event notification requirements. Corrective actions for incidents and breaches must be developed, tracked and closed out in a timely manner. • Monitor and close out corrective actions (eCAR) identified during environmental monitoring or audits/inspections. • Ensure any environmental incidents or breaches of environmental performance outcomes, performance standards or measurement criteria outlined in this EP, are reported immediately to the Woodside Project Manager.
Woodside HSE Adviser	• Ensure the environmental performance outcomes and performance standards are undertaken as detailed in this EP. • Support the Party Chief so the environmental performance outcomes are met, and the performance standards detailed in this EP are implemented during seismic operations. • Ensure environmental incidents or breaches of outcomes, standards or criteria, outlined in this EP, are reported as per the Woodside Corporate Event Notification Matrix. • Ensure periodic environmental inspections are completed. • Review Contractors' procedures, input into Toolbox talks and JSAs. • Provide day-to-day environmental support for activities in consultation with the Woodside Environmental Adviser.
Marine Fauna Observer	• Provide training through induction/briefing to all vessel crew likely to assist with marine fauna observations. • Record observations of marine fauna and monitor and report on compliance with acoustic operating requirements.

Title (role)	Environmental Responsibilities
PAM Operator	• Provide overall responsibility for the functioning, calibration and monitoring of the PAM system. • Work closely with MFOs to validate PAM detections against MFO observations and ranges, during daylight hours, in order to determine any error in PAM detection distances. Once a calibration has been established, the PAM operator will trigger shutdown procedures at night and during periods of low visibility when sperm or beaked whales enter the appropriate precaution zones. • Notify the Lead MFO, of any detections, to assess the location of the individual relative to the mitigation zones. If they are found to be within the agreed zones, then the Lead MFO will notify seismic operations, who will then initiate shutdown as appropriate. • Record all observations and mitigation actions.

7.4 Training and Competency

7.4.1 Overview

It is the responsibility of Woodside and its Contractors to ensure all personnel are suitably trained and competent in their respective roles.

Woodside, as part of its contracting process, assesses a proposed Contractor's environmental management system. This assessment is conducted for the Petroleum Activities Program as part of the pre-mobilisation process. The assessment determines whether there is an organisational structure that clearly defines the roles and responsibilities for key positions. The assessment also determines whether there is an up-to-date training matrix that defines any corporate and site/activity-specific environmental training and competency requirements.

As a minimum, environmental awareness training is required for all personnel, detailing awareness and compliance with the Contractor's environmental policy and environmental management system.

7.4.2 Inductions

Inductions are provided to all relevant personnel (Contractor, company representatives, seismic and support vessel crew) before mobilising to or arriving at the activity location. The induction covers the HSE requirements and environmental information specific to the activity type and location. Attendance records will be maintained.

The Petroleum Activities Program induction may cover information about:

- description of the activity
- ecological and socio-economic values of the activity location
- regulations relevant to the activity
- Woodside's Environmental Management System – Health, Safety, Environment and Quality Policy
- EP importance/structure/implementation/roles and responsibilities
- main environmental aspects/hazards and potential environmental impacts and related performance outcomes
- EPBC Act Policy Statement 2.1 requirements for MFOs
- oil spill preparedness and response
- monitoring and reporting on performance outcomes and standards using measurement criteria
- incident reporting.

7.4.3 Petroleum Activities Specific Environmental Awareness

Before the Petroleum Activities Program begins, a Woodside representative will hold a pre-activity meeting with all relevant personnel. The pre-activity meeting provides an opportunity to reiterate specific environmental sensitivities or commitments associated with the activity. Attendance lists are recorded and retained.

During operations, regular HSE meetings will be held on the seismic vessel and support vessel. During these meetings, environmental incidents are reviewed and awareness material presented.

Additional materials are to be provided to project personnel as required to facilitate/support compliance with performance standards and collection of data related to measurement criteria. Fauna Observation Kits will be available on project vessels to help personnel identify marine fauna associated reporting requirements.

7.4.4 Management of Training Requirements

All personnel on the seismic vessel and support vessel are required to be competent to perform their assigned positions. This may be in the form of external or 'on-the-job' training. The vessel Safety Training Coordinator (or equivalent) is responsible for identifying training needs, keeping records of training undertaken and identifying minimum training requirements.

7.5 Monitoring, Auditing, Management of Non-conformance and Review

7.5.1 Monitoring

Woodside and its Contractors will conduct a program of periodic monitoring during the Petroleum Activities Program – starting at mobilisation and continuing through the duration of the Petroleum Activities Program to activity completion. This information will be collected using the tools and systems outlined below, developed based on the environmental performance outcomes, standards and measurement criteria in this EP. The tools and systems will collect, as a minimum, the data (evidence) referred to in the measurement criteria in **Section 6.6** and **Section 6.7** and **Appendix D**.

The collection of this data (against the measurement criteria) will form part of the permanent record of compliance maintained by Woodside. It will form the basis for demonstrating that the environmental performance outcomes and standards are met, which will be summarised in a series of routine reporting documents.

7.5.1.1 Source-based Impacts and Risks

Environmental performance, where relevant, will be monitored via:

- daily reports which include leading indicator compliance
- periodic review of waste management and recycling records
- use of vessel's risk identification program that requires personnel on the vessel to record and submit safety and environment risk observation cards on a routine basis (frequency varies with Contractor)
- collection of evidence of compliance with the controls detailed in the EP relevant to offshore activities by the Woodside HSE Adviser (other compliance evidence is collected onshore)
- environmental discharge reports that record volumes of planned and unplanned discharges to ocean and atmosphere
- internal auditing and assurance program as described in **Section 7.5.2**.

Throughout this activity, Woodside will continuously identify new source-based risks and impacts through the monitoring and auditing systems and tools.

7.5.2 Auditing/Inspections

Environmental performance audits/inspections will be conducted to:

- Identify changes to existing or potential new environmental impacts and risk, and methods for reducing those to ALARP

- confirm that mitigation measures detailed in this EP are effectively reducing environmental impacts and risk, that mitigation measures proposed are practicable and provide appropriate information to verify compliance
- confirm compliance with the commitments (Performance Outcomes, Controls and Standards) detailed in this EP.

Internal audits, inspections and reviews will be conducted to review the environmental performance of the activities, specifically:

- pre-mobilisation inspection/audit report on seismic vessel prepared by a relevant person (before completing the survey mobilisation)
- marine assurance inspection/audit report (before completing the survey mobilisation)
- periodic reviews.

The internal audits/inspections and reviews, combined with the ongoing monitoring described in **Section 7.5.1**, and collection of evidence for measurement criteria are used to assess environmental performance outcomes and standards.

As part of Woodside's EMS and/or assurances processes, activities are periodically selected for environmental audits as per Woodside's internal auditing process.

Audit, inspection and review findings relevant to continuous improvement of environmental performance are tracked through the Environmental Commitments and Actions Register. This eCAR is used to track subsea support vessel and subsea activity compliance with EP commitments, including any findings and corrective actions.

Non-conformances identified will be reported and/or tracked in accordance with **Section 7.5.4**.

7.5.3 Marine Assurance

Woodside's marine assurance process is managed by the Marine Assurance Team of the Marine Services Group. The Woodside process is based on industry standards and consideration of guidelines and recommendations from recognised industry organisations such as Oil Companies International Marine Forum and International Maritime Contractors Association.

The process is mandatory for all vessels hired for Woodside operations, including for short term-hires (i.e. <3 months in duration). It defines applicable marine offshore assurance activities, ensuring all vessel operators operate seaworthy vessels that meet the requirements for a defined scope of work and are managed with a robust safety management system.

The process is multi-faceted and encompasses the following marine assurance activities:

- offshore vessel safety management system assessment (OVMSA)
- offshore vessel inspection (OVID)
- project support for tender review, evaluation, pre/post contract award.

OVID inspections are objective in nature and reflect what was observed by the Inspector while conducting the inspection. The inspection provides observations as opposed to non-conformities.

Where an OVID inspection and/or OVMSA Verification Review is not available and all reasonable efforts based on time and resource availability to complete an OVID inspection and/or OVMSA Verification Review are performed (i.e. short term vessel hire), the Marine Assurance Specialist Offshore may approve the use of an alternate means of inspection, known as a risk assessment.

7.5.3.1 Risk Assessment

Woodside conducts a risk assessment of vessels where either an OVMSA Verification Review and/or an OVID inspection cannot be completed. This is not a regular occurrence and is typically used when the requirements of the assurance process are unable to be met or the processes detailed are not applicable to a proposed vessel(s).

The risk-assessment is a semi-quantitative method of determining what further assurance process activity, if any, is required to assure a vessel for a particular task or role. The process compares the level of management control a vessel is subject to against the risk factors associated with the activity or role.

Several factors are assessed as part of a vessel risk assessment, including:

- management control factors:

company audit score (i.e. management system)

vessel HSE incidents

vessel Port State Control deficiencies

instances of Port State Control vessel detainment

years since previous satisfactory vessel inspection

age of vessel

contractors' prior experience operating for Woodside.

- activity risk factors:

health and safety risks (a function of the nature of the work and the area of operation)

environmental risks (a function of environmental sensitivity, activity type and magnitude of potential environment damage (e.g. largest credible oil spill scenario))

value risk (likely time and cost consequence to Woodside if the vessel becomes unusable)

reputation risk

exposure (i.e. exposure to risk based on duration of project)

industrial relations risk.

The acceptability of the vessel or requirement for further vessel inspections or audits is based on the ratio of vessel score to activity risk. If the vessel management control is not deemed to appropriately manage activity risk, then a satisfactory company audit and/or vessel inspection may be required before awarding work.

The risk assessment is valid for the period a vessel is on hire and for the defined scope of work.

7.5.4 Management of Non-conformance

Woodside classifies non-conformances with environmental performance outcomes and standards in this EP as 'environmental incidents'. Woodside employees and Contractors are required to report all environmental incidents, which are managed as per Woodside's internal event recording, investigation and learning requirements.

An internal computerised database called First Priority is used to record and report these incidents. Details of the event, immediate action taken to control the situation, investigation outcomes and corrective actions to prevent reoccurrence are all recorded. Corrective actions are monitored using First Priority and closed out in a timely manner.

Woodside uses a consequence matrix for classifying environmental incidents, with the significant categories being A, B and C (as detailed in **Section 2.6**). Detailed investigations are completed for all category A, B, C and high potential environmental incidents.

7.5.5 Management Review

Within the Environment function, senior management regularly monitors and reviews environmental performance and the effectiveness of managing environmental risks and performance. Within the Geotechnical Organisation function, Leadership Team managers regularly review environmental performance.

Risks are also reviewed before each survey activity starts, including operational, safety and environmental risks of the Petroleum Activities Program, to support continuous improvement as outlined in the Woodside Risk Management Framework (**Section 2.2**).

7.5.6 Learning and Knowledge Sharing

Learning and knowledge sharing occurs via a number of different methods including:

- HSE meetings
- event investigations
- event bulletins
- 'after action' reviews conducted at the end of each survey, including review of relevant environmental incidents
- ongoing communication with seismic vessel operators
- formal and informal industry benchmarking
- cross asset learnings
- Engineering and Technical Authorities discipline communications and sharing.

7.6 Environment Plan Management of Change and Revision

Management of changes relevant to this EP concerning the scope of the activity description (**Section 3**), including: review of advances in technology at stages where new equipment may be selected such as vessel contracting; changes in understanding of the environment, including all current advice from DoEE on species protected under EPBC Act and current requirements for Australian Marine Parks (**Section 4**); and potential new advice from external stakeholders (**Section 5**), will be managed in accordance with Regulation 17 of the Environment Regulations.

Risk will be assessed in accordance with the Environmental Risk Management Methodology (**Section 2.2**) to determine the significance of any potential new environmental impacts or risks not provided for in this EP. Risk assessment outcomes are reviewed in compliance with Regulation 17 of the Environment Regulations.

Minor changes where a review of the activity and the environmental risks and impacts of the activity do not trigger a requirement for a revision, under Regulation 17 of the Environment Regulations, will be considered a 'minor revision'. Minor administrative changes to this EP, where an assessment of the environmental risks and impacts is not required (such as document references and phone numbers), will also be considered a 'minor revision'. Minor revisions as defined above will be made to this EP using Woodside's document control process. Minor revisions will be tracked in a Management of Change register to ensure visibility of cumulative risk changes, as well as enable internal EP updates/reissuing as required. This document will be made available to NOPSEMA during regulator environment inspections.

7.7 Record Keeping

Compliance records (outlined in Measurement Criteria in **Section 6**) will be maintained.

Record keeping will be in accordance with Regulation 14(7) which addresses maintaining records of emissions and discharges.

7.8 Reporting

To meet the environmental performance outcomes and standards outlined in this EP, Woodside reports at a number of levels, as outlined in the next sections.

7.8.1 Routine Reporting (Internal)

7.8.1.1 Daily Progress Reports and Meetings

Daily reports for project activities are prepared and issued to key support personnel and stakeholders, by relevant managers responsible for the project. The report provides performance information about project activities, HSE, and current and planned work activities.

Meetings between key personnel are used to transfer information, discuss incidents, agree plans for future activities and develop plans and accountabilities for issue resolution.

7.8.1.2 HSE Meetings

Regular dedicated HSE meetings are held with the offshore and Perth-based management and advisers to address targeted HSE incidents and initiatives. Minutes of these meetings are produced and distributed as appropriate.

7.8.1.3 Performance Reporting

Performance reports are developed and reviewed by the Leadership Teams. These reports cover a number of subjects, including:

- HSE incidents (including high potential incidents and those related to this EP) and recent activities
- corporate Key Performance Indicator targets, which include environmental metrics
- outstanding actions as a result of audits/inspections or incident investigations
- technical high and low lights.

7.8.2 Routine Reporting (External)

7.8.2.1 Start and End Notifications of the Petroleum Activities Program

In accordance with Regulation 29 of the Environment Regulations, Woodside will notify NOPSEMA and DMIRS of the commencement of the Petroleum Activities Program at least ten days before the activity commences, and will notify NOPSEMA and DMIRS within ten days of completing the activity.

7.8.2.2 Other External Notifications

Prior to the commencement of the Petroleum Activity Woodside will Notify AHS to generate MSIN and NTM – navigation warning.

AMSA RCC will also be notified of the commencement of the Petroleum Activities Program.

DNP require notification to marineparks@environment.gov.au:

- When the EP is approved by NOPSEMA.
- at least 10 days prior to activities occurring within the Montebello or Gascoyne Marine Parks (excluding transiting) and upon conclusion of that activity.

7.8.2.3 Environmental Performance Review and Reporting

In accordance with applicable environmental legislation for the activity, Woodside is required to report information about environmental performance to the appropriate regulator. Regulatory reporting requirements are summarised in **Table 7-2**.

Table 7-2: Routine external reporting requirements

Report	Recipient	Frequency	Content
Monthly Recordable Incident Reports (Appendix E)	NOPSEMA	Monthly, by the 15th of each month.	Details of recordable incidents that have occurred during the Petroleum Activities Program for the previous month (if applicable).
Environmental Performance Report	NOPSEMA	After completing all activity close-out actions and documentation. Within three months of completing the activity.	In accordance with the Environment Regulations, the report will address compliance with environmental performance outcomes and achieving standards outlined in this EP.

7.8.2.4 End of the Environment Plan

The EP will end when Woodside notifies NOPSEMA that the Petroleum Activities Program has ended and all of the obligations identified in this EP have been fulfilled, and NOPSEMA has accepted the notification, in accordance with Regulation 25A of the Environment Regulations.

7.8.3 Incident Reporting (Internal)

Woodside has a defined process for reporting incidents internally. Woodside's Project Manager is responsible for ensuring reporting of environmental incidents meets the internal reporting requirements as defined in the Woodside HSE event notification matrix.

7.8.4 Incident Reporting (External) – NOPSEMA Reportable and Recordable

7.8.4.1 Reportable Incidents

A reportable incident is defined under Regulation 4 of the Environment Regulations as:

- *"an incident relating to the activity that has caused, or has the potential to cause, moderate to significant environmental damage".*

A reportable incident for the Petroleum Activities Program is:

- an incident that has caused environmental damage with a Consequence Level of Moderate (C) or above, as defined under Woodside's Risk Matrix (refer to **Table 2-3**)
- an incident that has the potential to cause environmental damage with a Consequence Level of Moderate (C) or above, as defined under Woodside's Risk Matrix (refer to **Table 2-3**).

The environmental risk assessment (**Section 6**) for the Petroleum Activities Program identifies those risks with a potential consequence level of Moderate (C) or above for environment. The incidents that have the potential to cause this level of impact include:

- accidental Introduction of IMS associated with ballast water transfer
- accidental transportation of IMS via vessel hull, internal niches or in-water equipment.
- Accidental hydrocarbon release as a result of vessel collision.

Any such incidents represent potential events which would be reportable incidents. Incidents are reported in consideration of NOPSEMA (2014) guidance stating, "if in doubt, notify NOPSEMA', and assessed case-by-case to determine if they trigger a reportable incident as defined in this EP and by the Regulations.

Notification

NOPSEMA will be notified of all reportable incidents, according to the requirements of Regulations 26, 26A and 26AA of the Environment Regulations. Woodside will:

- report all reportable incidents to the regulator (orally) as soon as practicable, but within two hours of the incident or of its detection by Woodside
- provide a written record of the reported incident to NOPSEMA, the National Offshore Petroleum Titles Administrator and the Department of the responsible State Minister (DMIRS) as soon as practicable after the oral reporting of the incident.
- complete a written report for all reportable incidents using a format consistent with the NOPSEMA Form FM0831 – Reportable Environmental Incident (**Appendix E**) which must be submitted to NOPSEMA as soon as practicable, but within three days of the incident or of its detection by Woodside
- provide a copy of the written report to the National Offshore Petroleum Titles Administrator and DMIRS, within seven days of the written report being provided to NOPSEMA.

DoE will be notified in accordance with requirements of the EPBC Act.

7.8.4.2 Recordable Incidents

A recordable incident is defined under Regulation 4 of the Environment Regulations as an incident arising from the activity that:

- *“breaches an environmental performance outcome or environmental performance standard, in the EP that applies to the activity, that is not a reportable incident.”*

Notification

NOPSEMA will be notified of all recordable incidents, according to the requirements of Regulation 26B(4), not later than 15 days after the end of the calendar month using the NOPSEMA Form – Recordable Environmental Incident Monthly Summary Report **(Appendix E**) detailing:

- a record of all recordable incidents that occurred during the calendar month
- all material facts and circumstances concerning the recordable incidents that the operator knows or is able, by reasonable search or enquiry, to find out
- any action taken to avoid or mitigate any adverse environment impacts of the recordable incidents
- the corrective action that has been taken, or is proposed to be taken, to prevent similar recordable incidents
- the action that has been taken, or is proposed to be taken, to prevent a similar incident occurring in the future.

7.8.4.3 Other External Incident Reporting Requirements

In addition to the notification and reporting of environmental incidents defined under the Environment Regulations and Woodside requirements, **Table 7-3** describes the incident reporting requirements that also apply in the Operational Areas.

For oil spill incidents, other agencies and organisations will be notified as appropriate to the nature and scale of the incident, as per procedures and contact lists in the Oil Pollution Emergency Arrangements (Australia) and the Oil Pollution First Strike Plan.

Table 7-3: AMSA and DoEE External incident reporting requirements

Incident	Responsible	Notifiable party	Notification Requirements	Contact	Contact Details
Any marine incidents during Petroleum Activities Program, as per AMSA requirements	Vessel Master	AMSA	Incident Alert Form 18 as soon as reasonably practicable*. Within 72 hours after becoming aware of the incident, submit Incident Report Form 19.	AMSA	reports@amsa.gov.au
Oil pollution incident in Commonwealth water	Vessel Master	AMSA	Without delay as per *Protection of the Sea Act*, part II, section 11(1). Verbally notify AMSA RCC of the hydrocarbon spill. Follow up with a written Pollution Report as soon as practicable after verbal notification.	Response Coordination Centre (RCC)	Phone: 1800 641 792 or +61 2 6230 6811 AFTN: YSARYCYX
Any oil pollution incident which has the potential to enter a National Park or requires oil spill response activities to be conducted within a National Park	Woodside	Department of Environment and Energy	Reported verbally, as soon as practicable.	Director of National Parks	Phone: 02 6274 2220
Activity causing unintentional death of or injury to fauna species listed as Threatened or Migratory under the EPBC Act	Woodside	Department of Environment and Energy	Within 7 days of becoming aware.	Secretary of the Department of Sustainability, Environment, Water, Population and Communities	Phone: +61 2 6274 1111 Email: EPBC.Permits@environment.gov.au

7.9 Emergency Preparedness and Response

7.9.1 Overview

Under Regulation 14(8) the implementation strategy must contain an oil pollution emergency plan and provide for updating the OPEP. Regulation 14(8AA) outlines the requirements for the OPEP which must include adequate arrangements for responding to and monitoring oil pollution.

A summary of how this EP and supporting documents address the various requirements of Environment Regulations relating to oil pollution response arrangements is shown in **Table 7-4**.

Table 7-4: Oil pollution and preparedness and response overview

Document/Section Reference	Environment Regulations Addressed	Relevant Content
North-west Australia 4D Marine Seismic Survey Environment Plan	Regulations 13(5) and (6) Regulations 14(3), (8), (8A), (8B) and (8C)	• Description of the OPEP. • Details of (oil pollution response) control measures that will be used to reduce the impacts and risks of the activity to ALARP and an acceptable level. • Details of the arrangements for updating and testing the oil pollution response arrangements.
Oil Spill Preparedness and Response Mitigation Assessment for North-west Australia 4D Marine Seismic Survey (Australia)	Regulations 13(5) and (6) Regulations 14(3), (8), (8A), (8AA), (8B), (8C) and (8D)	• Description of the OPEP. • Details of (oil pollution response) control measures that will be used to reduce the impacts and risks of the activity to ALARP and an acceptable level. • Details of the arrangements for responding to and monitoring oil pollution (to inform response activities), including control measures. • Details of the arrangements for updating and testing the oil pollution response arrangements. • Details of provision, monitoring impacts to the environment from oil pollution and response activities.
Oil Pollution Emergency Arrangements (Australia)	Regulations 14(8) and (8E).	• Description of the OPEP. • Demonstration that the oil pollution response arrangements are consistent with the national system for oil pollution preparedness and control.
North-west Australia 4D Marine Seismic Survey Oil Pollution First Strike Plan	Regulations 14(8) and (8AA)	• Description of the OPEP. • Details the arrangements for responding to and monitoring oil pollution (to inform response activities), including control measures.

7.9.2 Emergency Response Preparation

The Corporate Incident Coordination Centre, based in Woodside's head office in Perth, is the onshore coordination point for an offshore emergency. The CICC is staffed by an appropriately skilled team available on call 24 hours a day. The CICC, under the leadership of the CICC Duty Manager, supports the site-based Incident Management Team by providing, operations, logistics, planning, people management and public information (corporate affairs) support. A description of Woodside's Incident Command Structure and arrangements is further detailed in the Woodside Oil Pollution Emergency Arrangements (Australia) document.

An Emergency Response Plan will be drafted for the Petroleum Activities Program covered by this EP. The Emergency Response Plan will contain instructions for vessel emergency, medical emergency, search and rescue, reportable incidents, incident notification, contact information and activation of the Contractor’s emergency centre and Woodside Communication Centre.

In an emergency of any type, the Vessel Master will assume overall onsite command and act as the Incident Controller (IC). All persons aboard the vessel will be required to act under the IC’s directions. The vessel will maintain communications with the onshore Project Manager and/or other emergency services. Emergency response support can be provided by the Contractor’s emergency centre or Woodside Communication Centre if requested by the IC.

The survey vessels will have on-board equipment for responding to emergencies including medical, firefighting and hydrocarbon spill response equipment.

7.9.3 Oil and Other Hazardous Materials Spill

A significant hydrocarbon spill during the proposed Petroleum Activities Program is highly unlikely, but should such an event occur, it has the potential to cause a serious environmental and reputational damage if not managed properly. The Woodside Oil Pollution Emergency Arrangements (Australia) document, supported by the North-west Australia 4D Seismic Campaign – Oil Pollution First Strike Plan, provide tactical response guidance to the activity/area. Spill response for this Petroleum Activities Program is described further in **Appendix D**.

The Oil Spill Preparedness Manager is responsible for managing Woodside’s oil spill response equipment, and for maintaining oil spill preparedness and response documentation.

In a major spill, Woodside will request that AMSA (administrator of the National Plan) supports Woodside through advice and access to equipment, people and liaison. The interface and responsibilities, as defined under the National Plan, are described in the Woodside Oil Pollution Emergency Arrangements (Australia) document. AMSA and Woodside have a Memorandum of Understanding in place to support Woodside in the event of an oil spill.

The North-west Australia 4D Seismic Campaign – Oil Pollution First Strike Plan provides immediate actions required to commence a response.

The seismic vessel and support vessel will have SOPEPs in accordance with the requirements of MARPOL 73/78 Annex I. These plans outline responsibilities, specify procedures and identify resources available in the event of a hydrocarbon or chemical spill from vessel activities. The Oil Pollution First Strike Plan is intended to work in conjunction with the SOPEPs, if hydrocarbons are released to the marine environment from a vessel.

Woodside has established environmental performance outcomes, performance standards and measurement criteria to be used for oil spill response during the Petroleum Activities Program, as detailed in **Appendix D**.

7.9.4 Emergency and Spill Response Drills and Exercises

Testing of Woodside’s capability to respond to incidents will be conducted in alignment with Woodside’s emergency management and crisis management processes. The North-west Australia 4D Seismic Campaign testing arrangements are presented in **Table 7-5**.

The company emergency response testing regime is aligned to existing or developing risks associated with Woodside’s operations and activities. Corporate hazards/risks outlined in the corporate risk register, respective Safety Cases or project Risk Registers, are the key reference point for developing emergency management and crisis management exercises. External participants who may be invited to attend crisis exercises include government agencies, specialist service providers, oil spill response organisations or industry members with which we have mutual aid arrangements.

The objective is to exercise procedures, skills and teamwork of the Emergency Response and Command Teams in their ability to respond to emergency situations. After each exercise, the team holds a debrief session, during which the exercise is reviewed. Any lessons learnt or areas for improvement are identified and incorporated into emergency procedures where appropriate.

Table 7-5: Testing of response capability to incidents

Incident Type	Response Testing
Incident types that can be resolved by using existing resources, equipment and personnel. Incident is contained, controlled and resolved by site/regionally based teams using existing resources and functional support services.	At least one oil spill response drill to be conducted per survey activity and covered during inductions. This drill should test elements of the recommended response identified in the North-west Australia 4D Seismic Campaign – Oil Pollution First Strike Plan in relation to the level of the incident.

7.9.4.1 Testing of Oil Spill Response Arrangements

There are a number of arrangements which in the event of a spill will underpin Woodside's ability to implement a response across its petroleum activities. To ensure each of these arrangements is adequately tested, the Security and Emergency Management Capability and Development Team ensures tests are conducted in alignment with Woodside's testing schedule.

Woodside's testing schedule aligns with international good practice for spill preparedness & response management; the testing is compatible with the IPIECA Good Practice Guide and the Australian Emergency Management Institute Handbook.

The schedule identifies the type of test which will be conducted annually for each arrangement, and how this type will vary over a five year rolling schedule. Testing methods may include audits, drills, field exercises, functional workshops, assurance reporting, assurance monitoring and reviews of key external dependencies.

Activity-specific Oil Spill Pollution First Strike Plans are developed to meet the response needs of that particular activity's Worst Credible Spill Scenario. The ability to implement these plans may rely on specific arrangements or those common to other Woodside activities. Regardless of their commonality, each arrangement will be tested in at least one of the methods annually. The activity-specific Hydrocarbon Pollution First Strike Plan will be tested in alignment with **Table 7-5**. This ensures personnel are familiar with spill response procedures, reporting requirements, and roles/responsibilities.

At the completion of testing a report is produced to demonstrate the outcomes achieved against the tested objectives. The report will include the lessons learned, any improvement actions and a list of the participants. Alternatively an assurance report, assurance records, or audit report may be produced. These reports record findings and include any recommendations for improvement. Improvement actions and their close-out are actively recorded and managed.

7.9.5 Cyclone and Dangerous Weather Preparation

The Petroleum Activities Program is scheduled to potentially commence in Quarter 4 of 2019 which is towards the beginning of the cyclone season (November to April, with most cyclones occurring between January and March). The Contractor must have a Cyclone Contingency Plan (CCP) in place outlining the processes and procedures that would be implemented during a cyclone event, which will be reviewed for acceptability by Woodside.

The project vessels will receive daily forecasts from the BoM. If a cyclone (or severe weather event) is forecast, the path and its development will be plotted and monitored using the BoM data. If there is the potential for the cyclone (severe weather event) to affect the Petroleum Activities Program, the CCP will be actioned. If required, vessels can transit from the proposed track of the cyclone (severe weather event).

7.10 Implementation Strategy and Reporting of Performance Outcomes, Standards and Measurement Criteria

Table 7-6 summarises the environmental performance outcomes, performance standards and measurement criteria for the implementation strategy and reporting.

Table 7-6: Implementation strategy and reporting of environmental performance outcomes, performance standards and measurement criteria

Implementation Strategy (IS) Performance Objective	Implementation Strategy Performance Standard	Implementation Strategy Measurement Criteria
PO IS-1 All crew will be aware of their roles and responsibilities regarding environmental risks throughout the Petroleum Activities Program.	**PS IS-1.1** All personnel are required to attend an induction before commencing work. These inductions cover health, safety and environmental requirements for the seismic vessel and support vessel and environmental information specific to the Petroleum Activities Program location.	**MC IS-1.1** Induction attendance records.
	PS IS-1.2 A pre-activity meeting will be held with relevant personnel before conducting the Petroleum Activities Program, focusing on any specific environmental sensitivities associated with the seismic survey.	**MC IS-1.2** Pre-activity meeting attendance records and minutes.
	PS IS-1.3 During operations and regular HSE meetings will be held on the seismic vessel and support vessel. Environmental incidents will be reviewed and awareness material presented regularly.	**MC IS-1.3** Attendance is recorded and lists retained on the seismic vessel.
	PS IS-1.4 The vessel contractor must have a CCP accepted by Woodside and in place, outlining the processes and procedures that would be implemented during a cyclone event.	**MC IS-1.4** Record of Woodside-approved Contractor CCP in place prior to activities commencing.
PO IS-2 Woodside and its Contractors will perform a program of periodic auditing/inspections to review the environmental performance of the activities during the Petroleum Activities Program – starting at mobilisation of each activity and continuing through the duration of each activity to activity completion.	**PS IS-2.1** This information will be collected using the tools and systems outlined in **Section 7.5**, developed based on the environmental performance outcomes, standards and measurement criteria in this EP.	**MC-IS 2.1** Monitoring reports.
	PS IS-2.2 Pre-mobilisation inspection/audit report on seismic vessel prepared by a relevant person.	**MC-IS 2.2** Pre-mobilisation Inspection/Audit Report.
	PS IS-2.2 Periodic inspections will be performed on the seismic vessel to review environmental performance.	**MC-IS 2.2** Periodic inspection report, daily progress reports.

Implementation Strategy (IS) Performance Objective	Implementation Strategy Performance Standard	Implementation Strategy Measurement Criteria
PO IS-3 All external reporting requirements relevant to this EP will be met.	**PS IS-3.1** Woodside will submit an environmental performance report to NOPSEMA.	**MC IS-3.1** Record of submission of environmental performance reports to NOPSEMA.
PO IS-4 All external notification requirements, as applicable, to this EP will be met.	**PS IS-4.1** Woodside will notify NOPSEMA and DMIRS of the commencement of the Petroleum Activities Program at least ten days before the activity commences. Woodside will notify NOPSEMA and DMIRS within ten days of completing the activity.	**MC IS-4.1** Record of notification to NOPSEMA. Record of notification to DMIRS.
	PS IS-4.2 Woodside will notify AHS to generate MSIN and NTM – navigation warning.	**MC IS-4.2** Records demonstrate that AHS has been notified before each activity commences, no less than two weeks, to generate MSIN and NTM, and that these have been issued.
	PS IS-4.3 AMSA RCC is notified of the Petroleum Activities Program.	**MC IS-4.3** Records demonstrate AMSA RCC notified of the Petroleum Activities Program.
	PS IS-4.4 The EP will end when Woodside notifies NOPSEMA that the Petroleum Activities Program has ended and all of the obligations identified in this EP have been completed, and NOPSEMA has accepted the notification, in accordance with Regulation 25A.	**MC IS-4.4** Record of notification to NOPSEMA.
	PS IS-4.5 NOPSEMA will be notified of all reportable incidents, according to the requirements of Regulations 26, 26A and 26AA of the Environment Regulations.	**MC IS-4.5.1** Record of notifications to NOPSEMA.
	PS IS-4.6 DoEE (if MNES affected) will be notified of oil spill incidents as soon as practicable following the occurrence.	**MC IS-4.6.1** Record of notification to DoEE (if MNES affected).
	PS IS-4.7 Any oil pollution incidents in Commonwealth waters will be reported without delay (by the Vessel Master) to AMSA RCC as per the *Protection of the Sea (Prevention of Pollution from Ships) Act*, Part II, Section 11(1). The verbal report shall be made via the national emergency 24-hour notification contact, and if AMSA requests a written report, it should be provided within 24 hours of AMSA's request.	**MC IS-4.7.1** Records of notification to AMSA.

Implementation Strategy (IS) Performance Objective	Implementation Strategy Performance Standard	Implementation Strategy Measurement Criteria
	PS IS-4.8 Woodside will provide a cetacean sightings/interactions report to DoE as per the EPBC Act Policy Statement 2.1.	**MC IS-4.8** Record of submission of cetacean sightings/interactions report to DoE.
	PS IS-4.9 DPIRD (formerly DoF), peak fishing bodies and known regional commercial fishing operators identified in this EP will be notified before and upon completing the proposed activity, including vessel details.	**MC IS-4.9** Records of notification to the DPIRD, peak fishing bodies and known commercial regional fishing operators identified in this EP.
	PS IS-4.10 AMSA will be notified of any marine incidents during Petroleum Activities Program, as per AMSA requirements.	**MC IS-4.10** Records of notification to AMSA.
	PS IS-4.11 The Director of National Parks will be notified of any oil pollution incident which has the potential to enter a National Park or requires oil spill response activities to be undertaken within a National Park.	**MC IS-4.11** Records of notification to Director of National Parks.
	PS IS-4.12 DNP to be notified of EP approval and at least 10 days prior to commencement of, and on completion of, activities within Marine Parks.	**MC IS-4.12** Records of notification to Director of National Parks.
PO IS-5 Unplanned emissions and discharges will be documented and records maintained.	**PS IS-5.1** The volumes of unplanned emissions and discharges that could result from the risks described in **Section 6.7.2** are documented through the completion of an event report form.	**MC IS-5.1** Records of completed forms for unplanned emissions and discharges.
PO IS-6 Personnel holding responsibilities in a response will test the arrangements supporting the activities OPEP to ensure they are effective and communicated.	**PS IS-6.1** Exercises will be conducted in alignment with the frequency identified in **Table 7-5**. These arrangements are conducted in accordance with Regulation 14 (8B) of the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*: • Arrangements will be tested when introduced. • Arrangements will be tested when the OPEP is significantly amended, and further testing will occur if a new activity location is added to the EP.	**MC IS-6.1** Spill response exercise reports and key participants maintained in the Woodside IMS system.

Implementation Strategy (IS) Performance Objective	Implementation Strategy Performance Standard	Implementation Strategy Measurement Criteria
	PS IS-6.2 Post-exercise reports will be developed for each exercise to measure performance against the objectives and the learnings from the plan updated in the OPEP following these learnings.	**MC IS-6.2** Spill response exercise reports and key participants maintained in the Woodside IMS system. Records managed in Hydrocarbon Spill Preparedness Unit (HSPU) Testing of Arrangements Register.
	PS IS-6.3 Close out of HSPU actions from exercising will be managed in the HSPU Testing of Arrangements Register.	**MC IS-6.3** Records managed in HSPU Testing of Arrangements Register.
PO IS-7 Woodside will ensure the arrangements supporting the activities OPEP are validated, revising the activities OPEP at least every five years.	**PS IS-7.1** Activity OPEPs will be revised at a least every five years in accordance with the Woodside Hydrocarbon Spill Preparedness and Response Procedure.	**MC IS-7.1** OPEP current and available.
PO IS-8 The OPEP will only be updated under specific circumstances to ensure the information is current.	**PS IS-8.1** Relevant documents from the OPEP will be reviewed when: • implementing an improved preparedness measure • the availability of equipment stockpiles changes • the availability of personnel changes that reduces or improves preparedness and the capacity to respond • a new or improved technology is introduced that may be considered in a response for this activity • incorporating, where relevant, lessons learned from exercises or events • national or state response frameworks and Woodside's integration with these frameworks changes.	**MC IS-8.1** The following records will be maintained: • HSPU Testing of Arrangements Register. • Woodside Internal Equipment Maintenance Register. • OPEP, current and available.
PO IS-9 Woodside will undertake marine assurance, to ensure all vessel operators operate seaworthy vessels that meet the requirements for a defined scope of work and are managed with a robust safety management system.	**PS IS-9.1** Marine assurance will be undertaken in accordance with Woodside's internal assurance process as detailed in **Section 7.5.2.**	**MC IS-9.1** Records demonstrate marine assurance reviews conducted as required.

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9. GLOSSARY AND ABBREVIATIONS

Term	Meaning
(the) Regulator	The Government Agency (State or Commonwealth) that is the decision maker for approvals and undertakes ongoing regulation of the approval once granted.
3D seismic data	A set of numerous closely-spaced seismic lines that provide a high spatially sampled measure of subsurface reflectivity and 3D image.
4D seismic data	A time-lapse seismic technique that enhances existing seismic data by providing information about how a reservoir changes over time.
Acceptability	The EP must demonstrate that the environmental impacts and risks of an activity will be of an acceptable level as per Regulation 10A(c).
ALARP	A legal term in Australian safety legislation, it is taken here to mean that all contributory elements and stakeholdings have been considered by assessment of costs and benefits, and which identifies a preferred course of action.
Australian Standard	An Australian Standard which provides criteria and guidance on design, materials, fabrication, installation, testing, commissioning, operation, maintenance, re-qualification and abandonment.
Ballast	Extra weight taken on to increase a ship’s stability to prevent rolling and pitching. Most ships use seawater as ballast. Empty tank space is filled with inert (non-combustible) gas to prevent the possibility of fire or explosion.
Bathymetry	Related to water depth, a bathymetry map shows the depth of water at a given location on the map.
Benthos/Benthic	Relating to the seabed, and includes organisms living in or on sediments/rocks on the seabed.
Biodiversity	Relates to the level of biological diversity of the environment. The EPBC Act defines biodiversity as: “the variability among living organisms from all sources (including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part) and includes: (a) diversity within species and between species; and (b) diversity of ecosystems.”
Biota	The animal and plant life of a particular region, habitat or geological period.
Cetacean	Whale and dolphin species.
Consequence	The worst case credible outcome associated with the selected event assuming some controls (prevention and mitigation) have failed. Where more than one impact applies (e.g. environmental and legal/compliance), the consequence level for the highest severity impact is selected.
Coral	Anthozoa that are characterised by stone like, horny, or leathery skeletons (external or internal). The skeletons of these animals are also called coral.
Coral Reef	A wave-resistant structure resulting from skeletal deposition and cementation of hermatypic corals, calcareous algae, and other calcium carbonate-secreting organisms.
Crustacean	A large and variable group of mostly aquatic invertebrates which have a hard external skeleton (shell), segmented bodies, with a pair of often very modified appendages on each segment, and two pairs of antennae (e.g. crabs, crayfish, shrimps, wood lice, water fleas and barnacles).
Cyclone	A rapidly-rotating storm system characterised by a low-pressure centre, strong winds, and a spiral arrangement of thunderstorms that produce heavy rain.
Datum	A reference location or elevation which is used as a starting point for subsequent measurements.
dB	Decibel – this is a measure of the overall noise level of sound across the audible spectrum with a frequency weighting (that is, ‘A’ weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.

Term	Meaning
dB re 1 μPa[2]	Measure of underwater noise, in terms of sound pressure. Because the dB is a relative measure, rather than an absolute measure, it must be referenced to a standard "reference intensity", in this case 1 micro Pascal (1 mPa), which is the standard reference that is used. The dB is also measured over a specified frequency, which is usually either a one Hertz bandwidth (expressed as dB re 1 mPa2/Hz), or over a broadband which has not been filtered. Where a frequency is not specified, it can be assumed that the measurement is a broadband measurement.
dB re 1μPa².s	Normal unit for sound exposure level.
Demersal	Living close to the floor of the sea (typically of fish).
DRIMS	Woodside's internal document management system.
EC_{50}	the concentration of a drug, antibody or toxicant which induces a response halfway between the baseline and maximum after a specified exposure time.
Echinoderms	Any of numerous radially symmetrical marine invertebrates of the phylum Echinodermata, which includes the starfishes, sea urchins, and sea cucumbers, which have an internal calcareous skeleton and often covered with spines.
Endemic	A species that is native to, or confined to a certain region.
Environment	The surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans and their interrelations (Source: ISO 14001).
Environment Plan	Prepared in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009, which must be assessed and accepted by the Designated Authority (NOPSEMA) before any petroleum-related activity can be conducted.
Environment Regulations	OPGGS (Environment) Regulation 2009.
Environmental approval	The action of approving something, which has the potential to have an adverse impact on the environment. Environmental impact assessment is generally required before environmental approval is granted.
Environmental Hazard	The characteristic of an activity or event that could potentially cause damage, harm or adverse effects on the environment.
Environmental impact	Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's activities, products or services (Source: HB 203:2006).
Environmental impact assessment	An orderly and systematic process for evaluating a proposal or scheme (including its alternatives), and its effects on the environment, and mitigation and management of those effects (Source: Western Australian *Environmental Impact Assessment Administrative Procedures 2010*).
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth legislation designed to promote the conservation of biodiversity and protection of the environment.
Epifauna	Benthic animals that live on the surface of a substrate.
Fauna	Collectively, the animal life of a particular region.
Flora	Collectively the plant life of a particular region.
IC_{50}	A measure of the effectiveness of a compound in inhibiting biological or biochemical function.
Infauna	Aquatic animals that live in the substrate of a body of water, especially in a soft sea bottom.
ISO 14001	ISO 14001 is an international standard that specifies a process (called an Environmental Management System or EMS) for controlling and improving a company's environmental performance. An EMS provides a framework for managing environmental responsibilities so that they become more efficient and more integrated into overall business operations.
Jig Fishing	Fishing with a jig, which is a type of fishing lure. A jig consists of a lead sinker with a hook moulded into it and usually covered by a soft body to attract fish.

Term	Meaning
LC_{50}	The concentration of a substance that is lethal to 50% of the population exposed to it for a specified time.
Likelihood	The description that best fits the chance of the selected consequence actually occurring, assuming reasonable effectiveness of the prevention and mitigation controls.
MARPOL (73/78)	The International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978. MARPOL 73/78 is one of the most important international marine environmental conventions. It was designed to minimize pollution of the seas, including dumping, oil and exhaust pollution. Its stated object is to preserve the marine environment through the complete elimination of pollution by oil and other harmful substances and the minimization of accidental discharge of such substances.
Meteorology	The study of the physics, chemistry, and dynamics of the earth's atmosphere, including the related effects at the air–earth boundary over both land and the oceans.
Mitigation	Management measures which minimise and manage undesirable consequences.
Oligotrophic	Low in plant nutrients and having a large amount of dissolved oxygen throughout.
pH	measure of the acidity or basicity of an aqueous solution.
Protected Species	Threatened, vulnerable or endangered species which are protected from extinction by preventive measures. Often governed by special federal or state laws.
Putrescible	Refers to food scraps and other organic waste associated with food preparation that will be subject to decay and rot (putrefaction).
Risk	The combination of the consequences of an event and its associated likelihood. For guidance see Environmental Guidance on Application of Risk Management Procedure.
Sessile	Organism that is fixed in one place; immobile.
Syngnathids	Family of fish which includes the seahorses, the pipefishes, and the weedy and leafy sea dragons.
Teleost	A fish belonging to the Teleostei or Teleostomi, a large group of fishes with bony skeletons, including most common fishes. The teleosts are distinct from the cartilaginous fishes such as sharks, rays, and skates.
Thermocline	A temperature gradient in a thermally stratified body of water.
Zooplankton	Plankton consisting of small animals and the immature stages of larger animals.

Abbreviation	Meaning
µm	Micrometer
3D	Three-dimensional
4D	Four-dimensional
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AHS	Australian Hydrographic Service
AHO	Australian Hydrographic Office
AIMS	Australian Institute of Marine Science
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
AMMC	Australian Marine Mammal Centre
AMOSC	Australian Maritime Oil Spill Centre
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
APASA	Asia Pacific Applied Science Associates
API	American Petroleum Institute
APPEA	Australian Petroleum Production and Exploration Association
AS (NZS)	Australian Standard (New Zealand Standard)
ASAP	As soon as practicable
ATSB	Australian Transport Safety Bureau
AUV	Autonomous underwater vehicle
AusSAR	Australian Search and Rescue
B1	Baseline survey
bbl	Oil barrel
BIA	Biologically important area
BoM	Bureau of Meteorology
BRUVS	Baited Remote Underwater Video Stations
CAES	Catch and Effort System
CALM	Department of Conservation and Land Management
CCG	Cape Conservation Group
CCP	Cyclone Contingency Plan
CFA	Commonwealth Fisheries Association
CICC	Corporate Incident Communication Centre
CMT	Crisis Management Team
COLREGS	International Regulations for Preventing Collisions at Sea 1972
COT	Casing Orientation Tool
CRR	Current Risk Rating
CS	Cost/Sacrifice
CSA	Cetacean Sightings Application

Abbreviation	Meaning
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CV	Company Values
DAWR	Department of Agriculture and Water Resources
dB	Decibel
DBCA	Department of Biodiversity, Conservation and Attractions
DEC	Department of Environment and Conservation
DEH	Department of Environment and Heritage
DEWHA	Department of Environment, Water, Heritage and the Arts
DMAC	Diving Medical Advisory Council
DMIRS	Department of Mines, Industry Regulation and Safety
DMP	Department of Mines and Petroleum
DNP	Director of National Parks
DoD	Department of Defence
DoE	Department of the Environment
DoEE	Department of Environment and Energy
DoF	Department of Fisheries
DoT	Department of Transport
DPaW	Department of Parks and Wildlife
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EC50	Half maximal effective concentration
eCAR	Environmental Commitments and Actions Register
EEZ	Exclusive Economic Zone
EGPMF	Exmouth Gulf Prawn Managed Fishery
EL50	Half effective loading concentration
EMBA	Environment That May be Affected
EMS	Environmental Management System
ENVID	Environmental hazard Identification
EP	Environment Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPO	Environmental Performance Outcome
EPS	Environmental Performance Standard
ERP	Emergency Response Plans
ESD	Emergency Shutdown
F	Feasibility
FPSO	Floating Production, Storage and Offtake vessel
FSB	Flow Support Base
g/m^2	Grams per square metre
GP	Good Practice
GTO	Geotechnical Operations

Abbreviation	Meaning
HAZID	Hazard identification
HF	High frequency
HSE	Health, Safety and Environment
HSPU	Hydrocarbon Spill Preparedness Unit
Hz	Hertz
IAGC	International Association of Geophysical Contractors
IAP	Incident Action Plan
IC50	Half maximal inhibitory concentration
ICC	Incident Controller
IMCA	International Marine Contractors Association
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IMO	International Maritime Organisation
IMS	Invasive Marine Species
IOGP	International Association of Oil & Gas Producers
IPIECA	International Petroleum Industry Environmental Conservation Association
IS	Implementation strategy
ISO	International Standards Organization
ISPP	International Sewage Pollution Prevention Certificate
ITF	Indonesian Through Flow
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
JRCC	Joint Rescue Coordination Centre
KEF	Key ecological feature
kHz	Kilohertz
km	Kilometre
kPa	Kilopascal
L	Litres
LC50	Lethal concentration, 50%
LCS	Legislation, Codes and Standards
LF	Low frequency
LNG	Liquefied natural gas
M1	First monitor survey
M2	Second monitor survey
MAMF	Marine Aquarium Managed Fishery
MC	Measurement Criteria
MDO	Marine diesel oil
MF	Medium frequency
MMA	Marine Management Area
MMF	Mackerel Managed Fishery

Abbreviation	Meaning
MNES	Matters of National Environmental Significance
MOD	Maximum-over-depth
MOPO	Matrix of Permitted Operations
MPA	Marine Protected Areas
MPRA	Marine Parks and Reserves Authority
ms^{-1}	Metres per second
MSIN	Maritime Safety Information Notifications
MSS	Marine Seismic Survey
MUZ	Multiple use zone
NSF	National Science Foundation
nm	Nautical mile (1,852 m) a unit of distance on the sea
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NT	Northern Territory
NTM	Notice to Mariners
NWMR	North-west Marine Region
NWS	North West Shelf
NWSTF	North West Slope Trawl Fishery
OBS	Ocean bottom seismographs
OIW	Oil in Water
OPEP	Oil Pollution Emergency Plan
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act*
OPMF	Onslow Prawn Managed Fishery
OVID	Offshore vessel inspection database
OVMSA	Offshore vessel safety management system assessment
PAM	Passive acoustic monitoring
PDSMF	Pilbara Demersal Scalefish Managed Fishery
PJ	Professional Judgement
PK	???
PMI	Potential mortal injury
PPA	Pearl Producers Association
ppb	Parts per billion
ppm	Parts per million
PS	Performance Standards
psi	Pounds per square inch
PSZ	Petroleum Safety Zone
PTS	Permanent Threshold Shift
RBA	Risk based analysis

Abbreviation	Meaning
RCC	Rescue Co-ordination Centre
ROV	Remotely operated vehicle
RUZ	Recreational Use Zone
SA	South Australia
SBTF	Southern Bluefin Tuna Fishery
SEL	Sound exposure levels
SIMAP	Spill Impact Mapping and Analysis Program
SIMOPS	Simultaneous Operations
SLB	Schlumberger Australia Pty Ltd
SMPEP	Spill Monitoring Programme Execution Plan
SNA	Safe Navigation Area
SOLAS	Safety of Life at Sea
SOPEP	Ship Oil Pollution Emergency Plan
SPL	Sound Pressure Levels
SRD	Streamer recovery device
SSMF	Specimen Shell Managed Fishery
SV	Societal Values
TTS	Temporary Threshold Shift
UK	United Kingdom
US	United States of America
UXO	Unexploded ordnance
WA	Western Australia
WAFIC	Western Australian Fishing Industry Council
WCDSCMF	West Coast Deep Sea Crustacean Managed Fishery
WCRLF	West Coast Rock Lobster Managed Fishery
WDTF	Western Deepwater Trawl Fishery
WHA	World Heritage Area
WMS	Woodside Management System
Woodside	Woodside Energy Ltd
WSTF	Western Skipjack Tuna Fishery
WTBF	Western Tuna Billfish Fishery

APPENDIX A: WOODSIDE ENVIRONMENT AND RISK MANAGEMENT POLICIES

WOODSIDE POLICY

Health, Safety, Environment and Quality Policy

OBJECTIVES

Strong health, safety, environment and quality (HSEQ) performance is essential for the success and growth of our business. Our aim is to be recognised as an industry leader in HSEQ through managing our activities in a sustainable manner with respect to our workforce, our communities and the environment.

At Woodside we believe that process and personal safety related incidents, and occupational illnesses, are preventable. We are committed to managing our activities to minimise adverse health, safety or environmental impacts, incorporating a right first time approach to quality.

PRINCIPLES

Woodside will achieve this by:

- implementing a systematic approach to HSEQ risk management
- complying with relevant laws and regulations and applying responsible standards where laws do not exist
- setting, measuring and reviewing objectives and targets that will drive continuous improvement in HSEQ performance
- embedding HSEQ considerations in our business planning and decision making processes
- integrating HSEQ requirements when designing, purchasing, constructing and modifying equipment and facilities
- maintaining a culture in which everybody is aware of their HSEQ obligations and feels empowered to speak up and intervene on HSEQ issues
- undertaking and supporting research to improve our understanding of HSEQ and using science to support impact assessments and evidence based decision making
- taking a collaborative and pro-active approach with our stakeholders
- requiring contractors to comply with our HSEQ expectations in a mutually beneficial manner
- publicly reporting on HSEQ performance

APPLICATION

Responsibility for the application of this policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control. Woodside managers are also responsible for promotion of this policy in non-operated joint ventures.

This policy will be reviewed regularly and updated as required.

December 2015

WOODSIDE POLICY

Risk Management Policy

OBJECTIVES

Woodside recognises that risk is inherent to its business and that effective management of risk is vital to delivering on our objectives, our success and our continued growth. We are committed to managing all risk in a proactive and effective manner.

Our approach to risk enhances opportunities, reduces threats and sustains Woodside's competitive advantage.

The objective of our risk management system is to provide a consistent process for the recognition and management of risks across Woodside's business. The success of our risk management system lies in the responsibility placed on everyone at all levels to proactively identify, manage, review and report on risks relating to the objectives they are accountable for delivering.

PRINCIPLES

Woodside achieves these objectives by:

- Applying a structured and comprehensive risk management system across Woodside which establishes common risk management understanding, language and methodology
- Identifying, assessing, monitoring and reporting risks to provide management and the Board with the assurance that risks are being effectively identified and managed
- Ensuring risks consider impacts across the following key areas of exposure: health and safety, environment, finance, reputation and brand, legal and compliance, and social and cultural
- Understanding our exposure to risk and applying this to our decision making
- Embedding risk management into our critical business activities and processes
- Assuring the effectiveness of risk controls and of the risk management process
- Building our internal resilience to the effects of adverse business impacts in order to sustain performance.

APPLICATION

The Managing Director of Woodside is accountable to the Board of Directors for ensuring this policy is effectively implemented.

Managers are responsible for promoting and applying the Risk Management Policy. Responsibility for the effective application of this policy rests with all Woodside employees, contractors and joint venturers engaged in activities under Woodside operational control.

This policy will be reviewed regularly and updated as required.

December 2012

APPENDIX B: RELEVANT REQUIREMENTS

Key Commonwealth Statutes and Regulations that may be applicable

Commonwealth Legislation	Legislation Summary
Air Navigation Act 1920 • Air Navigation Regulations 1947 • Air Navigation (Aerodrome Flight Corridors) Regulations 1994 • Air Navigation (Aircraft Engine Emissions) Regulations 1995 • Air Navigation (Aircraft Noise) Regulations 1984 • Air Navigation (Fuel Spillage) Regulations 1999	This Act relates to the management of air navigation.
Australian Radiation Protection and Nuclear Safety Act 1998	This Act relates to the protection of the health and safety of people, and the protection of the environment from the harmful effects of radiation.
Environment Protection and Biodiversity Conservation Act 1999 • Environment Protection and Biodiversity Conservation Regulations 2000	This Act protects matters of national environmental significance (NES). It streamlines the national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and culturally significant places. Under this Act, actions that may be likely to have a significant impact on matters of NES must be referred to the Commonwealth Environment Minister.
• Australian Marine Parks	Under the EPBC Act, Australian Marine Parks (AMPs), formally known as Commonwealth Marine Reserves, are recognised for conserving marine habitats and the species that live and rely on these habitats. The Director of Marine Parks (DNP) is responsible for managing AMP's (supported by Parks Australia), and is required to publish management plans for them.

	Other parts of the Australian Government must not perform functions or exercise powers in relation to these parks that are inconsistent with management plans (s.362 of the EPBC Act). The North-west Marine Parks Network Management Plan describes the requirements for management. Specific zones within the AMPs have been allocated conservation objectives as stated below (International Union for Conservation of Nature (IUCN) Protected Area Category) based on the Australian IUCN reserve management principles outlined in Schedule 8 of the EPBC Regulations 2000.
Environment Protection (Sea Dumping) Act 1981 • Environment Protection (Sea Dumping) Regulations 1983	This Act provides for the protection of the environment by regulating dumping matter into the sea, incineration of waste at sea and placement of artificial reefs.
Industrial Chemicals (Notification and Assessment Act) 1989	This Act creates a national register of industrial chemicals. The Act also provides for restrictions on the use of certain chemicals which could have harmful effects on the environment or health.
National Environment Protection Measures (Implementation) Act 1998 • National Environment Protection Measures (Implementation) Regulations 1999	This Act and Regulations provide for the implementation of National Environment Protection Measures (NEPMs) to protect, restore and enhance the quality of the environment in Australia and ensure that the community has access to relevant and meaningful information about pollution. The National Environment Protection Council has made NEPMs relating to ambient air quality, the movement of controlled waste between states and territories, the national pollutant inventory, and used packaging materials.

Commonwealth Legislation	**Legislation Summary**
Navigation Act 2012	This Act regulates navigation and shipping including Safety of Life at Sea (SOLAS). Although the Act does not apply to the operation of petroleum facilities, it may apply to some activities of operations support vessels.
Offshore Petroleum and Greenhouse Gas Storage Act 2006 • Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 • Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011 • Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009	This Act is the principal Act governing offshore petroleum exploration and production in Commonwealth waters. Specific environmental, resource management and safety obligations are set out in the Regulations listed.
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 • Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995	This Act provides for measures to protect ozone in the atmosphere by controlling and ultimately reducing the manufacture, import and export of ozone depleting substances (ODS) and synthetic greenhouse gases, and replacing them with suitable alternatives. The Act will only apply to Woodside if it manufactures, imports or exports ozone depleting substances.
Protection of the Sea (Powers of Intervention) Act 1981	This Act authorises the Commonwealth to take measures for the purpose of protecting the sea from pollution by oil and other noxious substances discharged from ships and provides legal immunity for persons acting under an AMSA direction.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 • Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994 • Marine Orders – Marine Pollution Prevention (Oil orders) • Marine Orders – Marine Pollution Prevention (Noxious liquid substances) • Marine Orders – Marine Pollution Prevention (Packaged harmful substances) • Marine Orders – Marine Pollution Prevention (Sewage)	This Act relates to the protection of the sea from pollution by oil and other harmful substances discharged from ships. Under this Act, discharge of oil or other harmful substances from ships into the sea is an offence. There is also a requirement to keep records of the ships dealing with such substances. The Act applies to all Australian ships, regardless of their location. It applies to foreign ships operating between 3 nautical miles (nm) off the coast out to the end of the Australian Exclusive Economic Zone (200 nm). It also applies within the 3nm of the coast where the State/Northern Territory does not have complementary legislation.

Commonwealth Legislation	Legislation Summary
• Marine Orders – Marine Pollution Prevention (Garbage) • MARPOL Convention	
Protection of the Sea (Harmful Antifouling Systems) Act 2006	This Act relates to the protection of the sea from the effects of harmful anti-fouling systems. It prohibits the application or reapplication of harmful anti-fouling compounds on Australian ships or foreign ships that are in an Australian shipping facility.
Biosecurity Act 2015 (and associated regulations)	This Act provides the Commonwealth with powers to take measures of quarantine, and implement related programs as are necessary, to prevent the introduction of any plant, animal, organism or matter that could contain anything that could threaten Australia's native flora and fauna or natural environment. The Commonwealth's powers include powers of entry, seizure, detention and disposal. This Act includes mandatory controls on the use of seawater as ballast in ships and the declaration of sea vessels voyaging out of and into Commonwealth waters. The Regulations stipulate that all information regarding the voyage of the vessel and the ballast water is declared correctly to the quarantine officers.
Environment Protection (Sea Dumping) Act 1981	Address Australia's obligations under the London Protocol. The aims of the London Protocol are to protect and preserve the marine environment from all sources of pollution, and to prevent, reduce and eliminate pollution by controlling the dumping of wastes and other materials at sea.

APPENDIX C: EPBC ACT PROTECTED MATTERS SEARCH

EPBC Act Protected Matters Report

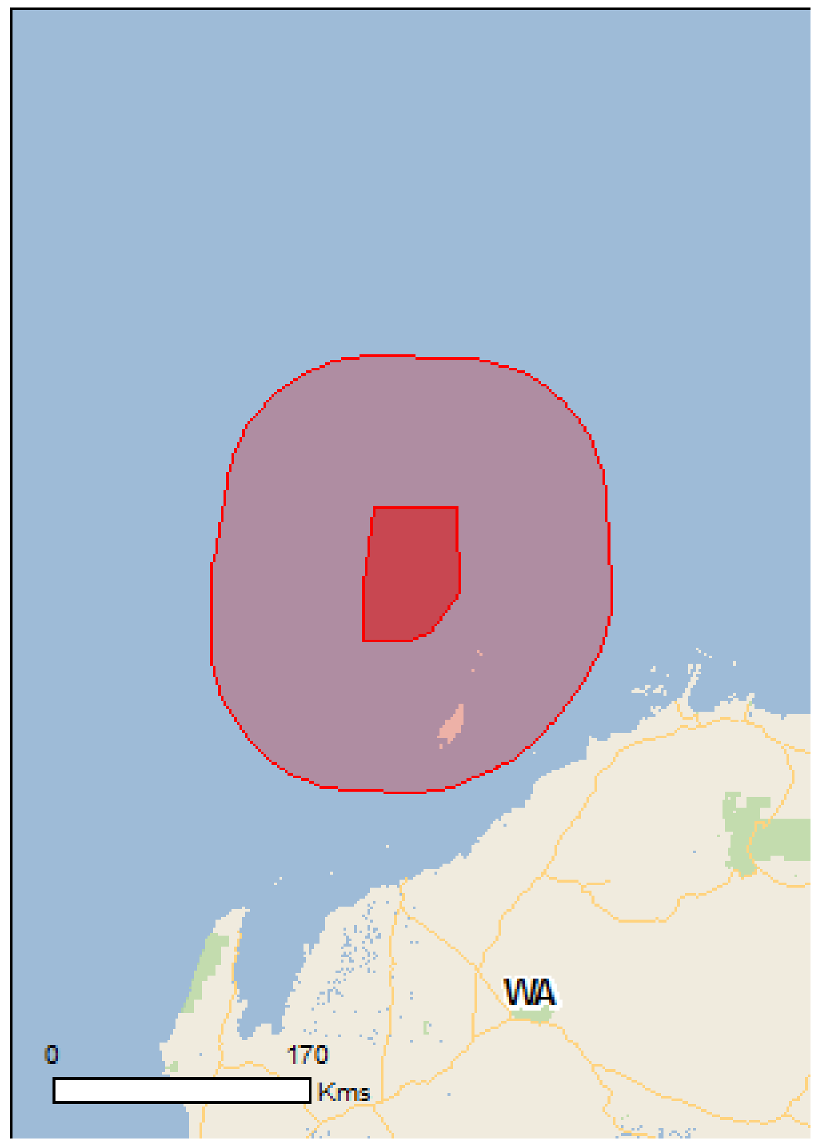
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 17/07/19 15:40:45

- Summary
- Details
  - Matters of NES
  - Other Matters Protected by the EPBC Act
  - Extra Information
- Caveat
- Acknowledgements



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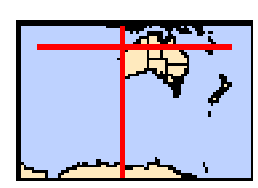

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	33
Listed Migratory Species:	51

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	91
Whales and Other Cetaceans:	29
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	1

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	6
Regional Forest Agreements:	None
Invasive Species:	1
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	3

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri		
Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica menzbieri		
Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Malurus leucopterus edouardi		
White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Fish		
Milyeringa veritas		
Blind Gudgeon [66676]	Vulnerable	Species or species habitat may occur within

Name	Status	Type of Presence
		area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies		
Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Isoodon auratus barrowensis		
Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus		
Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes hirsutus Central Australian subspecies		
Mala, Rufous Hare-Wallaby (Central Australia) [88019]	Endangered	Translocated population known to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Osphranter robustus isabellinus		
Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Petrogale lateralis lateralis		
Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Rhinonicteris aurantia (Pilbara form)		
Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Aipysurus apraefrontalis		
Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Ctenotus zastictus		
Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur

Name	Status	Type of Presence
		within area
Sharks		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Thalasseus bergii Crested Tern [83000]		Breeding known to occur within area

Name	Threatened	Type of Presence
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species

[Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area

Name	Threatened	Type of Presence
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area

Name	Status	Type of Presence
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks	[Resource Information]
Name	Label
Montebello	Multiple Use Zone (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Barrow Island	WA
Boodie, Double Middle Islands	WA
Lowendal Islands	WA
Montebello Islands	WA
Unnamed WA40828	WA
Unnamed WA41080	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Plants		
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 125 m depth contour	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

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Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

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Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-19.57 114.93361,-20.00306 114.8575,-20.31389 114.8575,-20.31722 115.14694,-20.26472 115.26528,-20.04611 115.44056,-19.575 115.415,-19.57 114.93361

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-Other groups and individuals

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Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

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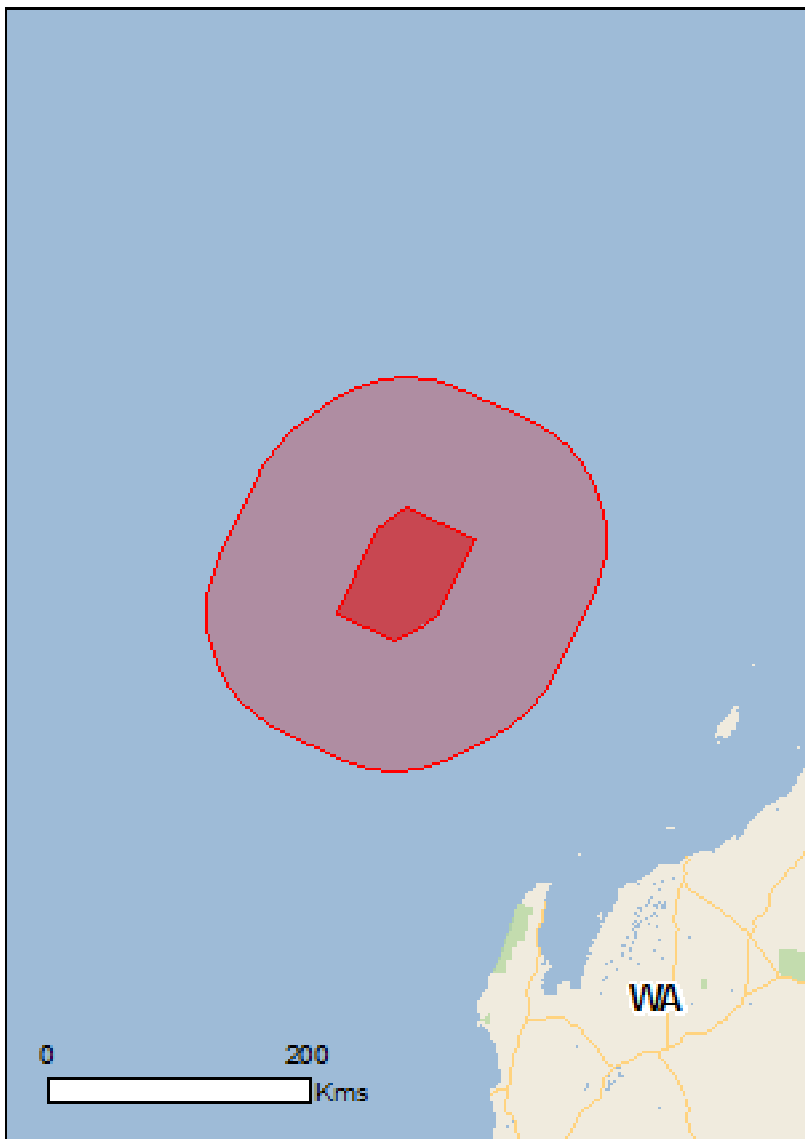
- Summary
- Details
  - Matters of NES
  - Other Matters Protected by the EPBC Act
  - Extra Information
- Caveat
- Acknowledgements



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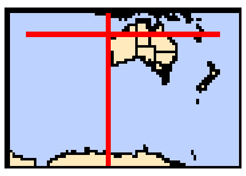

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	14
Listed Migratory Species:	27

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	22
Whales and Other Cetaceans:	26
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	1

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	None
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	1

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Pterodroma mollis		
Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat may occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Migratory Marine Species		
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat may occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Species or species habitat likely to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
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Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species

Name	Status	Type of Presence
		habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat likely to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Name	Label
Gascoyne	Multiple Use Zone (IUCN VI)

Extra Information

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Exmouth Plateau	North-west

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- -Ocean Biogeographic Information System
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Summary
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- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
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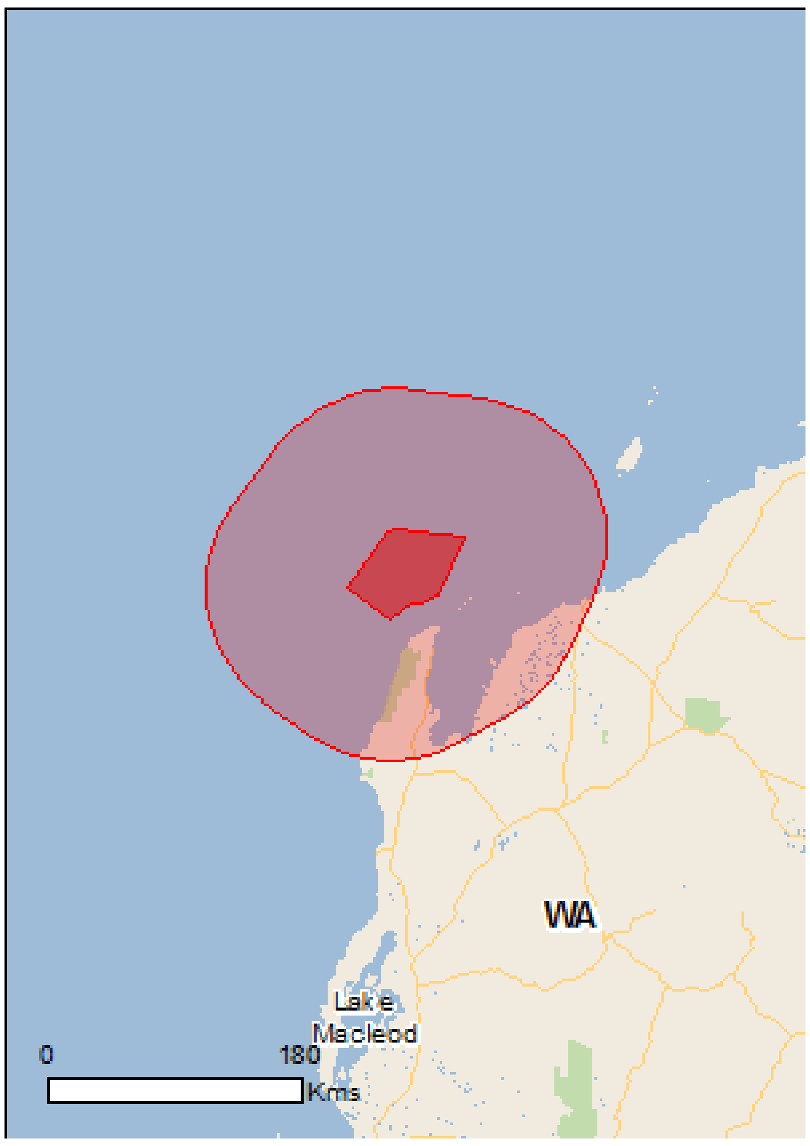

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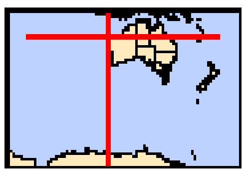

Summary

Matters of National Environmental Significance

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World Heritage Properties:	1
National Heritage Places:	1
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	33
Listed Migratory Species:	53

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

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A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	9
Commonwealth Heritage Places:	2
Listed Marine Species:	87
Whales and Other Cetaceans:	29
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	3

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	19
Regional Forest Agreements:	None
Invasive Species:	15
Nationally Important Wetlands:	4
Key Ecological Features (Marine)	5

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Status
The Ningaloo Coast	WA	Declared property

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
The Ningaloo Coast	WA	Listed place

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area. Generally the Commonwealth Marine Area stretches from three nautical miles to two hundred nautical miles from the coast.

Name
EEZ and Territorial Sea

Marine Regions [Resource Information]

If you are planning to undertake action in an area in or close to the Commonwealth Marine Area, and a marine bioregional plan has been prepared for the Commonwealth Marine Area in that area, the marine bioregional plan may inform your decision as to whether to refer your proposed action under the EPBC Act.

Name
North-west

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat may occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Pterodroma mollis		
Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Fish		
Milyeringa veritas		
Blind Gudgeon [66676]	Vulnerable	Species or species habitat known to occur within area
Ophisternon candidum		
Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
Mammals		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Dasyurus hallucatus		
Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Petrogale lateralis lateralis		
Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Pseudomys fieldi		
Shark Bay Mouse, Djoongari, Alice Springs Mouse [113]	Vulnerable	Species or species habitat likely to occur within area
Rhinonicteris aurantia (Pilbara form)		
Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Other		
Kumonga exleyi		
Cape Range Remipede [86875]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Aipysurus apraefrontalis		
Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area

Name	Status	Type of Presence
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharias taurus (west coast population)		
Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Ardenna pacifica		
Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas		
Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Fregata ariel		
Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Hydroprogne caspia		
Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Onychoprion anaethetus		
Bridled Tern [82845]		Breeding known to occur within area
Sterna dougallii		
Roseate Tern [817]		Breeding likely to occur within area

Name	Threatened	Type of Presence
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat likely to occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Isurus paucus Longfin Mako [82947]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Limosa lapponica		
Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus		
Osprey [952]		Breeding known to occur within area
Thalasseus bergii		
Crested Tern [83000]		Breeding known to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Defence - EXMOUTH ADMIN & HF TRANSMITTING
Defence - EXMOUTH NAVAL HF RECEIVING STATION (H/F Receiving Station, Learmonth, WA)
Defence - EXMOUTH VLF TRANSMITTER STATION
Defence - LEARMONTH - AIR WEAPONS RANGE
Defence - LEARMONTH - RAAF BASE
Defence - LEARMONTH RADAR SITE - TWIN TANKS EXMOUTH
Defence - LEARMONTH RADAR SITE - VLAMING HEAD EXMOUTH
Defence - LEARMONTH TRANSMITTING STATION

Commonwealth Heritage Places [Resource Information]

Name	State	Status
Natural		
Learmonth Air Weapons Range Facility	WA	Listed place
Ningaloo Marine Area - Commonwealth Waters	WA	Listed place

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur

Name	Threatened	Type of Presence
		within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding likely to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Phoxocampus belcheri Black Rock Pipefish [66719]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Breeding known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Migration route known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat likely to occur within area
Feresa attenuata Pygmy Killer Whale [61]		Species or species habitat may occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area

Name	Status	Type of Presence
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia simus Dwarf Sperm Whale [58]		Species or species habitat may occur within area
Lagenodelphis hosei Fraser's Dolphin, Sarawak Dolphin [41]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Peponocephala electra Melon-headed Whale [47]		Species or species habitat may occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Stenella coeruleoalba Striped Dolphin, Euphrosyne Dolphin [52]		Species or species habitat may occur within area
Stenella longirostris Long-snouted Spinner Dolphin [29]		Species or species habitat may occur within area
Steno bredanensis Rough-toothed Dolphin [30]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks	[Resource Information]
Name	Label
Gascoyne	Habitat Protection Zone (IUCN IV)
Gascoyne	Multiple Use Zone (IUCN VI)
Ningaloo	Recreational Use Zone (IUCN IV)

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Airlie Island	WA
Bessieres Island	WA
Bundegi Coastal Park	WA
Burnside And Simpson Island	WA
Cape Range	WA
Giralia	WA
Gnandaroo Island	WA
Jurabi Coastal Park	WA
Locker Island	WA
Muiron Islands	WA
Rocky Island	WA
Round Island	WA
Serrurier Island	WA
Tent Island	WA
Unnamed WA40322	WA
Unnamed WA44665	WA
Victor Island	WA
Whitmore,Roberts,Doole Islands And Sandalwood Landing	WA
Y Island	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Mammals		
Canis lupus familiaris		
Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus		
Goat [2]		Species or species habitat likely to occur within area
Equus asinus		
Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus		
Horse [5]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat may occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Bundera Sinkhole	WA
Cape Range Subterranean Waterways	WA
Exmouth Gulf East	WA
Learmonth Air Weapons Range - Saline Coastal Flats	WA

Key Ecological Features (Marine) [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Ancient coastline at 125 m depth contour	North-west
Canyons linking the Cuvier Abyssal Plain and the	North-west
Commonwealth waters adjacent to Ningaloo Reef	North-west
Continental Slope Demersal Fish Communities	North-west
Exmouth Plateau	North-west

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-21.21583 113.88944,-21.24333 113.83944,-21.57111 113.57944,-21.76361 113.86056,-21.66333 114.00194,-21.66361 114.06056,-21.61083 114.16694,-21.27333 114.34194,-21.21583 113.88944

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX D: OIL SPILL PREPAREDNESS AND RESPONSE STRATEGY SELECTION AND EVALUATION

Oil Spill Preparedness and Response Mitigation Assessment for North-west Australia 4D Marine Seismic Survey Environment Plan

Security & Emergency Management
Hydrocarbon Spill Preparedness Unit

June 2019
Revision: 0

TABLE OF CONTENTS

EXECUTIVE SUMMARY **7**

1 INTRODUCTION **9**

1.1 Overview **9**

1.2 Purpose **9**

1.3 Scope **9**

1.4 Oil spill response document overview **10**

2 RESPONSE PLANNING PROCESS **15**

2.1 Response planning process outline **17**

2.1.1 Response Planning Assumptions – Timing, Resourcing and Effectiveness 18

2.2 Environment plan risk assessment (credible spill scenarios) **19**

2.2.1 Hydrocarbon characteristics 21

2.3 Hydrocarbon spill modelling **21**

2.3.1 Stochastic modelling 22

2.3.2 Spill modelling results 25

3 IDENTIFY RESPONSE PROTECTION AREAS (RPAS) **27**

3.1 Identified sensitive receptor locations **28**

3.2 Identify Response Protection Areas **28**

3.2.1 Response Protection Areas (RPAs) 28

4 NET ENVIRONMENTAL BENEFIT ANALYSIS (NEBA) **29**

4.1 Pre-operational / Strategic NEBA **30**

4.2 Stage 1: Evaluate data **30**

4.2.1 Define the scenario(s) 30

4.2.2 Determining potential response options 31

4.2.3 Exclusion of response techniques 33

4.3 Stage 2: Predict Outcomes **33**

4.4 Stage 3: Balance trade-offs **33**

4.5 Stage 4: Select Best Response Options **33**

5 HYDROCARBON SPILL ALARP PROCESS **35**

5.1 Monitor and Evaluate (including operational monitoring) **36**

5.2 Vessel Shipboard Oil Pollution Emergency Plan **39**

6 ALARP EVALUATION **68**

6.1 Monitor and Evaluate – ALARP Assessment **68**

6.1.1 Monitor and Evaluate – Control Measure Options Analysis 68

6.1.2 Selected Control Measures 69

6.2 SOPEP – ALARP Assessment **70**

6.2.1 SOPEP – Control Measure Options Analysis 70

6.2.2 Selected control measures 70

6.3 Shoreline Clean-up – ALARP Assessment **71**

6.3.1 Existing Capability – Shoreline Clean-up 71

6.3.2 Response planning: North-west Australia 4D Marine Seismic Survey – Shoreline Clean-up 71

6.3.3 Shoreline Clean-up – Control measure options analysis 72

6.3.4 Selected Control Measures 73

6.4 Waste Management – ALARP Assessment **74**

6.4.1 Existing Capability – Waste Management 74
6.4.2 Waste Management – Control Measure Options Analysis 74
6.4.3 Selected control measures 75
6.5 Wildlife Response – ALARP Assessment 76
6.5.1 Existing Capability – Wildlife Response 76
6.5.2 Wildlife Response – Control Measure Options Analysis 76
6.5.3 Selected control measures 77
6.6 Scientific Monitoring – ALARP Assessment 78
6.6.1 Existing Capability – Scientific Monitoring 78
6.6.2 Scientific Monitoring – Control Measure Options Analysis 78
7 ENVIRONMENTAL RISK ASSESSMENT OF SELECTED RESPONSE TECHNIQUES 82
7.1.1 Identification of impacts and risks from implementing response techniques 82
7.1.2 Analysis of impacts and risks from implementing response techniques 82
7.1.3 Evaluation of impacts and risks from implementing response techniques 83
8 ALARP CONCLUSION 86
9 ACCEPTABILITY CONCLUSION 87
10 REFERENCES 88
11 GLOSSARY & ABBREVIATIONS 90
11.1 Glossary 90
11.2 Abbreviations 92
ANNEX A: NEBA DETAILED OUTCOMES 95
ANNEX B: OPERATIONAL MONITORING ACTIVATION AND TERMINATION CRITERIA 98
ANNEX C: OIL SPILL SCIENTIFIC MONITORING PROGRAM 102
ANNEX D: MONITORING PROGRAM AND BASELINE STUDIES FOR THE PAP 114
ANNEX E: TACTICAL RESPONSE PLANS 122

FIGURES

Figure 1-1: Woodside hydrocarbon spill document structure 11
Figure 2-1: Response planning and selection process 16
Figure 2-2: Response Planning Assumptions – Timing, Resourcing and Effectiveness 18
Figure 2-3: Proportion of total area coverage (AMSA 2014) 24
Figure 2-4: Oil thickness versus potential response options (from Allen and Dale 1996) 25
Figure 3-1: Identify Response Protection Areas flowchart 27
Figure 4-1: Net Environmental Benefit Analysis flowchart 29
Figure 5-1: Screen shot of the HSP competency dashboard 65
Figure 5-2: Screen shot for the Ops Point Coordinator role 65

TABLES

Table 0-1: Summary of the key details for assessment 7
Table 1-1: Hydrocarbon spill preparedness and response – document references 12
Table 2-1: Petroleum Activities Program credible spill scenarios 20
Table 2-2: Summary of thresholds applied to the stochastic hydrocarbon spill modelling to determine EMBA and environmental impacts 22
Table 2-3: Surface hydrocarbon thresholds for response planning 23
Table 2-4: Worst case credible scenario modelling results (Area C) 26
Table 3-1: Response Protection Areas from modelling 28
Table 4-1: Scenario summary information (WCCS) 30

Table 4-2: Oil fate, behaviour and impacts 31
Table 4-3: Response technique evaluation – surface release of marine diesel 32
Table 4-4: Selection and prioritisation of response techniques 34
Table 5-1: Supporting operational monitoring plans 36
Table 5-2: Environmental Performance – Monitor and Evaluate 37
Table 5-3: Response Planning Assumptions – Shoreline Clean-up 41
Table 5-4: Shoreline Clean-up Techniques and Recommendations 42
Table 5-5: Environmental Performance – Shoreline Clean-up 45
Table 5-6: Response Planning Assumptions – Waste Management....47
Table 5-7: Environmental Performance – Waste Management....48
Table 5-8: Key at-risk species potentially in RPAs and open ocean 49
Table 5-9: Oiled wildlife response stages 50
Table 5-10: Indicative oiled wildlife response level (adapted from the WA OWRP 2014) 51
Table 5-11: Environmental Performance – Oiled Wildlife Response....52
Table 5-12: Scientific monitoring deployment considerations....54
Table 5-13: Scientific monitoring response planning assumptions 54
Table 5-14: Environmental Performance – Scientific Monitoring....57
Table 5-15: Environmental Performance – Incident Management System 63
Table 6-1: Response Planning – Shoreline Clean-up....71
Table 6-2: Scientific Monitoring – Control Measure Options considered – A. Alternative control measures 78
Table 6-3: Scientific Monitoring - Control Measure Options considered – B. Additional control measures 78
Table 6-4: Scientific monitoring program operational plan actions 79
Table 6-5: ALARP and Acceptability Summary 80
Table 7-1: Analysis of risks and impacts 83

EXECUTIVE SUMMARY

Woodside Energy Ltd (Woodside) has developed its oil spill preparedness and response position for the North-west Australia 4D Marine Seismic Survey, hereafter known as the Petroleum Activities Program (PAP).

This document demonstrates that the risks and impacts from an unplanned hydrocarbon release, and the associated response operations, are controlled to As Low as Reasonably Practicable (ALARP) and acceptable levels. It achieves this by evaluating response options to address the potential environmental impacts resulting from an unplanned loss of hydrocarbon containment associated with the PAP described in the Environment Plan (EP). The content of this document then outlines Woodside's decisions and techniques for responding to a hydrocarbon release event and the process for determining its level of hydrocarbon spill preparedness.

A summary of the key facts and references to additional detail within this document are presented below.

Table 0-1: Summary of the key details for assessment

<table>
<tr><th>Key details of assessment</th><th colspan="2">Summary</th><th>Reference to additional detail</th></tr>
<tr><td>Worst Case Credible Scenario</td><td colspan="2">Hydrocarbon release due to vessel collision
Surface – instantaneous release of 190 m^3 of marine diesel.</td><td>Section 2.2</td></tr>
<tr><td>Hydrocarbon Properties</td><td colspan="2">Marine diesel is typically classed as an International Tanker Owners Pollution Federation (ITOPF) Group 2 oil.
Based on the modelling results, under a constant-wind case ~45% of the oil is predicted to evaporate within 24 hours. Under these calm conditions the majority of the remaining oil on the water surface will weather at a slower rate.
Under a variable-wind case, entrainment of marine diesel into the water column is indicated to be significant. Approximately 24 hours after the spill, around 45% of the oil mass is forecast to have entrained, a further 35% is forecast to have evaporated and 19% to have dissolved. This will leave a small proportion of the oil floating on the water surface (<1%).
The overall residual components, both floating and entrained, total 9.5m^3 (or 5% total volume).</td><td>Section 2.2.1
Section 6.7 of the EP
Appendix A of the First Strike Response Plan (FSRP)</td></tr>
<tr><td rowspan="3">Modelling Results</td><td colspan="2">A quantitative, stochastic assessment has been undertaken for credible spill scenarios to help assess the environmental risk of a hydrocarbon spill.
A total of 400 replicate simulations were completed for the scenarios to test for trends and variations in the trajectory and weathering of the spilled oil, with an even number of replicates completed using samples of metocean data that commenced within each calendar quarter.</td><td rowspan="3">Section 2.3</td></tr>
<tr><td>Minimum time to shoreline contact (above 100 g/m^2)</td><td>24 hours (Day 2) at Ningaloo Coast North and World Heritage Area (WHA). First shoreline contact totals 31 m^3.</td></tr>
<tr><td>Largest volume ashore at any single Response Priority Area (RPA) (above 100g/m^2)</td><td>39 m^3 at Ningaloo Coast North and WHA. This is the accumulated volume by Day 3.</td></tr>
</table>

	Largest total shoreline accumulation (above 100 g/m²) all shorelines	2,594 g/m² (Ningaloo Coast North and WHA).	
Net Environmental Benefit Analysis (NEBA)	Monitor and Evaluate, Source Control (if feasible), Shoreline Response and Oiled Wildlife Response, are all identified as potentially having a net environmental benefit (dependent on the actual spill scenario) and carried forward for further assessment.		Section 4
ALARP evaluation of selected response techniques	The evaluation of the selected response techniques shows the proposed controls reduced the risk to an ALARP and acceptable level for the risk presented in Section 2 and Section 3, without the implementation of considered additional, alternative or improved control measures.		Section 6

1 INTRODUCTION

1.1 Overview

Woodside Energy Ltd (Woodside) has developed its oil spill preparedness and response position for the PAP. This document outlines Woodside's decisions and techniques for responding to a hydrocarbon loss of containment event and the process for determining its level of hydrocarbon spill preparedness.

1.2 Purpose

This document, together with the documents listed below, meet the requirements of the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Environment Regulations) relating to hydrocarbon spill response arrangements.

- The North-west Australia 4D Marine Seismic Survey Environment Plan (EP)
- Oil Pollution Emergency Arrangements (OPEA) (Australia)
- The North-west Australia 4D Marine Seismic Survey Oil Pollution Emergency Plan (OPEP) including:
  - First Strike Response Plan (FSRP)
  - relevant Operations Plans
  - relevant Tactical Response Plans (TRPs)
  - relevant Supporting Plans
  - Data Directory.

The purpose of this document is to demonstrate that the risks and impacts from an unplanned hydrocarbon release and the associated response operations are controlled to ALARP and Acceptable levels.

1.3 Scope

This document demonstrates that the risks and impacts from an unplanned hydrocarbon release, and the associated response operations, are controlled to ALARP and acceptable levels. It achieves this by evaluating response options to address the potential environmental risks and impacts resulting from an unplanned loss of hydrocarbon containment associated with the PAP described in the EP. The content of this document then outlines Woodside's decisions and techniques for responding to a hydrocarbon release event and the process for determining its level of hydrocarbon spill preparedness. It should be read in conjunction with the documents listed in Table 1-1. The location of the Petroleum Activity Program is shown in Figure 3.1 of the EP.

The proposed PAP is comprised of six 4D seismic surveys that will be acquired across three different areas of the North West Shelf (NWS), as follows:

- **Area A,** which encompasses the Operational Areas for the Pluto 4D M2 and Harmony 4D M1 surveys, is located in the North Carnarvon Basin, Exmouth Plateau approximately: 28 km north-west of the Montebello Islands; 17 km west of Rankin Bank; 148 km north-west of Dampier; and 150 km north-northeast of the Ningaloo Coast WHA.
- **Area B,** which encompasses the Operational Area for the Scarborough 4D B1 survey, is located in the North Carnarvon Basin approximately: 217 km west-northwest of the Montebello Islands and Barrow Island; 204 km north-west of North West Cape; 248 km north-west of Onslow; and 185 km north-northeast of the Ningaloo Coast WHA.
- **Area C**, which encompasses the Operational Areas for the Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys, is located in the North Carnarvon Basin, Exmouth Sub-basin approximately: 110 km west-southwest of Barrow Island; 17 km north-west of North West Cape; 90 km west-northwest of Onslow; and adjacent to the boundary of the Ningaloo Coast WHA.

1.4 Oil spill response document overview

The documents outlined in Table 1-1 and Figure 1-1 are collectively used to manage the preparedness and response for a hydrocarbon release.

The Oil Pollution FSRP contains a pre-operational NEBA summary, outlining the selected response techniques for this PAP. Relevant Operational Plans to be initiated for associated response techniques are identified in the FSRP and relevant forms to initiate a response are appended to the FSRP.

The process to develop an Incident Action Plan (IAP) begins once the Oil Pollution FSRP is underway. The IAP includes inputs from the Monitor and Evaluate (MES) operations and the operational NEBA (Section 4). Planning, coordination and resource management are initiated by the Incident Management Team (IMT). In some instances, technical specialists may be utilised to provide expert advice. The planning may also involve liaison officers from supporting government agencies.

During each operational period, field reports are continually reviewed to evaluate the effectiveness of response operations. In addition, the operational NEBA is continually reviewed and updated to ensure the response techniques implemented continue to result in a net environmental benefit (see Section 4).

The response will continue as described in Section 5 until the response termination criteria have been met.

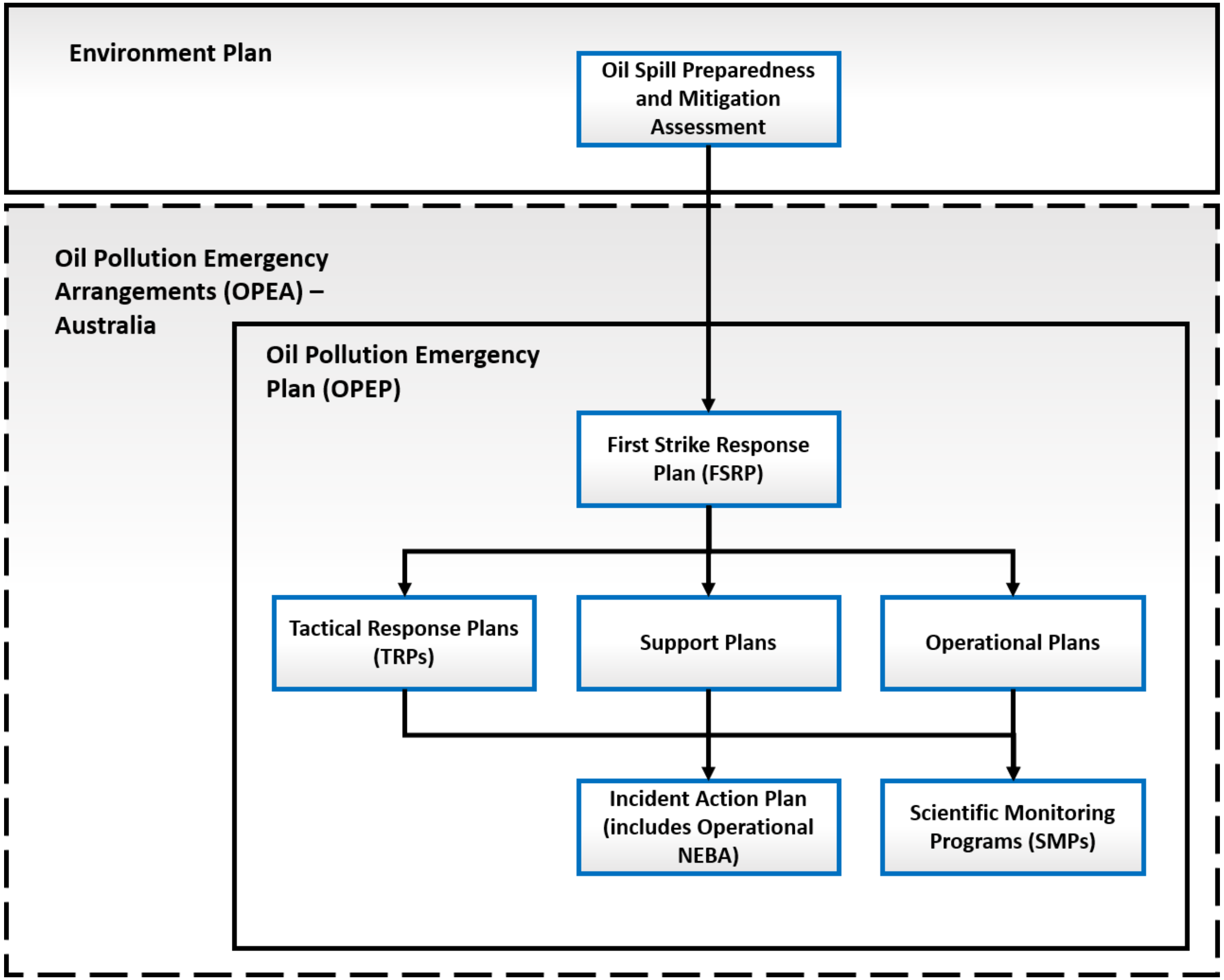


Figure 1-1: Woodside hydrocarbon spill document structure

Table 1-1: Hydrocarbon spill preparedness and response – document references

Document	Document overview	Stakeholders	Relevant information	Document subsections (if applicable)
North-west Australia 4D Marine Seismic Survey Environment Plan (EP)	Demonstrates that potential adverse impacts on the environment associated with the North-west Australia 4D Marine Seismic Survey (during both routine and non-routine operations) are mitigated and managed to ALARP and will be of an acceptable level.	NOPSEMA Woodside internal		EP Section 5 (Identification and evaluation of environmental risks and impacts, including credible spill scenarios) EP Section 6 (Implementation strategy – including emergency preparedness and response) EP Section 6 (Reporting and compliance) EP Section 6 (Performance outcomes, standards and measurement criteria)
Oil Pollution Emergency Arrangements (OPEA) Australia	Describes the arrangements and processes adopted by Woodside when responding to a hydrocarbon spill from a petroleum activity.	Regulatory agencies Woodside internal	All	
Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) for the North-west Australia 4D Marine Seismic Survey (this document)	Evaluates response options to address the potential environmental impacts resulting from an unplanned loss of hydrocarbon containment associated with the PAP described in the EP.	Regulatory agencies Corporate Incident Control Centre (CICC): Control function in an ongoing spill response for activity-specific response information.	All Performance outcomes, standards and measurement criteria related to hydrocarbon spill preparedness and response are included in this document.	

Document	Document overview	Stakeholders	Relevant information	Document subsections (if applicable)
North-west Australia 4D Marine Seismic Survey Oil Pollution FSRP	Facility specific document providing details and tasks required to mobilise a first strike response. Primarily applied to the first 24 hours of a response until a full IAP specific to the event is developed. Oil Pollution FSRPs are intended to be the first document used to provide immediate guidance to the responding IMT.	Site-based IMT for initial response, activation and notification. CICC for initial response, activation and notification. CICC: Control function in an ongoing spill response for activity-specific response information.	Initial notifications and reporting required within the first 24 hours of a spill event. Relevant spill response options that could be initiated for mobilisation in the event of a spill. Recommended pre-planned tactics. Details and forms for use in immediate response. Activation process for oil spill trajectory modelling, aerial surveillance and oil spill tracking buoy details.	
Operational Plans	Lists the actions required to activate, mobilise and deploy personnel and resources to commence response operations. Includes details on access to equipment and personnel (available immediately) and steps to mobilise additional resources depending on the nature and scale of a release. Relevant operational plans will be initially selected based on the Oil Pollution FSRP; additional operational plans will be activated depending on the nature and scale of the release.	CICC: Operations and Logistics functions for first strike activities. CICC: Planning Function to help inform the IAP on resources available.	Locations from where resources may be mobilised. How resources will be mobilised. Details of where resources may be mobilised to and what facilities are required once the resources arrive. Details on how to implement resources to undertake a response.	• Vessel Shipboard Oil Pollution Emergency Plan (SOPEP) • Operational Monitoring Plan: - OM01: Predictive Modelling to Assess Resources at Risk - OM02: Surveillance and reconnaissance to detect hydrocarbons and resources at risk - OM03: Monitoring of hydrocarbon presence, properties, behaviour and weathering in water - OM04: Pre-emptive Assessment of Sensitive Receptors - OM05: Shoreline Assessment • Shoreline Clean up • Oiled Wildlife • Scientific Monitoring

Document	Document overview	Stakeholders	Relevant information	Document subsections (if applicable)
Tactical Response Plans	Provides options for response techniques in selected RPAs. Provides site, access and deployment information to support a response at the location.	CICC: Planning Function to help develop IAPs, and Logistics Function to assist with determining resources required.	Indicative response techniques. Access requirements and/or permissions. Relevant information for undertaking a response at that site. Where applicable, may include equipment deployment locations and site layouts.	• Mangrove Bay • Turquoise Bay • Yardie Creek • Muiron Islands • Jurabi to Lighthouse Beaches
Support Plans	Support Plans detail Woodside's approach to resourcing and the provision of services during a hydrocarbon spill response.	CICC: Operations, Logistics and Planning functions.	Strategy for mobilising and managing additional resources outside of Woodside's immediate preparedness arrangements.	Marine Logistics People & Global Capability Surge Labour Requirement Plan Health & Safety Aviation IT (FSRP) IT (Extended Response) Communications (FSRP) Communications (Extended Response) Stakeholder Engagement Accommodation & Catering Waste Management Guidance for Oil Spill Claims Management (Land based) Security Support Plan Hydrocarbon Spill Responder Health Monitoring Guideline

2 RESPONSE PLANNING PROCESS

This document details Woodside's process for identifying potential response options for the hydrocarbon release scenarios, identified in the EP. Figure 2-1 outlines the interaction between Woodside's response, planning/preparedness and selection process.

This structure has been used because it shows how the planning and preparedness activities inform a response and provides indicative guidance on what activities would be undertaken, in sequential order, if a real event were to occur. The process also evaluates alternative, additional and/or improved control measures specific to the PAP.

The North-west Australia 4D Marine Seismic Survey FSRP then summarises the outcome of the response planning process and provides initial response guidance and a summary of ongoing response activities, if an incident were to occur.

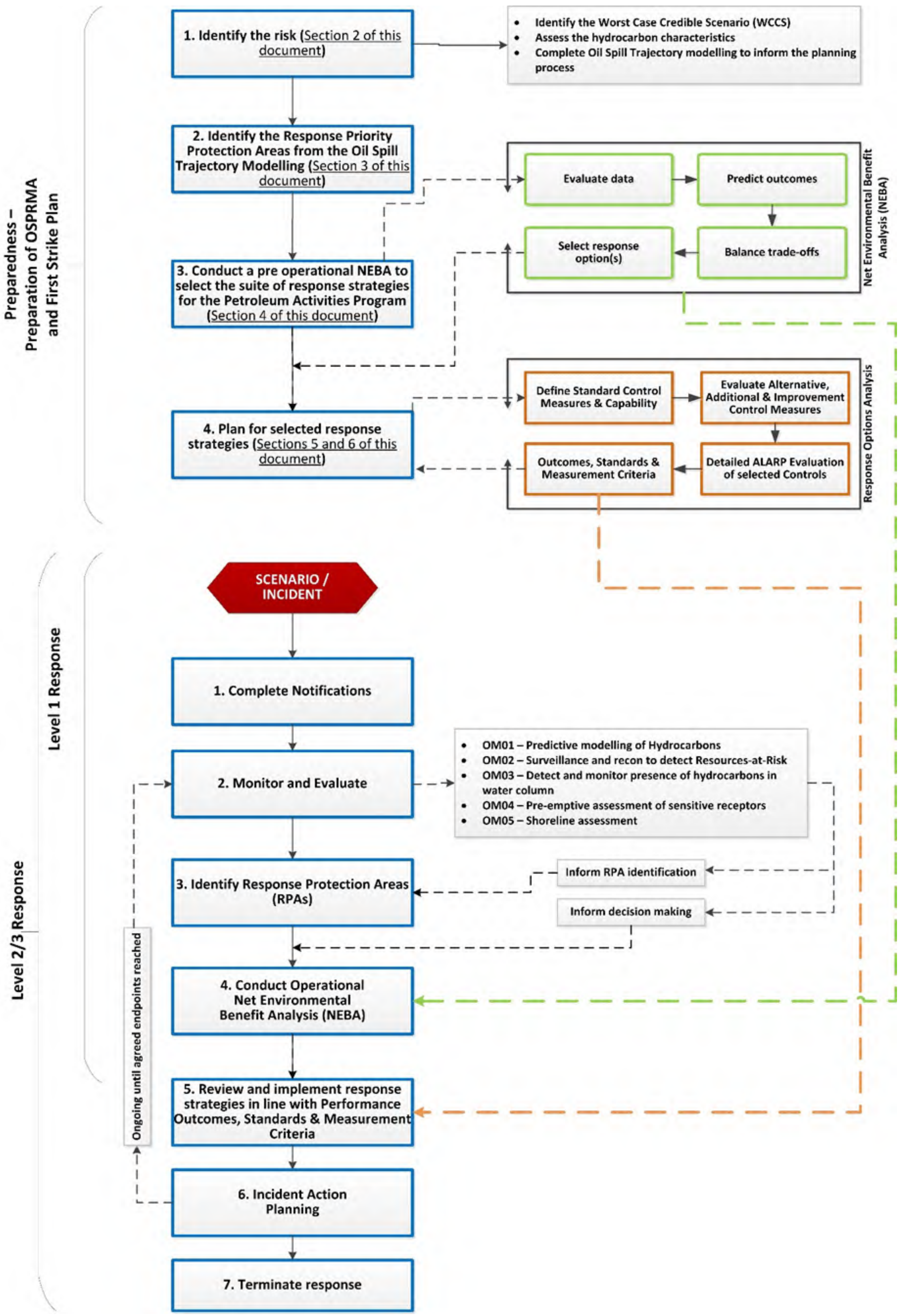


Figure 2-1: Response planning and selection process

2.1 Response planning process outline

This document is expanded below to provide additional context on the key steps in determining capability, evaluating ALARP and hydrocarbon spill response requirements.

Section 1. INTRODUCTION

Section 2. RESPONSE PLANNING PROCESS

- Identification of worst-case credible scenario(s) (WCCS)
- Spill modelling for WCCS

Section 3. IDENTIFY RESPONSE PROTECTION AREAS (RPAs)

- Areas predicted to be contacted at concentration >100g/m^2.

Section 4. NET ENVIRONMENTAL BENEFIT ANALYSIS (NEBA)

- Pre-operational NEBA (during planning/ALARP evaluation): this must be reviewed during the initial response to an incident to ensure its accuracy
- Selected response techniques prioritised and carried forward for ALARP assessment

Section 5. HYDROCARBON SPILL ALARP PROCESS

- Determines the response need based on predicted consequence parameters.
- Details the environmental performance of the selected response options based on the need.
- Sets the environmental performance outcomes, environmental performance standards and measurement criteria.

Section 6. ALARP EVALUATION

- Evaluates alternative, additional, and improved options for each response technique to demonstrate the risk has been reduced to ALARP.
- Provides a detailed ALARP assessment of selected control measure options against:
  - predicted cost associated with implementing the option
  - predicted change to environmental benefit
  - predicted effectiveness / feasibility of the control measure

Section 7. ENVIRONMENTAL RISK ASSESSMENT OF SELECTED RESPONSE TECHNIQUES

- Evaluation of impacts and risks from implementing selected response options

Section 8. ALARP CONCLUSION

Section 9. ACCEPTABILITY CONCLUSION

2.1.1 Response Planning Assumptions – Timing, Resourcing and Effectiveness

IMT Call-out/ Notification	Contract Activation	Response Option Mobilisation	Response Option Deployment	Response Option Effectiveness
This is the time taken from call-out to mobilise the IMT to the designated Incident Control Centre	This is the time taken once the IMT has been mobilised to activate specific contracts for resources (SFRT, FWADC, AMOSC, AMSA, OSRL, etc)	This is the time taken to mobilise resources from home location to laydown/staging area (expected to be airport or sea port) close to response area	This is the time taken to deploy resources from laydown/staging area (expected to be airport or sea port) to response area/field	This relates to the performance of equipment/response option as well as required personnel resourcing (Specialists/Supervisors + support personnel)
Approx 2-4 hours	Approx 2-4 hours	Response Technique specific	Field/Location specific	Response Strategy specific

Figure 2-2: Response Planning Assumptions – Timing, Resourcing and Effectiveness

For the purpose of defining terms related to response planning and timing, the following definitions have been developed;

- Activation – Is the time taken to activate the appropriate contract and/or arrangements by the IMT once the IMT has mobilised to the Incident Control Centre (ICC). For planning purposes, this is expected to be 2-4 hours post IMT mobilisation to ICC (where the IMT mobilisation is 2-4 hours).
- Mobilisation – Is the time taken following contract activation to mobilise the resources/equipment from its home location (e.g., Dampier, Singapore, Perth, etc.) to the staging area/laydown area (expected to be a nearby seaport or airport). Mobilisation time includes movement of resources from primary storage location to designated deployment location/staging airfield and seaport inclusive of all required access, loading, permits/approvals, transit and unloading activities. If a resource is comprised of multiple components (i.e., vessel with fuel, crew, supplies, hoses, pumps, powerpacks, etc.), the mobilisation time is calculated from the longest lead time item that must be present for the resource to be safely and effectively deployed.
- Deployment – Is the time taken to deploy the required resource(s) from the staging area/laydown area (expected to be a nearby seaport or airport) to the required location in the field (offshore, nearshore, shoreline) where the resource will be utilised.

2.2 Environment plan risk assessment (credible spill scenarios)

Potential hydrocarbon release scenarios from the PAP have been identified during the risk assessment process (presented in Section 6.7.1 of the EP). Further descriptions of risk, impacts and mitigation measures (which are not related to hydrocarbon preparedness and response) are provided in Section 6.7 of the EP. Five unplanned events or credible spill scenarios for the PAP have been selected as representative across types, sources and incident/response levels, up to and including the WCCS.

Table 2-1 presents the credible scenarios for the PAP. The WCCS for the activity is then used for response planning purposes, as all other scenarios are of a lesser scale and extent. By demonstrating capability to manage the response to the WCCS, Woodside assumes other scenarios that are smaller in nature and scale can also be managed by the same capability. Response performance measures have been defined based on a response to the WCCS.

Table 2-1: Petroleum Activities Program credible spill scenarios

Scenario No.	Scenario selected for planning purposes	Scenario description	Maximum credible volume released (liquid m³)[1]	Incident Level	Hydrocarbon (HC) type	Residual proportion (entrained/floating)	Residual volume (liquid m³)	Key credible scenarios informing response planning
Scenario 01	Yes	Breach of support vessel fuel tanks due to collision with seismic vessel	105 m^3	1	Marine diesel	5%	5.25 m^3	Release of up to 105 m^3 marine diesel from support vessel due to collision with the seismic vessel
Scenario 02	Yes	Breach of seismic vessel fuel tanks due to collision with support vessel	190 m^3	1	Marine diesel	5%	9.5 m^3	Release of up to 190 m^3 marine diesel from the seismic vessel due to collision with the support vessel
Scenario 03	Yes	Breach of fuel tanks due to project vessel-other vessel collision including commercial shipping/ fisheries	190 m^3	1	Marine diesel	5%	9.5 m^3	Release of up to 190 m^3 marine diesel from a project vessel due to collision with another vessel
Scenario 04	No	Partial or total failure of a bulk transfer hose or fittings during bunkering, due to operational stress or other integrity issues	<200 L	1	Marine diesel	5%	10 L	Release of <200 L of marine diesel from failure of hose or fittings during bunkering
Scenario 05	No	Partial or total failure of a bulk transfer hose or fittings during bunkering, combined with a failure in procedure to shutoff fuel pumps	8 m^3	1	Marine diesel	5%	0.4 m^3	Release of 8 m^3 of marine diesel from failure of hose or fittings during bunkering

2.2.1 Hydrocarbon characteristics

Hydrocarbon characteristics, including modelled weathering data and ecotoxicity, are included in Section 6.7.2 of the EP.

Marine diesel

Marine diesel is typically classed as an ITOPF Group 2 oil.

From the modelling study outputs, the mass balance forecast for a constant-wind case for marine diesel shows that approximately 45% of the oil is predicted to evaporate within 24 hours. Under these calm conditions the majority of the remaining oil on the water surface will weather at a slower rate due to being comprised of the longer-chain compounds with higher boiling points. Evaporation of the residual compounds will slow significantly, and they will then be subject to more gradual decay through biological and photochemical processes.

Under a variable-wind case, where the winds are of greater strength, entrainment of marine diesel into the water column is indicated to be significant. Approximately 24 hours after the spill, around 45% of the oil mass is forecast to have entrained, a further 35% is forecast to have evaporated and 19% to have dissolved, leaving only a small proportion of the oil floating on the water surface (<1%). The residual components, both entrained or floating, total 9.5m^3 (5%), most of which will tend to remain entrained beneath the surface under conditions that generate wind waves (>6 m/s).

The increased level of entrainment in the variable-wind case will result in a higher percentage of biological and photochemical degradation, where the decay of the floating slicks and oil droplets in the water column occurs at an approximate rate of 1.8% per day with an accumulated total of ~13% after 7 days, in comparison to a rate of ~0.2% per day and an accumulated total of 1.5% after 7 days in the constant-wind case. Given the large proportion of entrained oil and the tendency for it to remain mixed in the water column, the remaining hydrocarbons will decay and/or evaporate over time scales of several weeks to a few months. This long weathering duration will extend the area of potential effect, requiring the break-up and dispersion of the slicks and droplets to reduce concentrations below the thresholds considered in the modelling study.

2.3 Hydrocarbon spill modelling

Oil spill trajectory modelling tools are used for environmental impact assessment and during response planning to understand spatial scale and timeframes for response operations. Woodside recognises that there is a degree of uncertainty related to the use of modelling data and has subsequently utilised conservative approaches to volumes, weathering, spatial areas, timing and response effectiveness to scale capability to need.

The Oil Spill Model and Response System (OILMAP) and Integrated Oil Spill Impact Model System (SIMAP) models have been developed over three decades of planning, exercises, actual responses, several peer reviews, and validation studies. OILMAP was originally derived from the United States Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Type A model (French et al. 1996), for assessing marine transport, biological impact and economic damage that was also used under the United States Oil Pollution Act 1990 Natural Resource Damage Assessment (NRDA) regulations. Notable spills where the model has been used and validated against actual field observations include, Exxon Valdez (French McCay 2004), North Cape Oil Spill (French McCay 2003), along with an assessment of 20 other spills (French McCay and Rowe, 2004). In addition, test spills designed to verify fate, weathering and movement algorithms have been conducted regularly and in a range of climate conditions (French and Rines 1997; French et al. 1997; Payne et al. 2007; French McCay et al. 2007).

Further to this, the algorithms have been updated using the latest findings from the Macondo/Deepwater Horizon well blowout in the Gulf of Mexico and validated according to the Deepwater Horizon (DWH) oil spill in support of the Natural Resource Damage Assessment (NRDA) (Spaulding et al. 2015; French McCay et al. 2015, 2016). Finally, the OILMAP and SIMAP models have been used extensively in Australia to prosecute pollution offences, predict discharge locations and likely spill volumes based on weathering and surveillance observations, and has been used as expert witness evidence in Australian court proceedings, aiding the prosecution to determine spill quantum estimates.

2.3.1 Stochastic modelling

Stochastic modelling has been completed for the scenarios outlined in Table 2-1. The scope of the PAP includes undertaking marine seismic surveys across three discrete areas (A, B and C). Given the separate areas, two modelling scenarios have been applied to the two areas (A and C) closest to sensitive receptors. One is a 190 m^3 release of marine diesel at Area A (APASA 2013), and 190 m^3 release of marine diesel at a release location along the eastern boundary of Area C (RPS 2019).

No quantitative assessment of a release of marine diesel resulting from a vessel collision incident has been undertaken for Area B as part of this EP because Area A and Area C have been determined as the WCCS being closer to shore than Area B.

A total of 400 replicate simulations were completed for the scenarios to test for trends and variations in the trajectory and weathering of the spilled oil, with an even number of replicates completed using samples of metocean data that commenced within each calendar quarter. Further details relating to the assessments for the scenarios can be found in Section 6.7.1 of the EP.

2.3.1.1 Environmental impact thresholds – Environment that May Be Affected (EMBA) and hydrocarbon exposure

The outputs of the stochastic spill modelling are used to assess the potential environmental impact from the credible scenarios. The stochastic modelling results are used to delineate areas of the marine and shoreline environment that could be exposed to hydrocarbon levels exceeding environmental impact threshold concentrations. The summary of all the locations where hydrocarbon thresholds could be exceeded by any of the simulations modelled is defined as Environment that May Be Affected (EMBA) and is discussed further in Section 6.7.1 of the EP. As the weathering of different fates of hydrocarbons (surface, entrained and dissolved) differs due to the influence of the metocean mechanism of transportation, a different EMBA is presented for each fate within the EP.

A conservative approach – adopting accepted contact thresholds for impacts on the marine environment – is used to define the EMBA. These hydrocarbon thresholds are presented in Table 2-2 below and described in Section 6.7.1 of the EP.

Table 2-2: Summary of thresholds applied to the stochastic hydrocarbon spill modelling to determine EMBA and environmental impacts

Threshold	Description
10 g/m^2	Surface hydrocarbon
500 ppb	Entrained hydrocarbon (ppb)
500 ppb	Dissolved aromatic hydrocarbon (ppb)
100 g/m^2	Shoreline accumulation

2.3.1.2 Response planning thresholds for surface and shoreline hydrocarbon exposure

Thresholds to determine the EMBA are used to predict and assess environmental impacts and inform the Scientific Monitoring Program (SMP), however they do not appropriately represent the thresholds at which an effective response can be implemented. Additional response thresholds are used for response planning and to determine areas where response techniques would be most effective. These are summarised in Table 2-3.

In the event of an actual response additional modelling would be conducted using real-time data and field information to inform Incident Management Team decisions.

Surface spill concentrations are expressed as grams per square metre (g/m^2) (Section 2.2). The thresholds used are derived from oil spill response planning literature and industry guidance and are summarised below.

2.3.1.3 Surface hydrocarbon concentrations

Table 2-3: Surface hydrocarbon thresholds for response planning

Surface hydrocarbon concentration (g/m^2)	Description	Bonn Agreement Oil Appearance Code (BAOAC)	Mass per area (g/m^2)
>10	Predicted minimum threshold for commencing operational monitoring	Code 3 – Dull metallic colours	5 to 50
50	Predicted minimum floating oil threshold for containment and recovery and surface dispersant application [1]	Code 4 – Discontinuous true oil colour	50 to 200
100	Predicted optimum floating oil threshold for containment and recovery and surface dispersant application	Code 5 – Continuous true oil colour	>200
Shoreline hydrocarbon concentration (g/m^2)	**Description**	**National Plan Guidance on Oil Contaminated Foreshores**	**Mass per area (g/m^2)**
100	Predicted minimum shoreline accumulation threshold for shoreline assessment operations	Stain	>100
250	Predicted minimum threshold for commencing shoreline clean-up operations	Level 3 - Thin Coating	200 to 1000

The surface thickness of oil at which dispersants are typically effective is approximately 100 g/m^2. However, substantial variations occur in the thickness of the oil within the slick, and most fresh crude oils spread within a few hours, so that overall the average thickness is 0.1 mm (or approx. 100 g/m^2) [ITOPF] 2011). Additionally, the recommended rate of application for surface dispersant is typically 1-part dispersant to 20 or 25 parts of spilled oil. These figures assume a 0.1 mm slick thickness, averaged over the thickest part of the spill, to calculate a litres/hectare application rate from vessels and aircraft. In practice, this can be difficult to achieve as it is not possible to accurately assess the thickness of the floating oil.

Some degree of localised over-dosage and under-dosage is inevitable in dispersant response. An average oil layer thickness of 0.1 mm is often assumed, although the actual thickness can vary over a wide range (from less than 0.0001 mm to more than 1 mm) over short distances (International Petroleum Industry Environment Conservation Association [IPIECA] 2015).

Guidance from the Australian Maritime Safety Authority (AMSA 2015) indicates that spreading of spills of Group 2 or 3 products will rapidly decrease slick thickness over the first 24 hours of a spill resulting in the potential requirement of up to a ten (10) fold increase in capability on day 2 to achieve the same level of performance.

Further guidance from the European Maritime Safety Authority (EMSA) states that spraying the 'metallic' looking area of an oil slick (Bonn Agreement Oil Appearance Code [BAOAC] 3, approx. 5 to 50 μm) with dispersant from spraying gear designed to treat an oil layer 0.1 mm (100 μm) thick, will inevitably cause dispersant over-treatment by a factor of 2 to 20 times (EMSA 2012).

[1] At 50g/m^2, containment and recovery and surface dispersant application operations are not expected to be particularly effective. This threshold represents a conservative approach to planning response capability and containing the spread of surface oil.

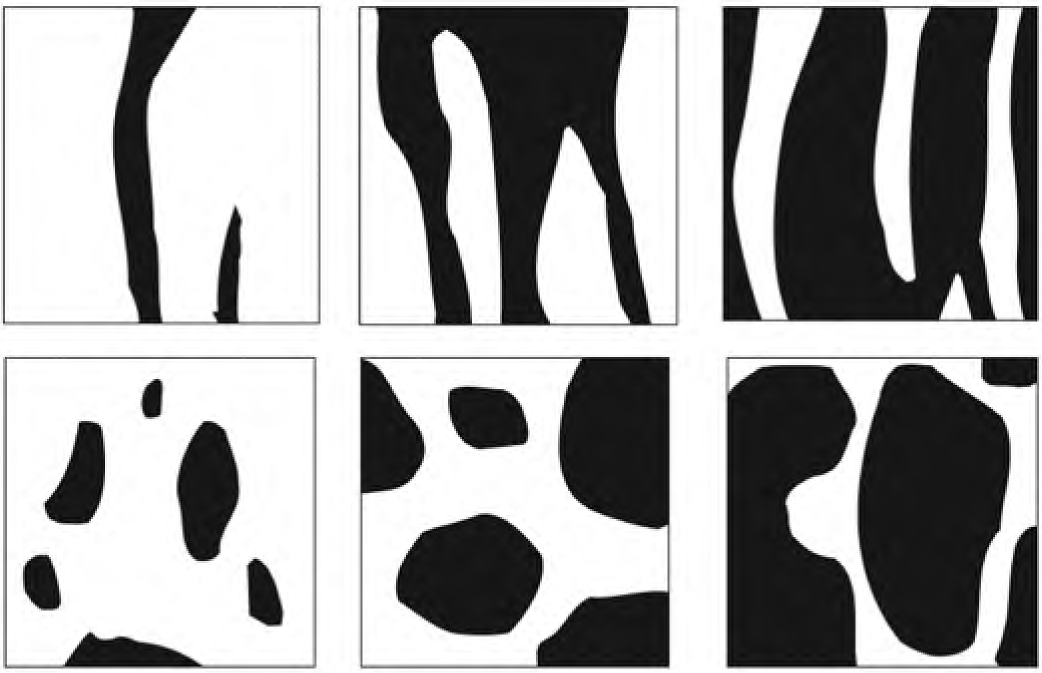
Therefore, dispersant application should be concentrated on the thickest areas of an oil slick and Woodside intends on applying surface dispersants to only BAOAC 4 and 5. Spraying areas of oil designated as BAOAC Code 4 (Discontinuous true oil colour) with dispersant will, on average, deliver approximately the recommended treatment rate of dispersant.

Spraying areas of oil designated as BAOAC Code 5 with dispersant (Continuous true oil colour and more than 0.2 mm thick) will, on average, deliver approximately half the recommended treatment rate of dispersant. Repeated application of these areas of thicker oil, or increased dosage ratios, will be required to achieve the recommended treatment rate of dispersant (EMSA 2012).

Guidance from the National Oceanic and Atmospheric Administration (NOAA) in the United States is found in the document: *Characteristics of Response Strategies: A Guide for Spill Response Planning in Marine Environments 2013* (NOAA 2013). This guide outlines advice for response planning across all common techniques, including surface dispersant spraying and containment and recovery. It states that oil thickness can vary by orders of magnitude within distinct areas of a slick, thus the actual slick thickness and oil distribution of target areas are crucial for determining response method feasibility. Further to this, ITOPF also states that in terms of oil spill response, sheen can be disregarded as it represents a negligible quantity of oil, cannot be recovered or otherwise dealt with to a significant degree by existing response techniques, and is likely to dissipate readily and naturally (ITOPF 2014).

Figure 2-3 below from AMSA's Identification of Oil on Water – Aerial Observation and Identification Guide (AMSA 2014) shows expected percent coverage of surface hydrocarbons as a proportion of total surface area. Wind-rows, heavy oil patches and tar balls, for example, must be considered, as they influence oil encounter rates, chemical dosages and ignition potential. Each method has different thickness thresholds for effective response.

From this information and other relevant sources (Allen and Dale 1996, EMSA 2012, Spence 2018) the surface threshold of 50 g/m^2 was chosen as an average / equilibrium thickness (50 g/m^2 is an average is 50% coverage of 0.1 mm Bonn Agreement Code 4 - discontinuous true oil colour, or 25% coverage of 0.2 mm Bonn Agreement Code 5 – continuous true oil colour which would represent small patches of thick oil or wind-rows.



25% 50% 75%

Figure 2-3: Proportion of total area coverage (AMSA 2014)

Figure 2-4 illustrates the general relationships between on-water response techniques and slick thickness. Wind-rows, heavy oil patches and tar balls, for example, must be considered, as they influence oil encounter rates, chemical dosages and ignition potential. Each method has different thickness thresholds for effective response.

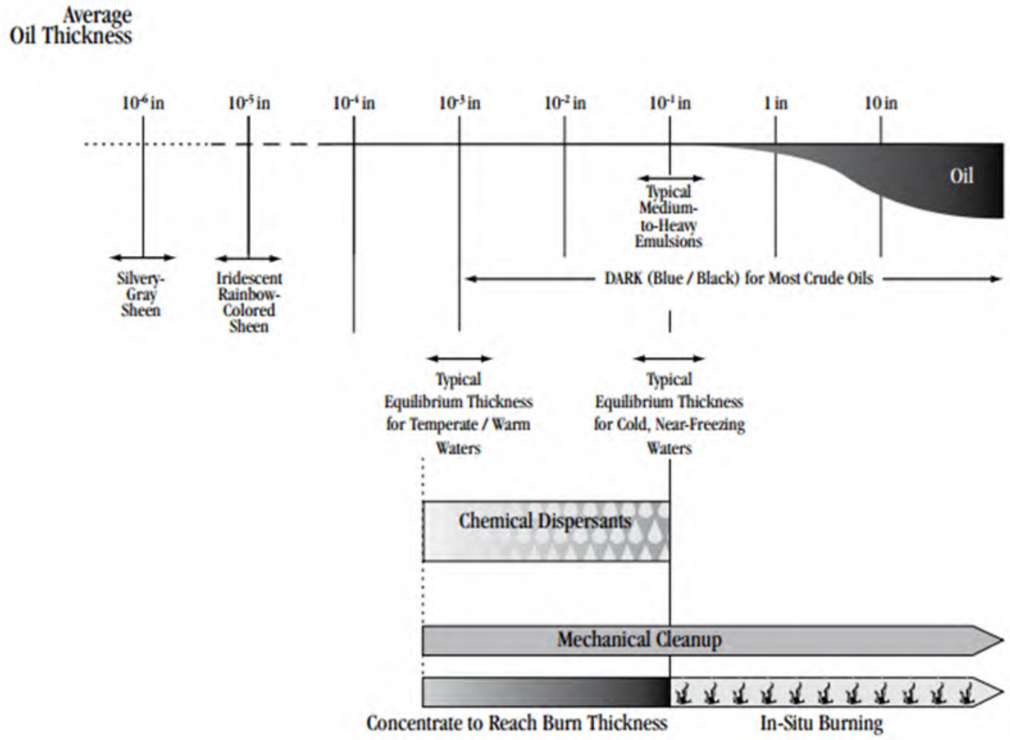


Figure 2-4: Oil thickness versus potential response options (from Allen and Dale 1996)

Wind and wave influence on the feasibility of mechanical clean-up operations drops significantly because of entrainment and/or splash-over as short period waves develop beyond 2–3 ft (0.6–0.9 m) in height. Waves and wind can also be limiting factors for the safe operation of vessels and aircraft.

2.3.2 Spill modelling results

The following spill modelling results are provided:

Details of the scenario and modelling inputs are included along with the following modelling results in Table 2-4.

- Area C: Fastest time to shoreline contact (above 100g/m^2);
- Area C: Largest volume ashore at any single RPA (above 100g/m^2); and
- Area C: Largest volume ashore on all shorelines from a single model run (above 100g/m^2).

Table 2-4: Worst case credible scenario modelling results (Area C)

Scenario description	Results
Worst-case credible scenario(s) (WCCS) Total volume released (m^3 in hours)	Hydrocarbon release due to vessel collision Surface – 190 m^3 over 4 hours
Worst-case credible scenario(s) (WCCS) Residual volume remaining post-weathering (m^3)	Surface/subsurface – 9.5 m^3
Minimum time to shoreline contact (above 100 g/m^2)	24 hours (Day 2) at Ningaloo Coast North and WHA (first shoreline contact totals 31 m^3)
Largest volume ashore at any single RPA (above 100 g/m^2)	39 m^3 at Ningaloo Coast North and WHA. This is the accumulated volume by Day 3.
Largest total shoreline accumulation (above 100 g/m^2) all shorelines	2,594 g/m^2 at Ningaloo Coast North and WHA.

Response planning has been based on the above modelling results and is detailed in Section 4.2.

3 IDENTIFY RESPONSE PROTECTION AREAS (RPAs)

In a response, operational monitoring programs – including trajectory modelling and vessel/aerial observations – would be used to predict RPAs that may be impacted. For the purposes of planning and appropriately scaling a response, modelling has been used to identify RPAs as outlined below in Figure 3-1.

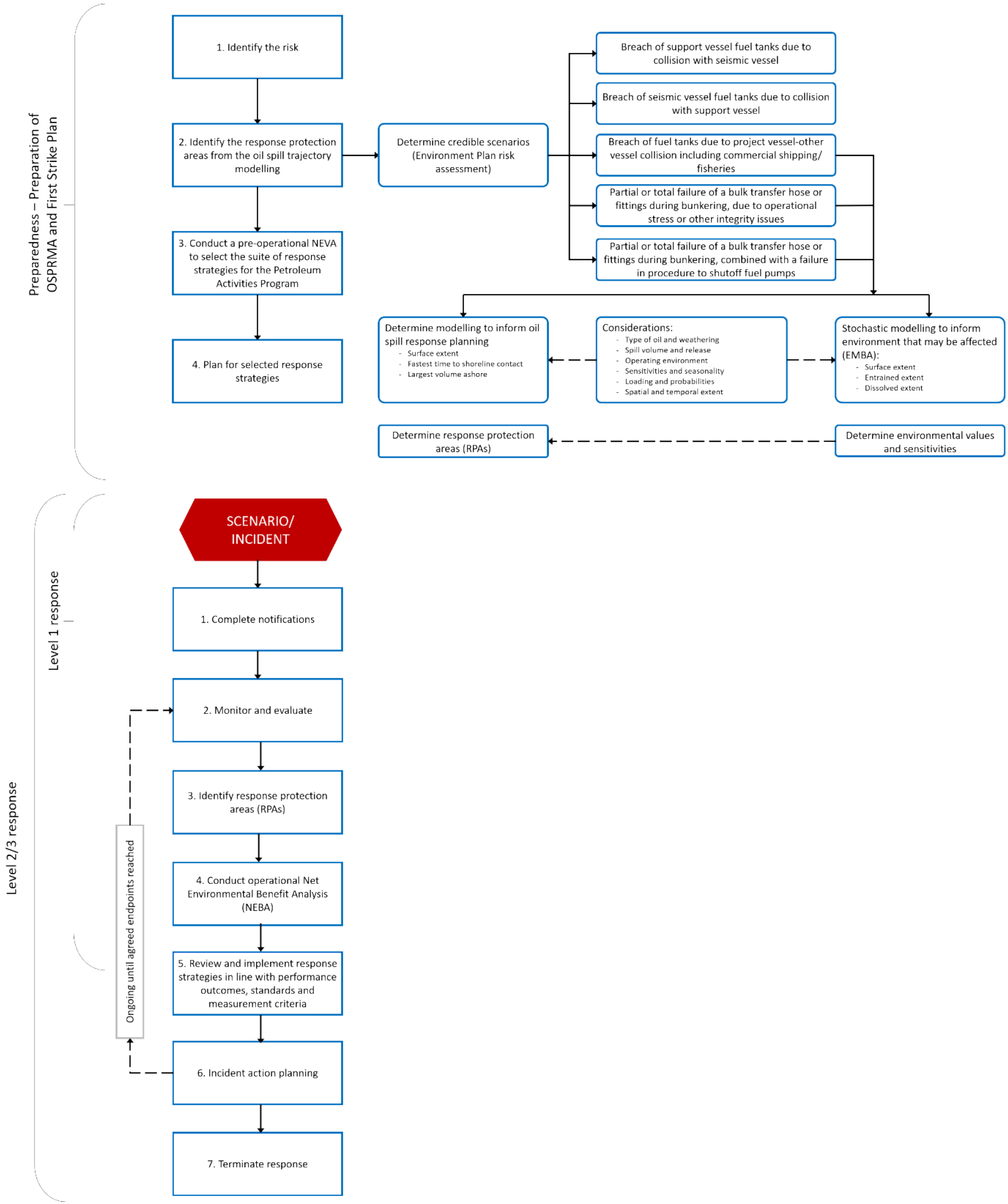


Figure 3-1: Identify Response Protection Areas flowchart

3.1 Identified sensitive receptor locations

Section 6.7.2 of the EP includes the list of sensitive receptor locations that have been identified by stochastic modelling as meeting the requirements outlined below:

- Receptors with the potential to incur surface, entrained or shoreline accumulation contact above environmental impact thresholds
- Receptors within the EMBA which meet the following:
  - a number of priority protection criteria/categories
  - International Union for Conservation of Nature (IUCN) marine protected area categories
  - high conservation value habitat and species
  - important socio-economic/heritage value.

3.2 Identify Response Protection Areas

RPAs have been selected on the basis of their environmental ecological, social, economic, cultural and heritage values and sensitivities as described in Section 6 of the EP. Only those at which a shoreline response could feasibly be conducted (accumulation >100 g/m^2 for shoreline assessment and/or contact with surface slicks >10 g/m^2 for operational monitoring as specified in Table 2-4) have been selected for response planning purposes.

3.2.1 Response Protection Areas (RPAs)

While not discounting other sensitivities, the identified RPAs have been used as the basis for demonstrating the capability to respond to the nature and scale of a spill from the WCCS and prioritising response techniques.

Table 3-1 outlines the location which was identified from the modelling runs for the WCCS (see Section 6.7.2 of the EP). Additional sensitive receptors are presented in the existing environment description (Section 4 of the EP) and impact assessment section (Section 6.7.2 of the EP) for each respective spill scenario. The pre-operational NEBA (Section 4) considers the results from the stochastic modelling to ensure all feasible response techniques are considered in the planning phase, therefore additional receptors are also included in the pre-operational NEBA.

The RPA identified in Table 3-1 is used to plan for the nature and scale of a shoreline response.

Table 3-1: Response Protection Areas from modelling

Areas of coastline contacted	Conservation status	IUCN protection category	Minimum time to shoreline contact (above 100 g/m^2) in hours [2]	Maximum shoreline accumulation (above 100 g/m^2) in m^3 [3]
Ningaloo Coast North and WHA	State waters Marine Park World Heritage Area Australian Marine Park (AMP)	IV – Recreational Use Zone	24 hours (Day 2) (first shoreline contact totals 31 m^3)	39 m^3. This is the accumulated volume by Day 3

[2] This volume and time represent the first time to contact on defined shoreline polygon and the maximum volume ashore for that 24 hour period.
[3] This volume and time represent the maximum volume ashore on defined shoreline polygon for any 24 hour time period.

4 NET ENVIRONMENTAL BENEFIT ANALYSIS (NEBA)

A NEBA is a structured process to consider which response techniques are likely to provide the greatest net environmental benefit.

The NEBA process typically involves four key steps outlined in Figure 4-1: evaluate data, predict outcomes, balance trade-offs, and select response options. These steps are followed in the planning/preparedness process and would also be followed in a response.

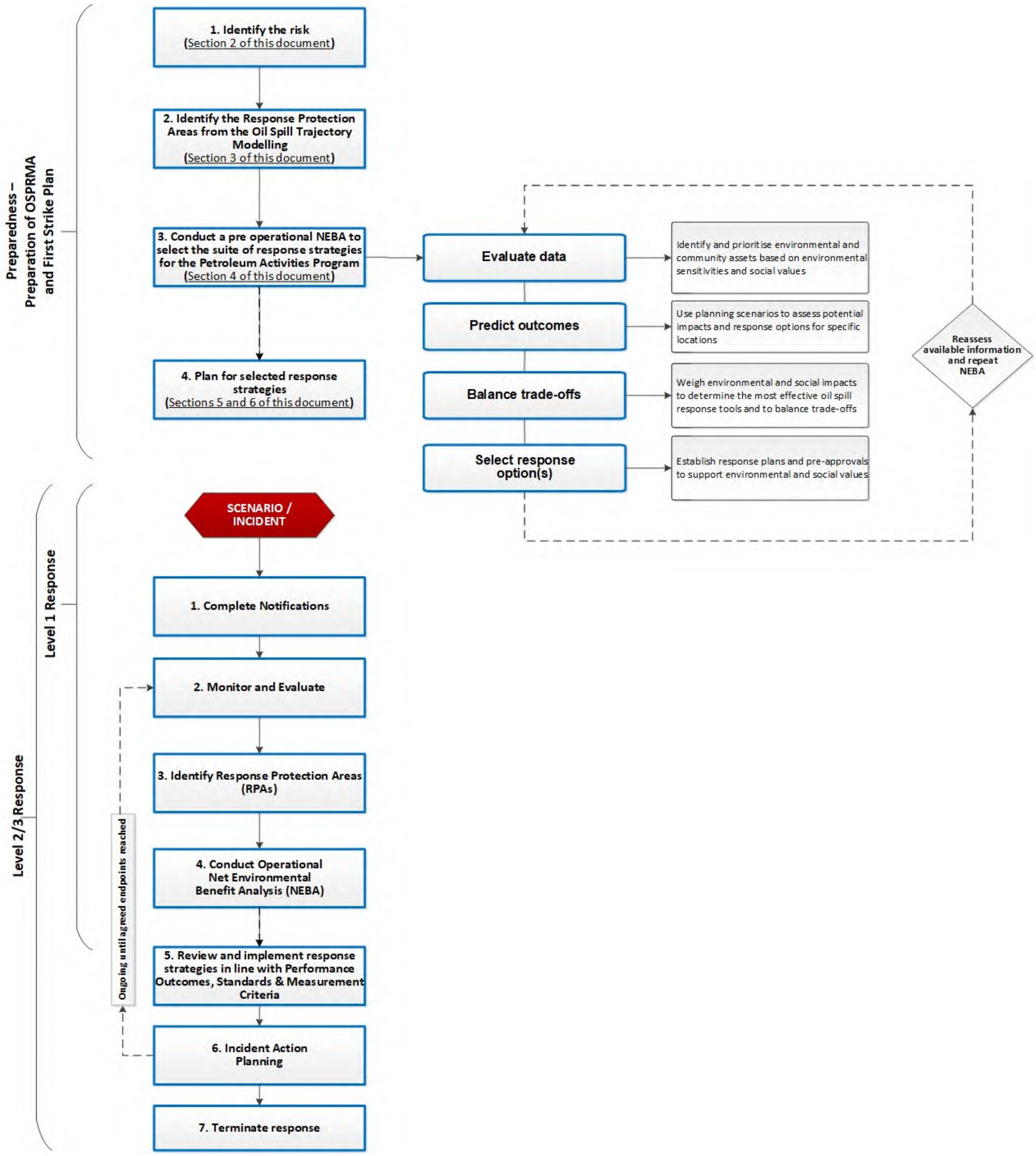


Figure 4-1: Net Environmental Benefit Analysis flowchart

4.1 Pre-operational / Strategic NEBA

The pre-operational NEBA identifies positive and negative impacts to sensitive receptors from implementing the response techniques. Feasibility is considered by assessing the receptors potentially impacted above response thresholds (Section 2.3.1.2) and the surface concentrations (Section 2.3.2) from the modelling.

Completing a pre-operational NEBA is a key response planning control that reduces the environmental risks and impacts of implementing the selected response techniques. Comprehensive details of the pre-operational NEBA for this PAP are contained in ANNEX A: NEBA detailed outcomes.

4.2 Stage 1: Evaluate data

Woodside identifies and prioritises environmental and community assets based on environmental sensitivities and social values, informed through the use of trajectory modelling. Interpretation of stochastic oil spill modelling determines the EMBA for the release, which defines the spatial area that may be potentially impacted by the PAP activities.

4.2.1 Define the scenario(s)

Woodside uses scenarios identified from the risk assessment in the EP to assess potential impacts and response options for specific locations. The WCCS is then selected for modelling and is used for this pre-operational NEBA. Outlier locations with potential environmental impacts, selected from the stochastic modelling may also be included for assessment. Response thresholds and modelling are then used to assess the feasibility/effectiveness and scale of the response.

Table 4-1: Scenario summary information (WCCS)

Scenario summary information (WCCS)	
Scenario	Hydrocarbon release due to vessel collision Surface release
Location	Area C
Oil Type	Marine diesel
Fate and Weathering	Based on the modelling results, under a constant-wind case ~45% of the oil is predicted to evaporate within 24 hours. Under these calm conditions the majority of the remaining oil on the water surface will weather at a slower rate. Under a variable-wind case, entrainment of marine diesel into the water column is indicated to be significant. Approximately 24 hours after the spill, around 45% of the oil mass is forecast to have entrained, a further 35% is forecast to have evaporated and 19% to have dissolved. This will leave a small proportion of the oil floating on the water surface (<1%). The overall residual components, both floating and entrained, total 9.5m^3 (or 5% total volume).
Volume and duration of release	190 m^3 instantaneous release at 50 m^3/hr

4.2.1.1 Hydrocarbon characteristics

Marine diesel

Marine diesel is classed as an ITOPF Group 2 oil. It is a mixture of volatile and persistent hydrocarbons with some residual components. The fate and effects are detailed in Section 2.2.1.

Table 4-2: Oil fate, behaviour and impacts

Area C - Ningaloo Coast North and WHA RPA	
Minimum time to shoreline contact (above 100 g/m²)	24 hours (Day 2) at Ningaloo Coast North and WHA (first shoreline contact totals 31 m³).
Largest volume ashore at any single RPA (above 100 g/m²)	39 m³ at Ningaloo Coast North and WHA. This is the accumulated volume by Day 3.
Largest total shoreline accumulation (above 100g/m²)	2,594 g/m²

4.2.1.2 Determining potential response options

The available response techniques based on current technology can be summarised under the following headings:

- Monitor and evaluate (including operational monitoring)
- Source control via vessel SOPEP
- Containment and recovery
- In-situ burning
- Surface dispersant application:
  - aerial dispersant application
  - vessel dispersant application
- Mechanical dispersion
- Shoreline protection and deflection:
  - protection
  - deflection
- Shoreline clean-up:
  - Phase 1 – Mechanical clean-up
  - Phase 2 – Manual clean-up
  - Phase 3 – Final polishing
- Oiled wildlife response

Support functions include:

- Waste management
- Scientific monitoring

An assessment of the feasible response options for the scenario is included below in Table 4-3. These options are evaluated against parameters including oil type, volume and characteristics, prevailing weather conditions, logistical support, and resource availability to determine their deployment feasibility.

A shortlist of the feasible response options is then carried forward for the ALARP assessment with a justification for the exclusion of other response techniques included in Section 4.2.2. This assessment will typically result in a range of available options, that are deployed at different areas (at-source, offshore, nearshore and onshore) and times through the response. The NEBA process assists in prioritising which options to use where and when, and at which stages throughout the response.

Table 4-3: Response technique evaluation – surface release of marine diesel

Response Technique	Effectiveness	Feasibility	Decision	Rationale for the decision
Monitor and Evaluate	Marine diesel is visible on the water surface and the movement of slicks can be visually monitored. Components of marine diesel may remain entrained in the water column, which can be determined using monitoring methods.	Monitoring of a marine diesel spill is a feasible response technique and outputs can be used to guide decision making on the use of other response techniques. Techniques include predictive modelling, surveillance and reconnaissance, monitoring of hydrocarbon presence in water, pre-emptive assessment of sensitive receptors at risk, and monitoring of contaminated resources.	**Yes**	• Validates trajectory and weathering models • Determines location and state of the slick • Provides forecasts of spill trajectory • Determines effectiveness of response techniques • Confirms impact to receptors
Source control via vessel SOPEP	Controlling the spill of marine diesel at source would be the most effective way to limit the quantity of hydrocarbon entering the marine environment.	A spill of marine diesel from a vessel collision will be instantaneous and source control will be limited to what the vessel or facility can achieve whilst responding to the incident.	**Yes**	Ability to stop or minimise the spill at source will be dependent upon the specific spill circumstances and whether it is safe for response personnel to access/isolate the source of the spill.
Containment and Recovery	Rapid spreading and thinning of marine diesel would make containment and recovery an ineffective response technique.	Inappropriate for use on marine diesel due to potential vapours posing a safety risk to responders.	**No**	Marine diesel would evaporate and spread too thinly to allow this response technique to be effective.
In situ burning	Marine diesel is not suitable for in situ burning due to rapid evaporation, minimum thickness requirements and window of opportunity.	Inappropriate for use on marine diesel	**No**	Inappropriate for use on marine diesel
Surface Dispersant Application	Dispersants are not considered effective when applied on thin surface films such as marine diesel, as the dispersant droplets tend to pass through the surface films without binding to the hydrocarbon.	Inappropriate for use on marine diesel	**No**	Inappropriate for use on marine diesel
Mechanical dispersion	Mechanical disturbance of the slick will encourage further entrainment thus decreasing the volume of floating hydrocarbon potentially impacting the shoreline and promoting additional natural biodegradation. Increased entrainment may expose additional marine organisms to aromatic hydrocarbons in the water column.	Although this technique is feasible, natural met ocean conditions would negate the need. In addition, safety of response personnel and the potential presence of key sensitive receptors may prohibit this technique.	**No**	Mechanical dispersion using vessel agitation is not considered necessary in open water met ocean conditions as natural agitation from wind and wave action would occur.
Shoreline Protection and Deflection	Shoreline protection and deflection can be effective at preventing contamination of sensitive resources.	The modelling undertaken predicts that a marine diesel spill would be prone to rapid spreading and evaporation preventing effective protection and deflection operations within the minimum time to shoreline contact (23 hours).	**No**	Not appropriate technique due to the hydrocarbon characteristics and predicted minimum time to shoreline contact.
Shoreline Clean up	Shoreline clean-up is an effective means of hydrocarbon removal from contaminated shorelines where coverage is at an optimum level of 250 g/m^2.	The modelling undertaken predicts that a marine diesel spill would be prone to rapid spreading and evaporation, however, there is predicted to be contact above 100 g/m^2 at the RPA within 23 hours and 250 g/m^2 (40 m^3) at the RPA within 24 hours. If Monitor and Evaluate activities indicate hydrocarbons in sufficient concentration will contact shorelines (at 250 g/m^2), existing TRPs will be utilised to guide response operations.	**Yes**	RPAs predicted to be contacted are based on modelling outputs and thus may differ under the prevailing conditions of a real event. If RPAs are at risk, based on real-time modelling during a spill event, shoreline clean-up techniques will be deployed to expedite clean-up of the impacted sites. This will only be feasible where coverage is around 250 g/m^2.
Oiled Wildlife	Oiled wildlife response is an effective response technique for reducing the overall impact of a spill on wildlife. This is mostly achieved through hazing to prevent additional fauna from being contaminated and through rehabilitation of fauna already subject to contamination.	Hazing of seabirds is likely to be the most effective element of an oiled wildlife response and would be undertaken as directed by monitoring and evaluation. In addition, any wildlife rehabilitation could only be undertaken by trained specialists.	**Yes**	Seabirds are unlikely to be present in any large numbers but are nevertheless vulnerable to surface exposures if in close proximity to a marine diesel spill event. Unlikely to be effective for marine mammals and reptiles but response to any oiled wildlife will be undertaken as and where required.

4.2.2 Exclusion of response techniques

4.2.2.1 Containment and Recovery

Rapid spreading and thinning of diesel would result in a marginal reduction in diesel on the surface. Diesel would evaporate and spread too thinly to allow this response technique to be effective.

4.2.2.2 In situ Burning

Diesel is not suitable for in situ burning due to rapid evaporation, minimum thickness requirements and window of opportunity.

4.2.2.3 Surface dispersant application

Dispersants are not considered effective when applied on thin surface films such as diesel, as the dispersant droplets tend to pass through the surface films without binding to the hydrocarbon, making it unsuitable for effective treatment. A marine diesel spill is also expected to dissipate rapidly on the surface and become entrained due to local metocean conditions.

4.2.2.4 Mechanical dispersion

Mechanical dispersion using vessel agitation is not considered necessary in open water metocean conditions as natural agitation from wind and wave action would occur.

4.2.2.5 Shoreline Protection and Deflection

The modelling undertaken predicts that a diesel spill would be prone to rapid spreading and evaporation preventing effective protection and deflection operations within the minimum time to shoreline contact (23 hours).

4.3 Stage 2: Predict Outcomes

Woodside uses planning scenarios to assess potential impacts and response options for specific locations. Locations with potential environmental impacts, selected from the stochastic modelling are included for assessment. Response thresholds and modelling are then used to assess the feasibility/effectiveness of a response.

4.4 Stage 3: Balance trade-offs

Woodside considers environmental impacts and response effectiveness/feasibility to determine the most effective oil spill response tools and balance trade-offs, using an automated NEBA tool. The tool considers potential benefits and impacts associated with a response at sensitive receptors and then considers the effectiveness/feasibility of the response to select the response techniques carried forward to the ALARP assessment (ANNEX A: NEBA detailed outcomes).

4.5 Stage 4: Select Best Response Options

To select the response technique, all the other stages in the NEBA process are considered and used to establish response plans and any pre-approvals to support protection of identified environmental and social values.

The response techniques implemented may vary according to a particular spill. The hydrocarbon type released and the sensitivities of the receptors (both ecological and socio-economic) may influence the response. The pre-operational NEBA broadly evaluates each response technique and supports decisions on whether they are feasible and of net environmental benefit. Response techniques that are not feasible or beneficial are rejected at this stage and not progressed to planning.

Further risks and impacts from implementing these selected response options are outlined in Section 7.

Table 4-4: Selection and prioritisation of response techniques

Response planning scenario	Key characteristics for response planning (times are minimum times to contact for first receptor and/or shoreline contacted above response threshold)	Feasibility of response techniques									Outline response technique
		Monitor and evaluate	Source control via vessel SOPEP	Containment and recovery	In situ burning	Surface dispersant application	Mechanical dispersion	Shoreline protection and deflection	Shoreline clean-up	Oiled wildlife response	
Release of up to 190 m^3 marine diesel from a vessel collision	Fastest time to shoreline accumulation >100 g/m^2: 23 hours (Ningaloo Coast North and WHA (first shoreline contact totals 31 m^3). Largest shoreline accumulation: 39 m^3 at Ningaloo Coast North and WHA. This is the accumulated volume by Day 3.	Yes Primary Technique	Yes	No	No	No	No	No	Yes	Yes	Monitor and evaluate. Vessel SOPEP. Plan for shoreline monitoring and clean-up where contact predicted above response threshold. Plan for oiled wildlife response and implement if oiled wildlife is observed.

From the NEBA undertaken on the WCCS identified (Area C) for the North-west Australia 4D Marine Seismic Survey, the primary response techniques are;

- Monitor and evaluate
- Source control via vessel SOPEP
- Shoreline clean-up on priority impacted coastlines
- Oiled wildlife response, based on monitor and evaluate outputs and field reports

Support functions may include:

- Waste management
- Scientific monitoring programs

5 HYDROCARBON SPILL ALARP PROCESS

Woodside's hydrocarbon spill ALARP process is aligned with guidance provided by NOPSEMA in *Guideline N-04750-GL1687* (NOPSEMA 2016) and is set out in the 'Woodside Hydrocarbon Spill Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) Development Guidelines'.

From the identified response planning need and pre-operational NEBA, Woodside conducts a structured, semi-quantitative hydrocarbon spill process which has the following steps:

1. Considers the Response Planning Need identified from the modelling against existing Woodside capability;
2. Considers alternative, additional, and improved options for each response technique/control measure by providing an initial and, if required, detailed evaluation of;
    - Predicted cost associated with adopting the control measure,
    - Predicted change/environmental benefit, and
    - Predicted effectiveness/feasibility of the control measure.
3. Evaluates the risks and impacts of implementing the proposed response techniques, and any further control measures with associated environmental performance to manage these additional risks and impacts.

Woodside considers the risks and impacts from a hydrocarbon spill to have been reduced to ALARP when:

1. A structured process for identifying and considering alternative, additional, and improved options has been completed for each selected response technique;
2. The analysis of alternate, additional, and improved control measures meets one of the following criteria:
    - All identified, reasonably practicable control measures have been adopted; or
    - No identified reasonably practicable additional, alternative and/or improved control measures would provide further overall increased proportionate environmental benefit; or
    - No reasonably practical additional, alternative, and/or improved control measures have been identified.
3. Where an alternative, additional and/or improved control measure is adopted, a measurable level of environmental performance has been assigned.
4. Higher order impacts/ risks have received more comprehensive alternative, additional, and improved control measure evaluations and do not just compare the cost of the adopted control measures to the costs of an extreme or clearly unreasonable control measure.
5. Cumulative effects have been analysed when considered in combination across the whole activity.

The response technique selection is based on the risk assessment conducted in the EP. The risk assessment identifies the type of oil, volume of release, duration of release, predicted fate, weathering and the EMBA (along with other requirements such as time to impact and predicted volumes ashore). Modelling is then used to inform the NEBA and the prioritisation of suitable response options. The scale of the response techniques selected in the pre-operational NEBA is informed through the assessment of results from modelling.

For the purpose of the ALARP assessment, the following terms and definitions have been used:

- Response techniques are considered the control measures that reduce consequences from hydrocarbon spill events. The terms 'response technique' and 'control measure' are used interchangeably.

- Cost is defined as the time, effort and/or trouble taken in financial, safety, design/storage/installation, capital/lease, and/or operations/maintenance terms to adopt a control measure.
- Where the predicted change to environmental impact is compared against standard environmental values and sensitivities impacts using positive or negative criteria from the NEBA Impact Ranking Classification Guidance in **ANNEX A**.

5.1 Monitor and Evaluate (including operational monitoring)

Monitor and evaluate includes the gathering and evaluation of data to inform the oil spill response planning and operations. It includes fate and trajectory modelling, spill tracking, weather updates and field observations. This response option is deployed in some capacity for every event.

The table below provides the operations monitoring plans that support the successful execution of this response technique.

Table 5-1: Supporting operational monitoring plans

ID	Title
OM01	Predictive modelling of hydrocarbons to assess resources at risk
OM02	Surveillance and reconnaissance to detect hydrocarbons and resources at risk
OM03	Monitoring of hydrocarbon presence, properties, behaviour and weathering in water
OM04	Pre-emptive assessment of sensitive receptors at risk
OM05	Shoreline assessment

Woodside maintains an *Operational Monitoring Operational Plan*. If shoreline contact is predicted, RPAs will be identified and assessed before contact. If shorelines are contacted, a shoreline assessment survey will be completed to guide effective shoreline clean-up operations. This plan includes the process for the IMT to mobilise resources depending on the nature and scale of the spill.

The proximity of Exmouth to the spill event location means that multiple logistical options are available to monitor the spill in relatively short timeframes. The primary mobilisation base for initial monitoring activities would be Exmouth. However, in the event of an extended spill with potential to impact receptors further afield, monitoring activities may also be mobilised from Exmouth.

5.1.1 Response need based on predicted consequence parameters

The following statements identify the key parameters upon which a response need can be based:

- Floating surface oil in sufficient concentrations for effective operational monitoring is expected to be >10 g/m^2 with surface concentrations of 100 g/m^2 up to 22 km from the vessel location for the WCCS surface release.
- The shortest timeframe that shoreline contact from floating oil is predicted to be 24 hours (Day 2).
- The time to contact for oil at concentrations of entrained hydrocarbons greater than 500 ppb at receptor waters is 1 hour at Ningaloo Coast North.
- Arrangements for support organisations who provide specialist services or resources should be tested regularly.
- Plans, procedures and support documents need to be in place for Operational and Support functions. These should be reviewed and updated regularly.
- The duration of the spill may extend up to 4 hours, with response operations extending to four (4) days based on the predicted time to complete shoreline clean-up operations.

5.1.2 Environmental performance based on need

Table 5-2: Environmental Performance – Monitor and Evaluate

Environmental Performance Outcome		To gather information from multiple sources to establish an accurate common operating picture as soon as possible and predict the fate and behaviour of the spill to validate planning assumptions and adjust response plans as appropriate to the scenario.		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.8)**
1	Oil spill trajectory modelling	1.1	Initial modelling available within 6 hours using the Rapid Assessment Tool	1, 3B, 3C, 4
		1.2	Detailed modelling available within 4 hours of APASA receiving information from Woodside	
		1.3	Detailed modelling service available for the duration of the incident upon contract activation	
2	Tracking buoy	2.1	Tracking buoy located on facility/vessel and ready for deployment 24/7	1, 3A, 3C, 4
		2.2	Deploy tracking buoy from facility within 2 hours as per the First Strike Response Plan.	1, 3A, 3B, 4
		2.3	Contract in place with service provider to allow data from tracking buoy to be received 24/7 and processed.	1, 3B, 3C, 4
		2.4	Data received to be uploaded into Woodside COP daily to improve the accuracy of other monitor and evaluate strategies.	1, 3B, 4
3	Satellite imagery	3.1	Contract in place with 3rd party provider to enable access and analysis of satellite imagery. Imagery source/type requested on activation of service.	1, 3C, 4
		3.2	3rd party provider will confirm availability of an initial acquisition within 2 hours	1, 3B, 3C, 4
		3.3	First image received within 24 hours of Woodside confirming to 3rd party provider its acceptance of the proposed acquisition plan.	1
		3.4	3rd party provider to submit report to Woodside per image. Report is to include a polygon of any possible or identified slick(s) with metadata.	1
		3.5	Data received to be uploaded into Woodside COP daily to improve accuracy of other monitor and evaluate strategies.	1, 3B, 4
		3.6	Satellite Imagery services available and employed during response	1, 3C, 4
4	Aerial surveillance	4.1	2 trained aerial observers available to be deployed by day 1 from resource pool.	1, 2, 3B, 3C, 4
		4.2	One aircraft available for two sorties per day, available for the duration of the response from day 1.	1, 3C, 4
		4.3	Observer to compile report during flight as per First Strike Response Plan. Observers report available to the IMT within 2 hours of landing after each sortie.	1, 2, 3B, 4
		4.4	Unmanned Aerial Vehicles/Systems (UAV/UASs) to support Shoreline Clean-up Assessment Teams (SCAT), containment and recovery and surface dispersal and pre-emptive assessments as contingency if required.	1, 2
5	Hydrocarbon detections in water	5.1	Activated 3rd party service provider as per First Strike Response Plan. Deploy resources by Day 1: • 2 specialists in water quality monitoring	1, 2, 3C, 3D, 4
		5.2	Water monitoring services available and employed during response	1, 3C, 4
		5.3	Preliminary results of water sample as per contractor's implementation plan within 7 days of receipt of sample at accredited lab.	
6	Pre-emptive assessment of sensitive receptors	6.1	By Day 2, deployment of 2 specialists from resource pool in establishing the status of sensitive receptors.	1, 2, 3B, 3C, 4
		6.2	Daily reports provided to IMT on the status of the receptors to prioritise RPAs and maximise effective utilisation of resources.	1, 3B, 4

7	Shoreline assessment	7.1	By Day 2, deployment of 2 specialists in Shoreline Contamination Assessment Techniques (SCAT) from resource pool for each of the RPAs with predicted impacts at greater than 100 g/m^2.	1, 2, 3B, 3C, 4
		7.2	SCAT reports provided to IMT daily detailing the assessed areas to maximise effective utilisation of resources	1, 3B, 4
		7.3	Shoreline access routes with the least environmental impact identified will be selected by a specialist in SCAT operations	1

The control measures and capability of Woodside and its third-party service providers are shown to support Monitor and Evaluate activities up to and including the identified WCCS. This is demonstrated by the following:

- Woodside has a documented, structured and tested capability for Monitor and Evaluate operations including internal trajectory modelling capabilities, tracking buoys located offshore and contracted aerial observation platforms with access to trained observers.
- Woodside and its third-party service providers ensure there is sufficient capability for the duration of the response.
- Woodside has assessed the existing capability available and considered potential alternative, additional and improved control measures. Where control measures have been selected and implemented, they are included in Section 6.1.
- The health and safety, financial, capital and operations/maintenance costs of implementing the alternative, additional or improved control measures identified and not carried forward are considered grossly disproportionate to the environmental benefit gained and/or not reasonably practicable for this PAP.
- The Monitor and Evaluate capability outlined in this section is part of the response developed to manage potential risks and impacts associated with the scenarios to ALARP, and there are no further additional, alternative and improved control measures other than those implemented that would provide further benefit.

5.2 Source Control via Vessel SOPEP

Vessel source control will be conducted, where feasible and in accordance with MARPOL 73/78 Annex I, by the Vessel Master under the Shipboard Oil Pollution Environment Plan (SOPEP) triggered by any loss of containment from the PAP vessels.

The SOPEP provides guidance to the Master and Officers on board the vessel with respect to the extra steps to be taken when an unexpected pollution incident has occurred or is likely to occur. The SOPEP contains all information and operational instructions required by IMO Resolution MEPC.54 (32) adopted on 6 March 1992, as amended by resolution MEPC.86 (44) adopted on 13 March 2000.

Its purpose is to set in motion the necessary actions to stop or minimise oil discharge and mitigate its effects and outlines responsibilities, pollution reporting requirements, procedures and resources needed in the event of a hydrocarbon spill from vessel activities.

In the event of the WCCS vessel collision event, the vessel master may engage precautionary marine manoeuvres to avoid collision or commence pumping operations to transfer marine diesel and thus minimise the release.

5.2.1 Environmental performance based on need

Woodside has established control measures, environmental performance outcomes, performance standards and measurement criteria to be used for vessel-source oil spill response during the PAP which are detailed in Section 6.7 of the EP. The vessel master's roles and responsibilities are described in EP Section 7.3.

Performance standards for each contracted PAP vessel are detailed in the vessel's specific SOPEP.

These standards ensure that sufficient resources are available and are adequately tested to ensure implementation of the SOPEP in the event of a hydrocarbon spill.

5.3 Shoreline Clean-up

Shoreline clean-up may be undertaken using a broad range of techniques when floating hydrocarbons contact shorelines. The timing, location and extent of shoreline clean-up activities can vary from one scenario to another, depending on the hydrocarbon type, sensitivities and values contacted, shoreline type and access, degree of oiling, and area oiled.

Shoreline clean-up is typically undertaken as a three-phase process:

- Phase one (gross contamination removal) involving the collection of bulk oil, either floating against the shoreline or stranded on it.
- Phase two (moderate to heavy contamination removal) involving removal or in-situ treatment of shoreline substrates such as sand or pebble beaches.
- Phase three (final treatment or polishing) involving removal of the remaining residues of oil.

As phase one typically involves recovery of floating and pooled oil, and phase three removes minor volumes, they have not been considered in the assessment of response need for the scenarios identified.

The *Shoreline Clean-up Operational Plan* details the mobilisation and resource requirements for a shoreline clean-up operation including the logistics, support and facility arrangements to manage the movement of personnel and resources.

The *Shoreline Clean-up Operational Plan* includes the process for the IMT to mobilise resources depending on the nature and scale of the spill. Woodside would activate and mobilise trained and competent personnel in shoreline assessment before or following shoreline contact at response thresholds.

Shoreline clean-up consists of different manual and mechanical recovery techniques to remove hydrocarbons and contaminated debris from a shoreline; this is to minimise ongoing environmental contamination and impact. The National Plan also provides guidance on shoreline clean-up techniques as outlined in National Plan Guidance *Response, assessment and termination of cleaning for oil contaminated foreshores* (AMSA 2015).

5.3.1 Response need based on predicted consequence parameters

The following statements identify the key parameters upon which the response need can be based:

- The shortest timeframe that shoreline contact from floating oil above threshold is predicted to be 24 hours (Day 2) at Ningaloo Coast North and WHA (31 m^3).
- Pre-emptive assessment and shoreline assessments (OM04 and OM05) will be mobilised prior to shoreline contact.
- The duration of the spill may extend up to 4 hours, with response operations extending to four (4) days based on the predicted time to complete shoreline clean-up operations.
- Following Shoreline Assessment and agreement of prioritisation with WA Department of Transport, clean-up operations would commence until agreed termination criteria are reached.
- Arrangements for support organisations who provide specialist services (trained personnel, labour hire, shoreline clean-up, and site management equipment) and/or resources and should be tested regularly.
- Tactical Response Plans (TRPs) for RPAs along with other relevant plans, procedures and support documents should be in developed and in place for Operational and Support functions. These should be reviewed and updated regularly.

In addition, a number of assumptions are required to estimate the response need for shoreline clean-up. These assumptions have been described in the table below.

Table 5-3: Response Planning Assumptions – Shoreline Clean-up

Response planning assumptions: Shoreline clean-up	
Safety considerations	Shoreline clean-up operations cannot be implemented if the safety of response personnel cannot be guaranteed. This requires an initial and ongoing risk assessment of health and safety hazards and risks at the site. Personnel safety issues may include: • hydrocarbon gas and/or liquid exposure • high winds, waves and/or sea states • high ambient temperatures.
Manual shoreline clean-up operation (Phase 2)	One, manual shoreline clean-up operation (Phase 2) may include: • 1–2 x trained supervisor • 8–10 x personnel/labour hire • Supporting equipment for manual clean-up including rakes, shovels, buckets, plastic bags etc.
Physical properties	**Surface Threshold** • Lower – 100 g/m^2 - 100% coverage of 'stain' • Expected trigger to undertake detailed shoreline survey • Optimum – 250 g/m^2 – 25% coverage of 'coat' • Expected trigger to commence clean-up operations
Efficiency **(m^3 oil recovered per person per day)**	Manual shoreline clean-up (Phase 2) – approx. 0.25-1 m^3 oil recovered per person per 10 hr day is based on moderate to high coverage of oil (100 g/m^2 to 1,000 g/m^2) with manual removal, from studies of previous response operations and exercises
Field operation supervisors required (per team)	Manual shoreline clean-up (Phase 2) – 1-2 trained supervisor(s) per operation (assumes one team per operation)
Personnel/ labour hire (per team)	Manual shoreline clean-up (Phase 2) – 8-10 personnel/labour hire per operation (assumes one team per operation)

Table 5-4: Shoreline Clean-up Techniques and Recommendations

Technique	Description	Shoreline type		Application
		Recommended	Not recommended	
Natural recovery	Allowing shoreline to self-clean; no intervention undertaken.	Remote and inaccessible shorelines for personnel, vehicles and machinery. Other clean-up techniques may cause more damage than allowing the shoreline to naturally recover. Natural recovery may be recommended for areas with mangroves and coral reefs due to their sensitivity to disturbance from other shoreline clean-up techniques. High-energy shorelines: where natural removal rates are high, and hydrocarbons will be removed over a short timeframe.	Low-energy shorelines: these areas tend to be where hydrocarbon accumulates and penetrates soil and substrates.	May be employed, if the operational NEBA identifies that other clean-up techniques will have a negligible or negative environmental impact on the shoreline. May also be used for buried or reworked hydrocarbons where other techniques may not recover these.
Manual recovery	Use of manpower to collect hydrocarbons from the shoreline. Use of this form of clean-up is based on type of shoreline.	Remote and inaccessible shorelines for vehicles and machinery. Areas where shorelines may not be accessible by vehicles or machinery and personnel can recover hydrocarbons manually. Where hydrocarbons have formed semi-solid to solid masses that can be picked up manually. Areas where nesting and breeding fauna cannot or should not be disturbed.	Coral reef or other sensitive intertidal habitats, as the presence of a response may cause more environmental damage then allowing them to recover naturally. For some high-energy shorelines such as cliffs and sea walls, manual recovery may not be recommended as it may pose a safety threat to responders.	May be used for sandy shorelines. Buried hydrocarbons may be recovered using shovels into small carry waste bags, but where possible the shoreline should be left to naturally recover to prevent any further burying of hydrocarbons (from general clean-up activities).

Technique	Description	Shoreline type		Application
		Recommended	Not recommended	
Sorbents	Sorbent boom or pads used to recover fluid or sticky hydrocarbons. Can also be used after manual clean-up to remove any residues from crevices or from vegetation.	When hydrocarbons are free-floating close to shore or stranded onshore. As a secondary treatment method after hydrocarbon removal and in sensitive areas where access is restricted.	Access for deploying and retrieving sorbents should not be through soft or sensitive habitats or affect wildlife.	Used for rocky shorelines. Sorbent boom will allow for deployment from small shallow draught vessels, which will allow deployment close to shore where water is sheltered and to aid recovery. Sorbents will create more solid waste compared with manual clean-up, so will be limited to clean rocky shorelines.
Vacuum recovery, flushing, washing	The use of high volumes of low-pressure water, pumping and/or vacuuming to remove floating hydrocarbons accumulated at shorelines.	Suited to rocky or pebble shores where flushing can remobilise hydrocarbons (to be broken up) and aid natural recovery. Any accessible shoreline type from land or water. May be mounted on barges for water-based operations, on trucks driven to the recovery area, or hand-carried to remote sites. Flushing and vacuum may be useful for rocky substrate. Medium- to high-energy shorelines where natural removal rates are moderate to high. Where flushed hydrocarbons can be recovered to prevent further oiling of shorelines.	Marine diesel or areas of pooled light, fresh hydrocarbons may not be recoverable via vacuum due to fire and explosion risks. Shorelines with limited access. Flushing and washing not recommended for loose sediments. High-energy shorelines where access is restricted.	High volume low pressure (HVLP) flushing and washing into a sorbent boom could be used for rocky substrate, if protection booming has been unsuccessful in deflecting hydrocarbons from these areas.
Sediment reworking	Movement of sediment to surf to allow hydrocarbons to be removed from the sediment and move sand via heavy machinery.	When hydrocarbons have penetrated below the surface. Recommended for pebble/cobble shoreline types. Medium- to high-energy shorelines where natural removal rates are moderate to high.	Low-energy shorelines as the movement of substrate will not accelerate the natural cleaning process. Areas used by fauna which could potentially be affected by remobilised hydrocarbons.	Use of wave action to clean sediment: appropriate for sandy beaches where light machinery is accessible.

Technique	Description	Shoreline type		Application
		Recommended	Not recommended	
Vegetation cutting	Cutting vegetation to prevent oiling and reduce volume of waste and debris.	Vegetation cutting may be recommended to reduce the potential for wildlife being oiled. Where oiling is restricted to fringing vegetation.	Access in bird-nesting areas should be restricted during nesting seasons. Areas of slow-growing vegetation. Not necessary for vegetation contaminated by marine diesel.	May be used on shorelines where vegetation can be safely cleared to reduce oiling.
Cleaning agents (OSCA)	Application of chemicals such as dispersants to remove hydrocarbons.	May be used for manmade structures and where public safety may be a concern.	Natural substrates and in low-energy environments where sufficient mixing energy is not present.	Not recommended for shorelines. Could be used for manmade structures such as boat ramps.

5.3.2 Environmental performance based on need

Table 5-5: Environmental Performance – Shoreline Clean-up

Environmental Performance Outcome		To remove bulk and stranded hydrocarbons from shorelines and facilitate shoreline amenity habitat recovery.		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.8)**
8	Shoreline responders	8.1	Deployment of 1 shoreline clean-up team to contaminated RPAs comprised of: • 1-2 trained specialists per operation • 8-10 personnel/labour hire Personnel sourced through resource pool within 24 hours of request from the IMT.	1, 2, 3A, 3B, 3C, 4
		8.2	Relevant Tactical Response Plans (TRPs) will be identified in the FSRP for activation within 12 hours.	1, 3A, 3C, 4
		8.3	Relevant Tactical Response Plans (TRPs) available for shoreline contacted by accumulation >100 g/m^2 within 24 hours.	1, 3A, 3C, 4
		8.4	Clean-up operations for shorelines in line with results and recommendations from SCAT outputs	1, 3A, 3B
		8.5	All shorelines zoned and marked before clean-up operations commence to prevent secondary contamination and minimise the mixing of clean and oiled sediment and shoreline substrates.	
		8.6	Mobilise and deploy 1 shoreline clean-up operation to each site where operational monitoring predicts accumulations >100 g/m^2 by Day 2.	1, 2, 3A, 3C, 4
		8.7	Mobilise and deploy 3 shoreline clean-up operation to each site where operational monitoring predicts accumulations >100 g/m^2 by Day 3	
		8.8	The safety of shoreline response operations will be considered and appropriately managed. During shoreline clean-up operations: • All personnel in a response will receive an operational/safety briefing before commencing operations • Gas monitoring and site entry protocols will be used to assess safety of an operational area before allowing access to response personnel	1, 3B, 4
		8.9	Open communication line to be maintained between IMT and infield operations to ensure awareness of progress against plan(s)	1, 3A, 3B
9	Waste management	9.1	Contract with waste management services for transport, removal, treatment and disposal of waste	1, 3A, 3B, 3C, 4
		9.2	Access to at least 40-200 m^3 of solid waste storage available by Day 2. Then access to an additional 100-500 m^3 of solid waste storage by Day 3.	
		9.3	Waste management services available and employed during response	
10	Shoreline clean-up equipment	10.1	Contract in place with 3rd party providers to access equipment.	1, 3A, 3C, 4
		10.2	Equipment mobilised from closest stockpile within 12 hours.	
		10.3	Supplementary equipment mobilised from State, AMOSC, AMSA stockpiles mobilised within 24 hours.	1, 3C, 3D, 4
11	Management of environmental impact of response risks	11.1	If vessels are required for access, anchoring locations will be selected to minimise disturbance to benthic primary producer habitats. Where existing fixed anchoring points are not available, locations will be selected to minimise impact to nearshore benthic environments with a preference for areas of sandy seabed where they can be identified	1

		11.2	Shallow draft vessels will be used to access remote shorelines to minimise the impacts associated with seabed disturbance on approach to the shorelines	
		11.3	Vehicular access will be restricted on dunes, turtle nesting beaches an in mangroves	
		11.4	Shoreline access route (foot, car, vessel and helicopter) with the least environmental impact identified will be selected by a specialist in SCAT operations	
		11.5	Trained unit leaders will brief personnel prior to operations of the environmental risks of presence of personnel on the shoreline	

The resulting shoreline clean-up capability has been assessed against the WCCS. The range of techniques provide an ongoing approach to shoreline clean-up at identified RPAs. Woodside's capability can cover all required shoreline clean-up operations for the PAP.

Whilst modelling predicts shoreline contact from 24 hours at Ningaloo Coast North and WHA, Woodside is satisfied that the current capability is managing risks and impacts to ALARP.

The capability available meets and exceeds the need identified for this activity. The shoreline clean-up capability has the following expected performance (if required during a response):

- Woodside has the capacity to mobilise and deploy 1 shoreline clean-up team (approximately 18-24 responders in total) by Day 2, 3-5 shoreline clean-up teams (approximately 45-60 responders in total) by Day 3 and 5-8 shoreline clean-up teams (approx. 72-96 responders in total) by Day 4 using existing labour hire contracts with Woodside, AMOSC, Core Group, AMSA, WA DoT and OSRL Team Leaders.
- Assessment of response capability indicates that for a worst-case scenario the actual teams required would meet the available capability and the response would be completed within 4 days of the incident.
- Woodside has considered deployment of additional personnel to undertake shoreline clean-up operations but is satisfied that the identified level of resource is balanced between cost, time and effectiveness. The most significant constraint on expanding the scale of response operations is accommodation and transport of personnel in the Exmouth to Port Hedland region and management of response generated waste. From previous assessment of accommodation in this region, Woodside estimates that current accommodation can cater for a range of 500-700 personnel per day for an ongoing operation.
- TRPs have been developed for all identified RPAs excepting international locations.
- Woodside has assessed the existing capability available and considered potential alternative, additional and improved control measures. Where control measures have been selected and implemented, they are included in Section 0.

No further control measures that may result in an increased environmental benefit that involve moderate to significant cost and/or dedication of resources have been adopted as the limited scale and timeframe for deployment of this technique does not justify the excessive costs of identified alternate, improved or additional controls.

5.4 Waste Management

Waste management is considered a support technique to shoreline clean-up and wildlife response. Waste generated and collected during the response that will require handling, management and disposal may consist of:

- Liquids (hydrocarbons and contaminated liquids) collected during shoreline clean-up and wildlife response, and/or
- Solids/semi-solids (oily solids, garbage, contaminated materials) and debris (e.g. seaweed, sand, woods, and plastics) collected during shoreline clean-up and wildlife response.

Expected waste volumes during an event are likely to vary depending on oil type, volume released, response techniques employed and weathering of hydrocarbons. Waste management, handling and capacity should be scalable to ensure continuous response operations can be maintained.

All waste management activities will follow the Environment Protection (Controlled Waste) Regulations 2004 and the waste will be managed to minimise final disposal volumes. Waste treatment techniques will consider contaminated solids treatment to allow disposal to landfill and solids with high concentrations of hydrocarbon will be treated and recycled where possible or used in clean fill if suitable.

The waste products would be transported from response locations to the nearest suitable staging area/waste transfer station for treatment, disposal or recycling. Waste will be transferred with appropriately licensed vehicles. Containers will be available for temporary waste storage and will be:

- Labelled with the waste type
- Provided with appropriate lids to prevent waste being blown overboard
- Bunded if storing liquid wastes
- Processes will be in place for transfers of bulk liquid wastes and include:
  - inspection of transfer hose undertaken prior to transfer
  - watchman equipped with radio visually monitors loading hose during transfer
  - tank gauges monitored throughout operation to prevent overflow

The Oil Spill Preparedness Waste Management Support Plan details the procedures, capability and capacity in place between Woodside and its primary waste services contractor (Veolia Waste Management) to manage waste volumes generated from response activities.

5.4.1 Response need based on predicted consequence parameters

Table 5-6: Response Planning Assumptions – Waste Management

	Response planning assumptions: Waste management
Waste loading per m^3 oil recovered (multiplier)	Shoreline clean-up (manual) – approx. 5-10 x multiplier for oily solid and liquid wastes generated by manual clean-up
	Oiled wildlife response – approx. 1 m^3 of oily liquid waste generated for each wildlife unit cleaned

5.4.2 Environmental performance based on need

Table 5-7: Environmental Performance – Waste Management

<table>
<tr><th colspan="2">Environmental Performance Outcome</th><td colspan="3">To minimise further impacts, waste will be managed, tracked and disposed of in accordance with laws and regulations.</td></tr>
<tr><th colspan="2">Control measure</th><th colspan="2">Performance Standard</th><th>Measurement Criteria (Section 5.8)</th></tr>
<tr><td rowspan="9">12</td><td rowspan="9">Waste Management</td><td>12.1</td><td>Contract with waste management services for transport, removal, treatment and disposal of waste</td><td rowspan="6">1, 3A, 3B, 3C, 4</td></tr>
<tr><td>12.2</td><td>Access to at least 40-200 m^3 of solid and liquid waste storage available by Day 2 upon activation of 3rd party contract.</td></tr>
<tr><td>12.3</td><td>Access to up to 100-500 m^3 by Day 3.</td></tr>
<tr><td>12.4</td><td>Recovered hydrocarbons and wastes will be transferred to licensed treatment facility for reprocessing or disposal.</td></tr>
<tr><td>12.5</td><td>Teams will segregate liquid and solid wastes at the earliest opportunity.</td></tr>
<tr><td>12.6</td><td>Waste management provider support staff available year-round to assist in the event of an incident with waste management as detailed in contract.</td></tr>
<tr><td>12.7</td><td>Open communication line to be maintained between IMT and waste management services to ensure the reliable flow of accurate information between parties.</td><td>1, 3A, 3B</td></tr>
<tr><td>12.8</td><td>Waste management to be conducted in accordance with Australian laws and regulations</td><td rowspan="2">1, 3A, 3B, 3C, 4</td></tr>
<tr><td>12.9</td><td>Waste management services available and employed during response</td></tr>
</table>

The resulting waste management capability has been assessed against the WCCS. The range of techniques provide an ongoing approach to waste management at identified RPAs.

Given the largest shoreline volumes ashore are predicted after Day 3 at a maximum volume of 39 m^3, a maximum of 500 m^3 of waste is expected across all shoreline clean-up operations, and the capability available exceeds the identified need.

It indicates that the waste management capability has the following expected performance:

- Shoreline operations may generate up to 500 m^3 over 4 days of operations.
- Woodside has assessed the existing capability available and considered potential alternative, additional and improved control measures. Where control measures have been selected and implemented, they are included in Section 6.4.3.

Veolia Waste Management has a waste treatment capacity of approximately 120,000 m^3, at both Exmouth Port and King Bay supply base, thus the waste management requirements are within Woodside's and Veolia's existing capacity.

5.5 Oiled wildlife response

Woodside would implement a response in accordance with the *Oiled Wildlife Operational Plan*. This plan includes the process for the IMT to mobilise resources depending on the nature and scale of the spill. Oiled wildlife operations would be implemented with advice and assistance from the Oiled Wildlife Advisor from the WA Department of Biodiversity, Conservation and Attractions (DBCA).

Oiled wildlife response is undertaken in accordance with the Western Australian Oiled Wildlife Response Plan to ensure it is conducted in accordance with legislative requirements under the *Animal Welfare Act 2002*.

If there is a net environmental benefit, oiled wildlife operations will be conducted 24 hours per day to reduce the time for rehabilitation and release of oiled wildlife. Hazing and pre-emptive capture techniques will be conducted in accordance with the Western Australian Oiled Wildlife Response Plan, specifically vessels used in hazing/pre-emptive capture will approach fauna at slow speeds to ensure animals are not directed towards the oil and deterrence/hazing and pre-emptive capture will only be conducted if Woodside has licensed authority from DBCA and approval from the Incident Controller.

Shoreline access will be considered as part of the operational NEBA. Vehicular access would be restricted on dunes, turtle nesting beaches and in mangroves. Woodside retains specialist personnel to support and manage oiled wildlife operations, including trained and competent responders in Exmouth and Dampier. Additional personnel would be sourced through Woodside's arrangements to support an oiled wildlife response as required.

5.5.1 Response need based on predicted consequence parameters

The following statements identify the key parameters upon which a response need can be based:

- Modelling predicts the shortest time to shoreline contact at 24 hours (Day 2) at Ningaloo Coast North and WHA.
- The offshore location of the release site is expected to initially result in low numbers of at-risk or impacted wildlife.
- If the surface oil approaches shorelines, potential for oiled wildlife impacts are likely to increase.
- It is estimated that an oiled wildlife response would be between Level 1 and 2, as defined in the WA Oiled Wildlife Response Plan (OWRP) (Table 5-10).

Table 5-8: Key at-risk species potentially in RPAs and open ocean

Species	Ningaloo Coast North and WHA
Marine turtles (including foraging and inter-nesting areas and significant nesting beaches)	✓
Whale sharks	✓
Seabirds and/or migratory shorebirds	✓
Cetaceans – migratory whales	✓
Cetaceans – dolphins and porpoises	✓
Dugongs	✓
Sharks and rays	✓

The oiled wildlife response technique targets key wildlife populations at risk within Commonwealth open waters and the nearshore waters as described in Section 5 of the EP. Responding to oiled wildlife consists of eight key stages, as described in Table 5-9 below.

Table 5-9: Oiled wildlife response stages

Stage	Description
Stage 1: Wildlife first strike response	Gather situational awareness including potential wildlife assets at risk.
Stage 2: Mobilisation of wildlife resources	Resources include personnel, equipment and facilities.
Stage 3: Wildlife reconnaissance	Reconnaissance to identify potentially affected animals.
Stage 4: IAP wildlife sub-plan development	The IAP includes the appropriate response options for oiled wildlife, including wildlife priorities for protection from oiling; deterrence measures (see below); and recovery and treatment of oiled wildlife; resourcing of equipment and personnel. It includes consideration of deterrence practices such as 'hazing' to prevent fauna from entering areas potentially contaminated by spilled hydrocarbons, as well as dispersing, displacing or relocating fauna to minimise/prevent contact and provide time for clean-up.
Stage 5: Wildlife rescue and staging	This includes the different roles of finding oiled wildlife, capturing wildlife, and holding and/or transportation of wildlife to oiled wildlife facilities.
Stage 6: Establishment of an oiled wildlife facility	Treatment facilities would be required for the first-aid, cleaning and rehabilitation of affected animals. A vessel-based 'on-water' facility would likely need to be established to enable stabilisation of oiled wildlife before transport to a suitable treatment facility. Suitable staging sites in the Dampier and Exmouth have been identified in the draft Regional OWROP, should a land-based site be required.
Stage 7: Wildlife rehabilitation	Considerations include a suitable rehabilitation centre and personnel, wildlife housing, record keeping and success tracking.
Stage 8: Oiled wildlife response termination	Once a decision has been made to terminate operations, the Incident Controller will stand down individual participating and supporting agencies.

Reconnaissance and primary response would be done during operational monitoring and surveillance activities. Where marine fauna are observed on water or transiting near or within the spill area, observations would be recorded through surveillance records. The shoreline assessments would be done in accordance with OM05, which would be used as a further tool to identify fauna and habitats contacted by hydrocarbons.

Staging sites would be established as forward bases for shoreline- or vessel-based field teams. Once recovered to a staging site, wildlife would be transported to the designated oiled wildlife facility or a temporary holding centre before being transported to the oiled wildlife facility. Temporary holding centres are required when there is significant distance between a staging site and the oiled wildlife facility, to enable stabilisation of oiled animals. The oiled wildlife facility is the primary location where animals would be housed and treated. The staging area and primary facility locations have been identified in Exmouth.

To deploy a response that is appropriate to the nature and scale of the event, as well as scalable over time, Woodside would implement an oiled wildlife response in consultation with DBCA and use the capability outlined in the WA OWRP, with additional capability if required (e.g. volunteers) accessible through Woodside's *People & Global Capability Surge Labour Requirement Plan*.

The WA OWRP provides indicative oiled wildlife response levels (Table 5-10) and the resources likely to be needed at each increasing level of response.

Table 5-10: Indicative oiled wildlife response level (adapted from the WA OWRP 2014)

OWR Level	Indicative personnel numbers	Indicative duration	Indicative number of birds (non-threatened species)	Indicative number of birds (threatened species)	Turtles (hatchlings, juveniles, adults)	Cetaceans	Pinnipeds	Dugongs
Level 1	6	<3 days	1–2/day <5 total	No complex birds	None	None	None	None
Level 2	26	4–14 days	1–5/day <20 total	No complex birds	<20 hatchlings No juv/adults	None	None	None
Level 3	59	4–14 days	5–10/day <50 total	1–5/day <10 total	<5 juv/adults <50 hatchlings	None	<5	None
Level 4	77	>14 days	5–10/day <200 total	5–10/day	<20 juv/adults <500 hatchlings	<5, or known habitats affected	5–50	Habitat affected only
Level 5	116	>14 days	10–100/ day >200 total	10–50/day	>20 juv/adults >500 hatchlings	>5 dolphins	>50	Dugongs oiled
Level 6	122	>14 days	>100/day	10–50/day	>20 juv/adults >500 hatchlings	>5 dolphins	>50	Dugongs oiled

5.5.2 Environmental performance based on need

Table 5-11: Environmental Performance – Oiled Wildlife Response

Environmental Performance Outcome		Oiled Wildlife Response is conducted in accordance with the WA OWRP to ensure it is conducted in accordance with legislative requirements to house, release or euthanise fauna under the *Animal Welfare Act 2002*.		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.8)**
13	Wildlife response equipment	13.1	Contracted capability to treat 100 individual fauna for immediate mobilisation to Response Priority Areas (RPAs)	1, 3A, 3B, 3C, 4
		13.2	Contracted capability to treat up to an additional 250 individual fauna within a five-day period.	
		13.3	National plan access to additional resources under the guidance of the DoT (up to a Level 5 oiled wildlife response as specified in the WA OWRP), with the ability to treat about 600 individual fauna by the time hydrocarbons contact the shoreline.	1, 3C, 4
		13.4	Vessels used in hazing/pre-emptive capture will approach fauna at slow speeds to ensure animals are not directed towards the hydrocarbons.	1, 3A, 3B, 4
		13.5	Facilities for the rehabilitation of oiled wildlife are operational 24/7 as per WA OWRP.	1, 3A, 4
14	Wildlife responders	14.1	Two wildlife divisional commanders to lead the oiled wildlife operations who have completed an Oiled Wildlife Response Management course.	1, 2, 3B
		14.2	Wildlife responders to be accessed through resource pool and additional agreements with specialist providers.	1, 2, 3A, 3B, 3C, 4
		14.3	Oiled wildlife operations would be implemented with advice and assistance from the Oiled Wildlife Advisor from the DBCA and in accordance with the processes and methodologies described in the WA OWRP and the relevant regional plan.	1
		14.4	Open communication line to be maintained between IMT and infield operations to ensure awareness of progress against plan(s).	1, 3A, 3B

The resulting wildlife response capability has been assessed against the WCCS. The range of techniques provide an ongoing approach to response at identified RPAs.

Under optimal conditions the capability available meets the need identified. It indicates that, the wildlife response capability has the following expected performance:

- Mobilisation and deployment of approximately one wildlife collection team by Day 2 at Ningaloo Coast North and WHA.
- Mobilisation and deployment of up to two central wildlife treatment and rehabilitation locations at Exmouth in accordance with WA OWRP, if required.

Wildlife collection operations would be expected to be completed within two weeks based on the potential shoreline impacts predicted. Additional capability could be deployed but given modelling predicts that impacts will desist after 4 days, additional personnel are unlikely to increase the net environmental benefit and this capability meets the need.

Woodside would establish a wildlife collection point at the RPA for identified oiled wildlife collection and sorting. From these locations, recovered wildlife would be transported to a central treatment location at Exmouth.

5.6 Scientific monitoring

A scientific monitoring program (SMP) would be activated following a Level 2 or 3 unplanned hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors. This would consider receptors at risk (ecological and socio-economic) for the entire predicted Environment that May Be Affected (EMBA) and in particular, any identified Pre-emptive Baseline Areas (PBAs) for the credible spill scenarios or other identified unplanned hydrocarbon releases associated with the operational activities (refer to Table 2-1: PAP credible spill scenarios).

The outputs of the stochastic hydrocarbon spill modelling are used to assess the environmental risk, in terms of delineating which areas of the marine environment are predicted to be exposed to hydrocarbons exceeding environmental threshold concentrations in the WCCS (refer to Table 2-2, Section 2.3). The summary of all the locations where hydrocarbon thresholds could be exceeded by any of the simulations modelled is defined as EMBA. It should be noted that the resulting SMP receptor locations differ from the RPAs presented and discussed in Section 0 of this document due to the applicability of different hydrocarbon threshold levels.

The SMP would be informed by the data collected via the operational monitoring program (OMP) studies, however, it differs from the OMP in being a long-term program independent of, and not directing, the operational oil spill response or monitoring of impacts from response. Activities (refer to ANNEX C: Oil Spill Scientific monitoring Program for operational monitoring overview).

Key objectives of the Woodside oil spill SMP are:

- Assess the extent, severity and persistence of the environmental impacts from the spill event; and
- Monitor subsequent recovery of impacted key species, habitats and ecosystems.

The SMP comprises ten targeted environmental monitoring programs to assess the condition of a range of physical-chemical (water and sediment) and biological (species and habitats) receptors including species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), environmental values associated with protected areas and socio-economic values, such as fisheries. The ten SMPs are as follows:

- SM01 – Assessment of the presence, quantity and character of hydrocarbons in marine waters (linked to OM01 to OM03)
- SM02 – Assessment of the presence, quantity and character of hydrocarbons in marine sediments (linked to OM01 and OM05)
- SM03 – Assessment of impacts and recovery of subtidal and intertidal benthos
- SM04 – Assessment of impacts and recovery of mangroves/saltmarsh habitat
- SM05 – Assessment of impacts and recovery of seabird and shorebird populations
- SM06 – Assessment of impacts and recovery of nesting marine turtle populations
- SM07 – Assessment of impacts to pinniped colonies including haul-out site populations
- SM08 – Desktop assessment of impacts to other non-avian marine megafauna
- SM09 – Assessment of impacts and recovery of marine fish (linked to SM03)
- SM10 – Assessment of physiological impacts to important fish and shellfish species (fish health and seafood quality/safety) and recovery.

5.6.1 Scientific Monitoring Deployment Considerations

Table 5-12: Scientific monitoring deployment considerations

Scientific Monitoring Deployment Considerations	
Existing baseline studies for sensitive receptor locations predicted to be affected by a spill	Pre-emptive Baseline Areas (PBAs) of the following two categories: • PBAs within the predicted <10-day hydrocarbon contact time prediction: The approach is to conduct a desktop review of available and appropriate baseline data for key receptors for locations (if any) that are potentially impacted within 10 days of a spill and look to conduct baseline data collection to address data gaps and demonstrate spill response preparedness. Planning for baseline data acquisition is typically commenced pre-PAP and execution of studies undertaken with consideration of weather, receptor type, seasonality and temporal assessment requirements. • PBAs >10 days' time to predicted hydrocarbon contact in the event of an unplanned hydrocarbon release (from the facility operational activities). SMP activation (as per the North-west Australia 4D Marine Seismic Survey Oil Pollution FSRP) directs the SMP team to follow the steps outlined in the SMP Operational Plan. The steps include: checking the availability and type of existing baseline data, with particular reference to any Pre-emptive Baseline Areas (PBAs) identified as >10 days to hydrocarbon contact. Such information is used to identify response phase PBAs and plan for the activation of SMPs for pre-emptive (i.e. pre-hydrocarbon contact) baseline assessment.
Pre-emptive Baseline in the event of a spill	Activation of SMPs in order to collect baseline data at sensitive receptor locations with predicted hydrocarbon contact time >10 days (as documented in ANNEX C: Oil Spill Scientific monitoring Program).
Survey platform suitability and availability	In the event of the SMP activation, suitable survey platforms are available and can support the range of equipment and data collection methodologies to be implemented in nearshore and offshore marine environments.
Trained personnel to implement SMPs suitable and available.	Access to trained personnel and the sampling equipment contracted for scientific monitoring via a dedicated scientific monitoring program standby contract.
Metocean conditions	The following met-ocean conditions have been identified to implement SMPs: • Waves <1 m for nearshore systems • Waves <1.5 m for offshore systems • Winds <20 knots • Daylight operations only SMP implementation will be planned and managed according to HSE risk reviews and the met-ocean conditions on a day to day basis by SMP operations.

5.6.2 Response planning assumptions

Table 5-13: Scientific monitoring response planning assumptions

Response Planning Assumptions	
Pre-emptive Baseline Areas (PBAs)	Pre-emptive Baseline Areas (PBAs) identified through the application of defined hydrocarbon impact thresholds during the Quantitative Spill Risk Assessment process and a consideration of the minimum time to contact at receptor locations fall into two categories: • PBAs for which baseline data are planned for and data collection may commence pre-PAP (≤ 10 days minimum time to contact), where identified as a gap. • PBAs (> 10 days minimum time to contact) for which baseline data may be collected in the event of an unplanned hydrocarbon release. Response phase PBAs are prioritised for SMP activities due to vulnerability (i.e. time to contact and environmental sensitivity) to potential impacts from hydrocarbon contact and an identified need to acquire baseline data. Time to hydrocarbon contact of >10 days has been identified as a minimum timeframe within which it is feasible to plan and mobilise applicable SMPs and commence collection of baseline

	(pre-hydrocarbon contact) data, in the event of an unplanned hydrocarbon release from North-west Australia 4D Marine Seismic Survey. Pre-emptive Baseline Areas for North-west Australia 4D Marine Seismic Survey are identified and listed in ANNEX D: Monitoring Program and Baseline Studies for the PAP, Table D-1. The PBAs together with the situational awareness (from the operational monitoring) are the basis for the response phase SMP planning and implementation.
Pre-Spill	A review of existing baseline data for receptor locations with potential to be contacted by floating or entrained hydrocarbons at environmental thresholds within ≤10 days has identified the following: • Ningaloo Coast WHA, North and Middle • Ningaloo State Marine Park, North and Middle • Ningaloo Australian Marine Park (AMP)* • Gascoyne Australian Marine Park (AMP)* • Montebello Australian Marine Park (AMP)* All the Australian Marine Parks (AMPs) are located in offshore waters where hydrocarbon exposure is possible on surface waters and upper surface layers of the water column. Seabed habitats and benthic communities will not be affected and SMP activities in the response phase will focus on coastal receptor sensitive locations.
In the Event of a Spill	Locations with >10 days to hydrocarbon contact, as well as the wider area, will be investigated and identified by the SMP team (in the Environment Unit of the ICC) as the spill event unfolds and as the situational awareness provided by the OMPs permits delineation of the spill affected area (for example, updates to the spill trajectory tracking). The full list is presented in ANNEX D: Monitoring Program and Baseline Studies for the PAP, based on the PAP credible spill scenarios (Table 2-1). To address the initial focus in a response phase SMP planning situation, Ningaloo coast (including WHA and State Marine Park), Ningaloo AMP, Montebello AMP and Gascoyne AMP are the identified receptor locations predicted to be contacted in <10 days. Based on modelling predictions no receptor locations contacted between >10 and 20 days were identified. The unfolding spill affected area predictions and confirmation of appropriate baseline data will determine the selection of receptor locations and SMPs to be activated in order to gather pre-emptive (pre-hydrocarbon contact) data. The timing of SMP activation and mobilisation of the individual SMPs to undertake data collection will be decided and documented by the Woodside SMP team following the process outlined in the SMP Operational Plan.
Baseline Data	A summary of the spill affected area and receptor locations as defined by the EMBA for the PAP worst case credible spill scenario, is presented in the North-west Australia 4D Marine Seismic Survey EP (Section 5). The key receptors at risk by location and corresponding SMPs based on the EMBA for the PAP are presented in ANNEX D: Monitoring Program and Baseline Studies for the PAP, as per the PAP worst credible spill scenarios. This matrix maps the receptors at risk with their location and the applicable SMPs that may be triggered in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors. Receptor locations and applicable SMPs are colour coded to highlight possible time to contact based on receptor locations identified as PBAs. The status of baseline studies relevant to the PAP are tracked by Woodside through the maintenance of a Corporate Environment Environmental Baseline Database (managed by the Woodside Environmental Science team), as well as accessing external databases such as I-GEM (Industry-Government Environmental Metadata database) (refer to ANNEX C: Oil Spill Scientific monitoring Program).

5.6.3 Summary – scientific monitoring

The resulting scientific monitoring capability has been assessed against the PAP worst case credible spill scenario. The range of strategies provide an ongoing approach to monitoring operations to assess and evaluate the scale and extent of impacts. All known reasonably practicable control measures have been adopted with the cost and organisational complexity of these options determined to be moderate and the overall delivery effectiveness determined to be medium. The SMP's main objectives can be met, with no additional, alternative or improved control measures providing further benefit.

5.6.4 Response planning: need, capability and gap – scientific monitoring

The receptor locations identified in ANNEX D: Monitoring Program and Baseline Studies for the PAP provide the basis of the SMPs likely to be selected and activated. Once the Woodside SMP Delivery team and Standby SMP contractor have been stood up and the exact nature and scale of the spill becomes known, the SMPs to be activated will be confirmed as per the process set out in the SMP Operational Plan.

Scope of SMP Operations in the event of a hydrocarbon spill:

Receptor locations of interest for the SMP during the response phase are:

- Ningaloo Coast WHA, North and Middle
- Ningaloo State Marine Park, North and Middle.
- Ningaloo Australian Marine Park (AMP)*
- Gascoyne Australian Marine Park (AMP)*
- Montebello Australian Marine Park (AMP)*

Documented baseline studies are available for certain sensitive receptor locations including the Ningaloo Coast and Montebello Australian Marine park (AMP) (ANNEX D: Monitoring Program and Baseline Studies for the PAP, Table D-2). The SMP strategy, however, would be to deploy SMP teams to maximise the opportunity to collect pre-emptive data at sensitive receptor locations such as nearshore habitats of the Ningaloo Coast. The exact locations where hydrocarbon contact occurs may be unpredictable, SM01 would be mobilised as a priority to be able to detect hydrocarbons and track the leading edge of the spill. Results of SM01 would be used to verify where hydrocarbon contact occurs, therefore, identifies the locations where SMP resources are a priority and pre-emptive baseline data can be collected.

The option analysis in Section **6.5.2.1** considers ways to reduce the gap by considering alternate, additional, and/or improved control measures on each selected response strategy.

5.6.5 Environmental performance based on need

Table 5-14: Environmental Performance – Scientific Monitoring

Environmental Performance Outcome		Woodside can demonstrate preparedness to stand up the SMP to quantitatively assess and report on the extent, severity, persistence and recovery of sensitive receptors impacted from the spill event		
Control measure		**Performance Standard**		**Measurement Criteria**
14	• Woodside has an established and dedicated SMP team comprising the Environmental Science Team and additional Environment Advisers within the Health, Safety, Environment and Quality (HSEQ) Function.	14.1	SMP team comprises a pool of competent Environment Advisers (stand up personnel) who receive training regarding the SMP, SMP activation and implementation of the SMP on an annual basis	• Training materials • Training attendance registers • Process that maps minimum qualification and experience with key SMP role competency and a tracker to manage availability of competent people for the SMP team including redundancy and rostering
15	• Woodside have contracted SMP service provider to provide scientific personnel to resource a base capability of one team per SMP (SM01-SM10, see ANNEX C: Oil Spill Scientific monitoring Program, Table C-2) as detailed in Woodside's [service provider] Implementation Plan, to implement the oil spill scientific monitoring programs. The availability of relevant personnel is reported to Woodside on a monthly basis via a simple report on the base-loading availability of people for each of the SMPs comprising field work for data collection (SMP resourcing report register). • In the event of a spill and the SMP is activated, the base-loading availability of scientific personnel will be provided by SMP standby contractor for the individual SMPs and where gaps in resources are identified, SMP standby contractor/Woodside will seek additional personnel (if needed) from other sources including Woodside's Environmental Services Panel.	15.1	Woodside maintains the capability to mobilise personnel required to conduct scientific monitoring programs SM01 – SM10 (except desktop based SM08): • Personnel are sourced through the existing standby contract with SMP standby contractor, as detailed within the SMP Implementation Plan. • Scientific Monitoring Program Implementation Plan describes the process for standing up and implementing the scientific monitoring programs. • SMP team stand up personnel receive training regarding the stand up, activation and implementation of the SMP on an annual basis	• OSPU Internal Control Environment tracks the quarterly review of the Oil Spill Contracts Master. • SMP resource report of personnel availability provided by SMP contractor on monthly basis (SMP resourcing report register). • Training materials • Training attendance registers • Competency criteria for SMP roles • SMP annual arrangement testing and reporting
16	• Roles and responsibilities for SMP implementation are captured in Table C-1 (ANNEX C: Oil Spill Scientific monitoring Program) and the SMP team (as per the organisational structure of the ICC) is outlined in SMP Operational Plan. Woodside has a	16.1	• Woodside have established an SMP organisational structure and processes to stand up and deliver the SMP.	• SMP Oil Spill Scientific Monitoring Operational Plan

	defined Crisis and Incident Management structure including Source Control, Operations, Planning and Logistics functions to manage a loss of well control response. • SMP Team structure, interface with SMP standby contractor and linkage to the ICC is presented in Figure C-1, ANNEX C: Oil Spill Scientific monitoring Program. • Woodside has a defined Command, Control and Coordination structure for Incident and Emergency Management that is based on the AIIMS framework utilised in Australia. • Woodside utilises an online Incident Management Information System (IMIS) to coordinate and track key incident management functions. This includes specialist modelling programs, geographic information systems (GIS), as well as communication flows within the Command, Control and Coordination structure. • SMP activated via the FSRP. • Step by step process to activation of individual SMPs provided in the SMP Operational Plan • All decisions made regarding SMP logged in the online IMIS (SMP team members trained in using Woodside's online Incident Management System) • SMP component input to the ICC Incident Action Plan (IAP) as per the identified ICC timed sessions and the SMP IAP logged on the online IMIS • Woodside Environmental Science Team provide awareness training on the activation and standup of the Scientific Monitoring Programme (SMP) for the Environment Advisers in Woodside who are listed on the SMP team on an annual basis. • Woodside Environmental Science Team provide awareness training on the activation and standup of the Scientific Monitoring Programme (SMP) for the SMP Standby provider. • Woodside Environmental Science Team co-ordinates an annual SMP arrangement testing exercise which the Standby SMP contractor SMP team participates in since 2016 (report on 2016 SMP simulation) and SMP standby contractor SMP arrangements (people and equipment availability) tested annually since 2016.			• SMP Implementation Plan • SMP annual arrangement testing and reporting

17	• Chartered and mutual aid vessels. • Suitable vessels would be secured from the Woodside support vessels, regional fleet of vessels operated by Woodside and other operators and the regional charter market. • Vessel suitability will be guided by the need to be equipped to operate grab samplers, drop camera systems and water sampling equipment (the individual vessel requirements are outlined in the relevant SMP methodologies (refer to Table C-2, ANNEX C: Oil Spill Scientific monitoring Program). • Nearshore mainland waters could use the same approach as for open water. Smaller vessels may be used where available and appropriate. Suitable vehicles and machinery for onshore access to nearshore SMP locations would be provided by Woodside's transport services contract and sourced from the wider market. • Dedicated survey equipment requirements for scientific monitoring range from remote towed video and drop camera systems to capture seabed images of benthic communities to intertidal/onshore surveying tools such as quadrats, theodolites and spades/trowels, cameras and binoculars (specific survey equipment requirements are outlined in the relevant SMP methodologies (refer to Table C-2, ANNEX C: Oil Spill Scientific monitoring Program). Equipment would be sourced through the existing SMP standby contract with Standby SMP contractor for SMP resources and if additional surge capacity is required this would be available through the other Woodside Environmental Services Panel Contractors and specialist contractors. SMP Standby contractor can also address equipment redundancy through either individual or multiple suppliers. MoUs are in place with one marine sampling equipment companies and one analytical laboratory (SMP resourcing report register). • Availability of SMP equipment for offshore/onshore scientific monitoring team mobilisation is within one week to ten days of the commencement of a hydrocarbon release. This meets the SMP mobilisation lead time that will support meeting the response objective of 'acquire, where practicable, the environmental baseline data prior to hydrocarbon contact required to support the post-response SMP.	17.1	Woodside maintains standby SMP capability to mobilise equipment required to conduct scientific monitoring programs SM01 – SM10 (except desktop based SM08): • Equipment are sourced through the existing standby contract with SMP standby contractor, as detailed within the SMP Implementation Plan.	• OSPU Internal Control Environment tracks the quarterly review of the Oil Spill Contracts Master. • SMP standby monthly resource reports of equipment availability provided by SMP contractor (SMP resourcing report register). • SMP annual arrangement testing and reporting

18	Woodside's SMP approach addresses the pre-PAP acquisition of baseline data for Pre-emptive Baseline Areas (PBAs) with ≤10 days if required following a baseline gap analysis process. Woodside maintains knowledge of Environmental Baseline data through: • Documentation annual reviews of the Woodside Baseline Environmental Studies Database, and specific activity baseline gap analyses. • Industry Government Environmental Meta-database (IGEM) Baseline Studies Database: http://www.igem.com.au/landing/ (Note – the IGEM password is documented in the SMP Operational Plan).	18.1	• Annual reviews of environmental baseline data • PAP specific Pre-emptive Baseline Area baseline gap analysis	• Annual review/update of Woodside Baseline Environmental Studies Database • Desktop review to assess the environmental baseline study gaps completed prior to EP submission • Accessing baseline knowledge via the SMP annual arrangement testing

Environmental Performance Outcome		SMP plan to acquire response phase monitoring targeting pre-emptive data achieved		
Control measure		**Performance Standard**		**Measurement Criteria**
19	Woodside's SMP approach addresses: • Scientific data acquisition for PBAs >10 days to hydrocarbon contact and activated in the response phase and • Transition into post-response SMP monitoring.	19.1	**<u>Pre-emptive Baseline Area (PBA) baseline data acquisition in the response phase</u>** If baseline data gaps are identified for PBAs that has predicted hydrocarbon contact (contact time >10 days), there will be a response phase effort to collect baseline data with priority in implementing SMPs given to receptors where pre-emptive baseline data can be acquired or improved. SMP team (within the Environment Unit of the ICC) contribute SMP component of the ICC Planning Function in development of the IAP.	• Response SMP plan • Woodside's online Incident Management System Records • SMP component of the Incident Action Plan.
		19.2	**<u>Post Spill contact</u>** For the receptors contacted by the spill in where baseline data are available, SMPs programs to assess and monitor receptor condition will be implemented post spill (i.e. after the response phase):	• SMP planning document • SMP Decision Log • Incident Action Plans (IAPs)
Environmental Performance Outcome		Implementation of the SMP (response and post-response phases)		
Control measure		**Performance Standard**		**Measurement Criteria**

20	• Scientific monitoring will address quantitative assessment of environmental impacts of a level 2 or 3 spill or any release event with the potential to contact sensitive environmental receptors. The SMP comprises ten targeted environmental monitoring programs. • SMP supporting documentation: (1) Oil Spill Scientific Monitoring Operational Plan; (2) SMP Implementation Plan and (3) SMP Process and Methodologies Guideline. • The Oil Spill Scientific Monitoring Operational Plan details the process of SMP selection, input to the IAP to trigger operational logistic support services. Methodology documents for each of the ten SMPs are accessible detailing equipment, data collection techniques and the specifications required for the survey platform support. • The SMP standby contractor holds a Woodside SMP implementation plan detailing activation processes, linkage with the Woodside SMP team and the general principles for the planning and mobilisation of SMPs to deliver the individual SMPs activated. Monthly resourcing report are issued by the SMP standby contractor (SMP resourcing report register). All SMP documents and their status are tracked via SMP document register.	20.1	**Implementation of SM01** SM01 will be implemented to assess the presence, quantity and character of hydrocarbons in marine waters during the spill event in nearshore areas	Evidence SM01 has been triggered: • Documentation as per requirements of the SMP Operational Plan • Woodside's online Incident Management System Records. • SMP component of the IAP • SMP data records from field
		20.2	**Implementation of SM02-SM10** SM02-SM10 will be implemented in accordance with the objectives and activation triggers as per Table C-2 of ANNEX C: Oil Spill Scientific monitoring Program	Evidence SMPs have been triggered: • Documentation as per requirements of the SMP Operational Plan • Woodside's online Incident Management System Records. • SMP component of the IAP • SMP Data records from field
		20.3	**Termination of SMP plans** The Scientific Monitoring Program will be terminated in accordance with termination triggers for the SMP's detailed in Table C-2 of ANNEX C: Oil Spill Scientific monitoring Program, and the Termination Criteria Decision-tree for Oil Spill Environmental Monitoring (Figure C-3 of ANNEX C: Oil Spill Scientific monitoring Program):	Evidence of Termination Criteria triggered: • Documentation and approval by relevant stakeholders to end SMPs for specific receptor types.

5.7 Incident Management System

The Incident Management System (IMS) is both a control measure and a measurement criteria. As a control measure the IMS function is to prompt, facilitate and record the completion of three key response planning processes detailed below. As a measurement criteria the IMS records the evidence of the timeliness of all response actions included in the environmental performance standards and the plans used of the PAP.

As the IMS does not directly remove hydrocarbons spilt into the marine environment there is no direct relationship to the response planning need.

5.7.1 Incident action planning

The ICC will be required to collect and interpret information from the scene of the incident to determine support requirements to the site-based IMT, develop an incident action plan (IAP) and assist the IMT with the execution of that plan. The site-based IC may request the ICC to complete notifications internally within Woodside, to stakeholders and government agencies as required. Depending on the type and scale of the incident either the ICC DM or IC will be responsible for ensuring the development of the IAP. Incident Action Planning is an ongoing process that involves continual review to ensure techniques to control the incident are appropriate to the situation at the time.

5.7.2 Operational NEBA process

In the event of a response Woodside will confirm that the response techniques adopted at the time of Environment Plan/Oil Pollution Emergency Plan (EP/OPEP) acceptance remain appropriate to reduce the consequences of the spill. This process verifies that there is a continuing net environmental benefit associated with continuing the response technique through the operational NEBA process. This process manages the environmental risks and impacts of response techniques during the spill response, an operational NEBA will be undertaken throughout the response, for each operational period.

The operational NEBA will consider the risks and benefits of conducting a response activity. For example, if vessels are required for access to nearshore or onshore areas, anchoring locations will be selected to minimise disturbance to benthic habitats. Vessel cleanliness would be commensurate with the receiving environment. The operational NEBA will consider the risks and benefits of conducting other response techniques.

The operational NEBA process is also used to terminate a response. Using data from operational and scientific monitoring activities the response to a hydrocarbon spill will be terminated in accordance with the termination process outlined in the Oil Pollution Emergency Arrangements (Australia). In effect the operational NEBA will determine whether there is net environmental benefit to continue response operations.

5.7.3 Stakeholder engagement process

Woodside will ensure stakeholders are engaged during the spill response in accordance with internal standards. This process requires that Woodside will:

- Undertake all required notifications (including government notifications) for stakeholders in the region (identified in the First-Strike Response Plan). This includes notification to mariners to communicate navigational hazards introduced through response equipment and personnel.
- In the event of a response, identify and engage with relevant stakeholders and continually assess and review.

5.7.4 Environmental performance based on need

Table 5-15: Environmental Performance – Incident Management System

Environmental Performance Outcome		To support the effectiveness of all other control measures and monitor/record the performance levels achieved.		
Control measure		**Performance Standard**		**Measurement Criteria (Section 5.8)**
21	Operational NEBA	21.1	Confirm that the response strategies adopted at the time of acceptance remain appropriate to reduce the consequences of the spill within 24 hours.	1, 3A
		21.2	Record the evidence and justification for any deviation from the planned response activities.	
		21.3	Record the information and data from operational and scientific monitoring activities used to inform the NEBA.	
22	Stakeholder engagement	22.1	Prompt and record all notifications (including government notifications) for stakeholders in the region are made	
		22.2	In the event of a response, identification of relevant stakeholders will be re-assessed throughout the response period.	
		22.3	Undertake communications in accordance with: Woodside Crisis Management Functional Support Team Guideline – Reputation; External Communication Operating Standard; External Stakeholder Engagement Operating Standard.	
23	Personnel required to support any response	23.1	Action planning is an ongoing process that involves continual review to ensure strategies to control the incident are appropriate to the situation at the time.	1, 3B
		23.2	A duty roster of trained and competent people will be maintained to ensure that minimum manning requirements are met all year round.	3C
		23.3	Immediately activate the IMT with personnel filling one or more of the following roles: • Operations Duty Manager; • D&C (Drilling and Completions) Duty Manager; • Operations Coordinator; • Deputy Operations Coordinator; • Planning Coordinator; • Logistics (materials, aviation, marine and support positions); • Management Support; • Health and Safety Advisor; • Environment duty Manager; • People Coordinator; • Public Information Coordinator; • Intelligence Coordinator; and • Finance Coordinator.	1, 2, 3B, 3C, 4
		23.4	Collect and interpret information from the scene of the incident to determine support requirements to the site-based IMT, develop an Incident Action Plan (IAP) and assist with the execution of that plan.	
		23.5	Security and Emergency Management (S&EM) advisors will be integrated into ICC to monitor performance of all functional roles.	
		23.6	Continually communicate the status of the spill and support Woodside to determine the most appropriate response by delivering on the responsibilities of their role.	
		23.7	Follow the OPEA, Operational Plans, FSRPs, support plans	1, 2, 3A, 4

			and the IAPs developed.	
		23.8	Contribute to Woodside's response in accordance with the aims and objectives set by the Duty Manager.	1, 2, 3B, 3C, 4

5.8 Measurement criteria for all response techniques

Woodside ensures compliance with environmental performance outcomes and standards through four primary mechanisms. The performance tables aforementioned identify which of these four mechanisms monitors the readiness, and records the effectiveness and performance of the control measures adopted.

1. The Incident Management System

The Incident Management System (IMS) supports the implementation of the Emergency & Crisis Management Procedure. The IMS provides a near real-time, single source of information for monitoring and recording an incident and measuring the performance of those control measures.

The Emergency & Crisis Management Procedure defines the management framework, including roles and responsibilities, to be applied to any size incident (including hydrocarbon spills). The organisational structure required to manage an incident is developed in a modular fashion and is based on the specific requirements of each incident. The structure can be scaled up or down.

The Incident Action Plan (IAP) process formally documents and communicated the:

- Incident objectives;
- Status of assets;
- Operational period objectives;
- Response techniques (defined during response planning); and
- The effectiveness of response techniques.

The information captured in the IMS (including information from personal logs and assigned tasks/close outs) confirms the response techniques implemented remain appropriate to reduce the consequences of the spill. The system also records all information and data that can be used to support the site-based IMT, development and the execution of the IAP.

2. The S&EM Competency Dashboard

The S&EM competency dashboard records the number of trained and competent responders that are available across Woodside, and some external providers, to participate in a response.

This number varies dependent on expiry of competency certificates, staff attrition, internal rotations, leave and other absences. As such the Dashboard is designed to identify the minimum manning requirements and to identify sufficient redundancy to cater for the variances listed above.

Figure 5-1 shows the minimum manning numbers for the different hydrocarbon spill response roles and the number of qualified persons against those roles.

Woodside's pool of trained responders is composed of but not limited to personnel from the following organisations:

- Woodside internal
- Australian Marine Oil Spill Centre (AMOSC) core group
- Oil Spill Response Limited (OSRL)
- Marine Spill Response Corporation (MSRC)
- AMSA
- Woodside contracted workforce

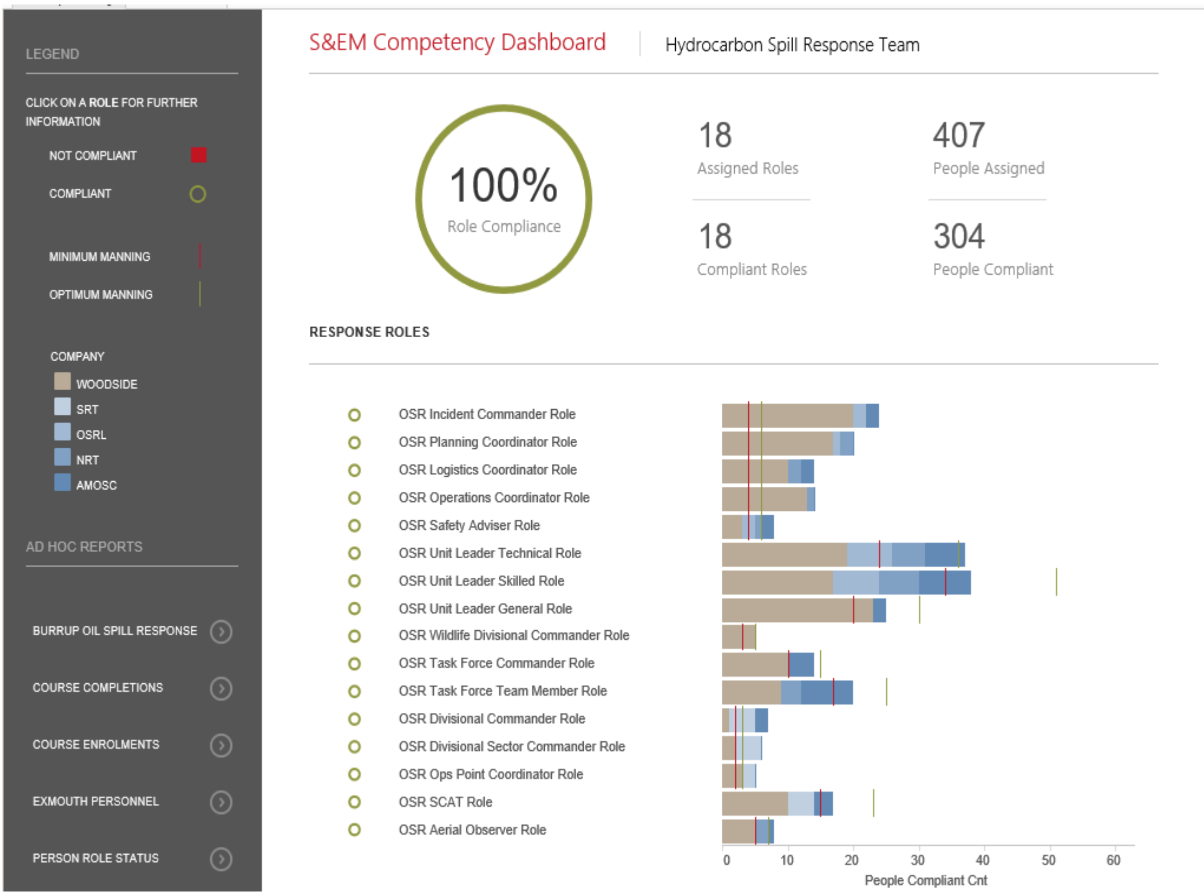


Figure 5-1: Example screen shot of the HSP competency dashboard

The Dashboard is one of Woodside's key means of monitoring its readiness to respond. It also and shows that Woodside can meet the requirements of the environmental performance standard that relate to filling certain response roles.

Figure 5-2 shows deeper dive into the Ops Point Coordinator role and the training modules required to show competence.

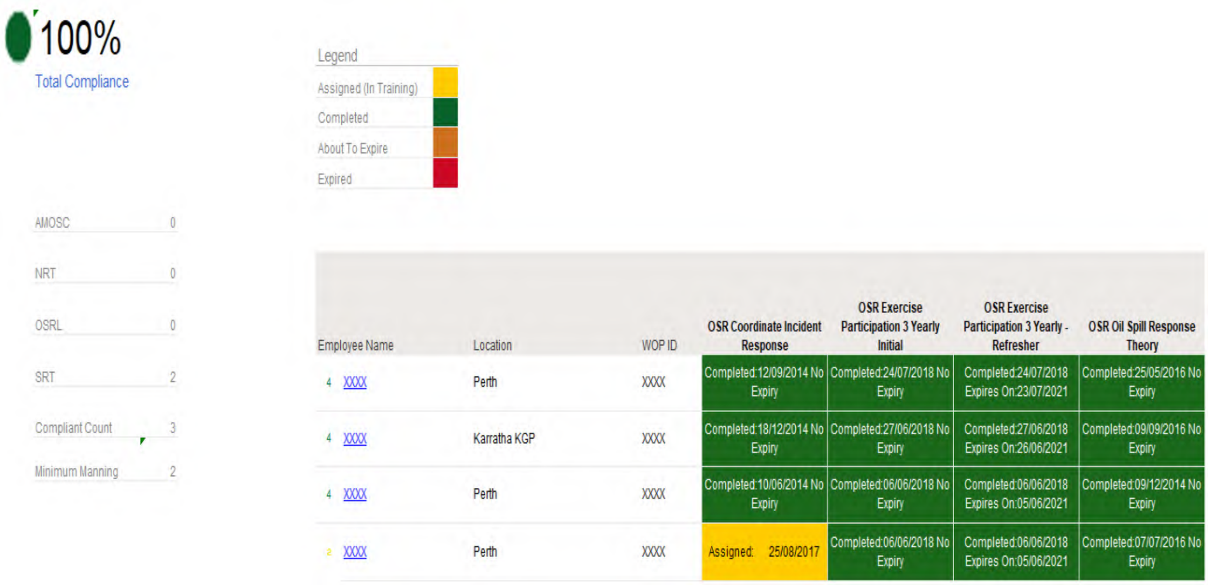


Figure 5-2: Example screen shot for the Ops Point Coordinator role

3. The Hydrocarbon Spill Preparedness ICE Assurance Process

The Hydrocarbon Spill Response Team has developed a Hydrocarbon Spill Preparedness and Response Internal Control Environment (ICE) process to align and feed into the Woodside Management System Assurance process for hydrocarbon spill. The process tracks compliance over four key control areas:

a) **Plans** – Ensures all plans (including: Oil Pollution Emergency Arrangements, first strike response plans, operational plans, support plans and tactical response plans) are current and in line with regulatory and internal requirements.

b) **Competency** – Ensures the competency dashboard is up to date and there are the minimum competency numbers across ICC, CMT and hydrocarbon spill response roles. The hydrocarbon spill training plan and exercise schedule, including testing of arrangements is also tracked. The Testing of Arrangements (TOA) register tracks the testing of all hydrocarbon spill response arrangements, key contracts and agreements in place with internal and external parties to ensure compliance.

c) **Capability** – Tracks and monitors capability that could be required in a hydrocarbon incident, including but not limited to: integrated fleet[4] vessel schedule, dispersant availability, rig/vessels monitoring, equipment stockpiles, tracking buoy locations and the CICC duty roster.

d) **Compliance & Assurance** – Ensures all regulator inspection outcomes are actioned and closed out, the global legislation register is up to date and that the key assurance components are tracked and managed. Assurance activities (including Audits) conducted on memberships with key Oil Spill Response Organisations (OSROs) including AMOSC and OSRL are also tracked and recorded in the ICE.

The ICE assurance process records how each commitment listed in the performance tables above is managed to ensure ongoing compliance monitoring. The level of compliance can be reviewed in real time and is reported on a monthly basis through the S&EM Function.

The completion of the assurance checks (over and above the ICE process) is also applied via the Woodside Integrated Risk & Compliance System (WiRCs) and subject to the requirements of Woodside's Provide Assurance Procedure.

4. The Hydrocarbon Spill Preparedness and Response Procedure

This procedure sets out how to plan and prepare for a liquid hydrocarbon spill to the marine environment. (Note, this procedure does not apply to scenarios relating to gas releases in the marine environment).

This procedure details the:

- Requirement for an Oil Pollution Emergency Plan (OPEP) to be developed, maintained, reviewed, and approved by appropriate regulators (where applicable) including:
- Defining how spill scenarios are developed on an activity specific basis;
- Developing and maintaining all hydrocarbon spill related plans;
- Ensuring the ongoing maintenance of training and competency for personnel;
- Developing the testing of spill response arrangements; and
- Maintaining access to identified equipment and personnel.
- Planning for hydrocarbon spill response preparedness
- Accountabilities for hydrocarbon spill response preparedness

[4] The Integrated fleet consists of vessels from multiple operators that have been contracted to Woodside to undertake a number of duties including hydrocarbon spill response

- Spill training requirements
- Requirements for spill exercising / testing of spill response arrangements
- Spill equipment and services requirements.

The procedure also details the roles and responsibilities of the dedicated Woodside Hydrocarbon Spill Preparedness team. This team is responsible for:

- Assuring that Woodside hydrocarbon spill responders meet competency requirements.
- Establishing the competency requirements, annual training schedule and a training register of trained personnel.
- Establishing and maintaining the total numbers of trained personnel required to provide an effective response to any hydrocarbon spill incident.
- Ensuring equipment and services contracts are maintained
- Establishing OPEPs
- Establishing OPEAs
- Priority response receptor determination
- ALARP determination
- Ensuring compliance and assurance is undertaken in accordance with external and internal requirements

6 ALARP EVALUATION

This Section should be read in conjunction with Section 5 which is the capability planned for this activity.

6.1 Monitor and Evaluate – ALARP Assessment

Alternative, Additional and Improved options have been identified and assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.1.1 Monitor and Evaluate – Control Measure Options Analysis

6.1.1.1 Alternative Control Measures

Option considered	Environmental consideration	Feasibility	Cost	Implemented
Aerostat (or similar inflatable observation platform) for localised aerial surveillance	Lead time to Aerostat surveillance is disproportionate to the environmental benefit. The system also provides a very limited field of visibility around the vessel it is deployed from.	Long lead time to access (>10 days) which exceeds the duration of modelled WCCS spill (clean up completed by Day four). Each system would require an operator to interpret data and direct vessels accordingly. Requires multiple systems for shoreline use.	Purchase cost per system approx. $300,000.	No
Use of Autonomous Underwater Vehicles (AUVs) for hydrocarbon presence and detection	Use of AUVs may be feasible and may provide an environmental benefit in assessing inaccessible areas for presence of hydrocarbons in the water however cost of purchase is disproportionate to the size and duration of the spill and environmental benefit when compared to the monitoring types already in place.	AUVs may be considered as an additional method of monitoring, should remote systems be required for health and safety reasons.	Cost $10,000 for mobilisation and $15,000 a day when deployed.	No

6.1.1.2 Additional Control Measures

Additional Control Measures considered *Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
Additional personnel trained in operational monitoring techniques and systems	Current arrangement provides an environmental benefit in the availability of trained personnel facilitating access to monitoring data used to inform all other response techniques. No improvement required.	No improvement can be made, all personnel in technical roles e.g. intelligence unit are trained and competent on the software systems. Personnel are trained and exercised regularly. Use of the software and systems forms part of regular work assignments and projects.	Cost for training in-house staff would be approx. $25,000	No
Additional satellite tracking buoys to enable greater area coverage	Current capability meets need. WEL has access to sufficient satellite tracking buoys from its own and service provider stockpiles. In addition, the increased capability would not provide an environmental benefit in light of the predicted short duration of the WCCS spill (spill duration is four hours with clean-up completed by Day four).	Tracking buoy on location at manned facility, additional needs are met from Woodside (WEL) owned stocks in King Bay Support Facility (KBSF) and Exmouth or can be provided by service provider.	Cost for an additional satellite tracking buoy would be $200 per day or $6,000 to purchase	No
Additional trained aerial observers	Current capability meets need. WEL has access to a pool of trained, competent observers at strategic locations to ensure timely and sustainable response. Additional observers are available through current contracts with AMOSC and OSRL	Current capability meets need. WEL has a pool of trained, competent observers at strategic locations to ensure timely and sustainable response. Additional observers are available through current contracts with AMOSC and OSRL Aviation standards & guidelines ensure all aircraft crews are competent for their roles. WEL maintains a pool of trained and competent aerial observers with various home base locations to be called upon at the time of an incident. Regular audits of oil spill response organisations ensure training and competency is maintained.	Cost for additional trained aerial observers would be $2,000 per person per day	No

6.1.1.3 Improved Control Measures

Improved Control Measures considered *Improved control measures are evaluated for improvements they could bring to the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
Faster activation time (one hour for Rapid Assessment tool and ADIOS)	Current capability meets the need. Improved control measure does not provide an environmental benefit because detailed modelling is already available within two hours.	Woodside Intelligence unit has remote access to modelling software should it be required. Detailed modelling is available within two hours of incident and allows time for mobilisation and information gathering to ensure accurate modelling results.	Given there is no environmental benefit, any costs are disproportionate to the benefit gained.	No
Faster turnaround time from modelling contractor	Current capability meets the need. Improved control measure does not provide an environmental benefit because detailed modelling is already available within two hours.	External contractor on ICC roster to be called as soon as required. However initial information needs to be gathered by ICC team to request an accurate model. External contractor has person on call to respond from their own location.	Modelling service with a faster activation time would be achieved via membership of an alternative modelling service at an annual cost of $50,000 for 24hr access plus an initial $5,000 per modelling run.	No
Night time aerial surveillance	The risk of undertaking the aerial observations at night is disproportionate to the limited environmental benefit. The images would be of low quality and as such the variable is not adopted.	Flights will only occur when deemed safe by the pilot. The risk of night operations, is disproportionate to the benefit gained, as images from sensors (IR, UV, etc). will be low quality. Flight time limitations will be adhered to.	No improvement can be made without risk to personnel health and safety and breaching Woodside's internal standards.	No

6.1.2 Selected Control Measures

Following review of alternative, additional and improved control measures, the following controls were selected for implementation for the PAP.

- Alternative
  - None selected
- Additional
  - None selected
- Improved
  - None selected

6.2 Source Control via Vessel SOPEP – ALARP Assessment

Alternative, Additional and Improved options have been assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.2.1 Source Control via Vessel SOPEP – Control Measure Options Analysis

6.2.1.1 Alternative control measures

Alternative Control Measures considered *Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
No reasonably practical alternative control measures identified.				N/A

6.2.1.2 Additional Control Measures

Additional Control Measures considered *Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
No reasonably practical alternative control measures identified.				N/A

6.2.1.3 Improved Control Measures

Improved Control Measures considered *Improved control measures are evaluated for improvements they could bring to the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
No reasonably practical alternative control measures identified.				N/A

6.2.2 Selected control measures

Following review of alternative, additional and improved control measures, the following controls were selected for implementation for the PAP.

- Alternative
  - None selected
- Additional
  - None selected
- Improved
  - None selected

6.3 Shoreline Clean-up – ALARP Assessment

Alternative, Additional and Improved options have been identified and assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.3.1 Existing Capability – Shoreline Clean-up

Woodside's existing level of capability is based on internal and third-party resources that are available 24 hours, 7 days per week. The capability presented below is displayed as ranges to incorporate operational factors such as weather, crew/vessel/aircraft/vehicle location and duties, survey or classification society inspection requirements, overflight/port/quarantine permits and inspections, crew/pilot duty and fatigue hours, re-fuelling/re-stocking provisions, and other similar logistic and operational limitation that are beyond Woodside's direct control.

6.3.2 Response planning: North-west Australia 4D Marine Seismic Survey – Shoreline Clean-up

Woodside has assessed existing capability against the WCCS and has identified that the range of techniques provide an ongoing approach to shoreline clean-up at identified RPAs. Woodside's capability can cover all required shoreline clean-up operations for the PAP.

Given modelling predicts shoreline contact from 24 hours (Day two) at Ningaloo Coast North and WHA at a volume of 31 m^3, Woodside is satisfied that the current capability is managing risks and impacts to ALARP.

These figures have been combined into a single response planning need that provides a worst-case scenario for planning purposes as outlined below. Given all other shoreline contact scenarios identified from modelling are longer time frames and lesser volumes, demonstration of capability against this need will ensure Woodside can meet requirements for any other outcome.

Woodside has identified several options which could be mobilised to achieve defined response objectives. Evaluation considers the benefit in terms of the time to respond and the scale of response made possible by each option. The evaluation of possible control measures is summarised in Section 6.3.3.

Table 6-1: Response Planning – Shoreline Clean-up

	Shoreline Clean-up (Phase 2)	Day	Day	Day	Day	Day	Day	Day	Week	Week	Week	Month	Month	Month
		1	2	3	4	5	6	7	2	3	4	2	3	4
	Shoreline accumulation (above 100g/m^2) - m^3	31	8	0	0	0	0	0	0	0	0	0	0	0
	Oil remaining following response operations - m^3	0	31	27	0	0	0	0	0	0	0	0	0	0
A	**Capability Required (number of operations)**													
A1	Shoreline clean-up operations required (lower)	3	4	3	0	0	0	0	0	0	0	0	0	0
A2	SCU operations required (upper)	6	8	5	0	0	0	0	0	0	0	0	0	0
B	**Capability Available (number of operations)**													
B1	Shoreline clean-up operations available - Stage 2 - Manual (lower)	0	1	3	5	8	10	10	105	105	105	560	560	560
B2	Shoreline clean-up operations available - Stage 2 - Manual (upper)	0	2	5	8	10	10	10	140	140	140	560	560	560
C	**Capability Gap**													
C1	Shoreline clean-up operations gap (lower)	3	3	0	0	0	0	0	0	0	0	0	0	0
C2	Shoreline clean-up operations gap (upper)	6	6	0	0	0	0	0	0	0	0	0	0	0

A1 and A2 – the number of Shoreline Clean-up operations required based on the hydrocarbon volumes ashore above 100g/m^2

B1 and B2 – the upper and lower number of shoreline clean-up operations available (based on response planning assumptions in Section 6.3).

C1 and C2 – the gap between the upper and lower number of shoreline clean-up operations required in A1 and A2 compared to the operations available in B1 and B2.

6.3.3 Shoreline Clean-up – Control measure options analysis

6.3.3.1 Alternative control measures

Alternative Control Measures considered *Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
No reasonably practical alternative control measures identified.				N/A

6.3.3.2 Additional control measures

Additional Control Measures considered *Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
Additional trained personnel available	The level of training and competency of the response personnel ensures the shoreline clean-up operation is delivered with minimum secondary impact to the environment. Training additional personnel does not provide an increased environmental benefit.	Additional personnel required to sustain an extended response can be sourced through the WEL *People & Global Capability Surge Labour Requirement Plan*. Additional personnel sourced from contracted OSRO's (OSRL/AMOSC) to manage other responders Response personnel are trained and exercised regularly in shoreline response techniques and methods. All personnel involved in a response will receive a full operational/safety brief prior to commencing operations	Additional specialist personnel would cost $2,000 per person per day.	No
Additional trained personnel deployed	Additional personnel conducting clean-up activities may be able to complete the clean-up in a shorter timeframe, but managing a smaller, targeted response is expected to achieve an environmental benefit through ensuring the shoreline clean-up response is suitable and scalable for the shoreline substrate and sensitivity type. This will ensure there is no increased impact from the shoreline clean-up through the presence of unnecessary personnel and equipment.	Additional personnel are available through existing contracts with oil spill response organisations, labour hire organisations and environmental panel contractors	Additional specialist personnel would cost $2,000 per person per day.	No

6.3.3.3 Improved control measures

Improved Control Measures considered *Improved control measures are evaluated for improvements they could bring to the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
Faster response/ mobilisation time	Given modelling predicts shoreline contact at approx. 24 hours (Day two), WEL considers that there is not sufficient time for deployment of protection and deflection operations at the RPA (Ningaloo Coast North and WHA) prior to impact.	Current capability meets the need. WEL has sufficient resources from its own response teams and trained personnel, contracted oil spill response service providers, government agencies and the associated mitigation equipment required to undertake shoreline clean-up within 24-48 hours of activation. Additional equipment from existing stockpiles and oil spill response service providers can be onsite within 24-48 hours. Hydrocarbons are predicted to strand after a period of approximately 24 hours (Day two) therefore allowing enough time to re-locate existing equipment, personnel and other resources to the most appropriate areas.	The cost of establishing a local stockpile of new mitigation equipment closer to the expected hydrocarbon stranding areas is not commensurate with the need. Additionally, the predicted RPA is based on modelling data which may differ with prevailing weather/met ocean conditions during an actual event.	No

6.3.4 Selected Control Measures

Following review of alternative, additional and improved control measures, the following controls were selected for implementation for the PAP.

- Alternative
  - None selected
- Additional
  - None selected
- Improved
  - None selected

6.4 Waste Management – ALARP Assessment

Alternative, Additional and Improved options have been identified and assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.4.1 Existing Capability – Waste Management

Woodside's existing level of capability is based on internal and third-party resources that are available 24 hours, 7 days per week. The capability presented below is displayed as ranges to incorporate operational factors such as weather, crew/vessel/aircraft/vehicle location and duties, survey or classification society inspection requirements, overflight/port/quarantine permits and inspections, crew/pilot duty and fatigue hours, re-fuelling/re-stocking provisions, and other similar logistic and operational limitation that are beyond Woodside's direct control.

6.4.2 Waste Management – Control Measure Options Analysis

6.4.2.1 Alternative control measures

Alternative Control Measures considered *Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
No reasonably practical alternative control measures identified.				N/A

6.4.2.2 Additional Control Measures

Additional Control Measures considered *Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
Increased waste storage capability	The procurement of waste storage equipment options on the day of the event will allow immediate response and storage of collected waste. The environmental benefit of immediate waste storage is to reduce ecological consequence by safely securing waste, allowing continuous response operations to occur.	Access to Veolia's storage options provides the resources required to store and transport sufficient waste to meet the need. Access to waste contractors' existing facilities enables waste to be stockpiled and gradually processed within the regional waste handling facilities. Additional temporary storage equipment is available through existing contract and arrangements with OSRL. Existing arrangements meet identified need for the PAP.	Cost for increased waste disposal capability would be approx. $1,300 per m3. Cost for increased onshore temporary waste storage capability would be approx. $40 per unit per day.	No

6.4.2.3 Improved Control Measures

Improved Control Measures considered *Improved control measures are evaluated for improvements they could bring to the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
Faster response time	The access to Veolia waste storage options provides the resources to store and transport waste, permitting the wastes to be stockpiled and gradually processed within the regional waste handling facilities. Bulk transport to Veolia's licensed waste management facilities would be undertaken via controlled-waste-licensed vehicles and in accordance with Environmental Protection (Controlled Waste) Regulations 2004. The environmental benefit from successful waste storage will reduce pressure on the treatment and disposal facilities reducing ecological consequences by safely securing waste. In addition, waste storage and transport will allow continuous response operations to occur. This delivery option would increase known available storage, eliminating the risk of additional resources not being available at the time of the event. However, the environmental benefit of Woodside procuring additional waste storage is considered minor as the risk of additional storage not being available at the time of the event is considered low and existing arrangements provide adequate storage to support the response.	WEL already maintains an equipment stockpile in Dampier to enable shorter response times to incidents. This stockpile includes temporary waste storage equipment. WEL has access to stockpiles of waste storage and equipment in Dampier and Exmouth through existing contracts and arrangements.	The incremental benefit of having a dedicated local WEL-owned stockpile of waste equipment and transport is considered minor and cost is considered grossly disproportionate to the benefit gained given predicted short-duration shoreline contact times.	No

6.4.3 Selected control measures

Following review of alternative, additional and improved control measures, the following controls were selected for implementation for the PAP.

- Alternative
  - None selected
- Additional
  - None selected
- Improved
  - None selected

6.5 Wildlife Response – ALARP Assessment

Alternative, Additional and Improved options have been identified and assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.5.1 Existing Capability – Wildlife Response

Woodside's existing level of capability is based on internal and third-party resources that are available 24 hours, 7 days per week. The capability presented below is displayed as ranges to incorporate operational factors such as weather, crew/vessel/aircraft/vehicle location and duties, survey or classification society inspection requirements, overflight/port/quarantine permits and inspections, crew/pilot duty and fatigue hours, re-fuelling/re-stocking provisions, and other similar logistic and operational limitation that are beyond Woodside's direct control.

6.5.2 Wildlife Response – Control Measure Options Analysis

6.5.2.1 Alternative control measures

Alternative Control Measures considered *Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
Direct contracts with service providers	This option duplicates the capability accessed through AMOSC and OSRL and would compete for the same resources. Does not provide a significant increase in environmental benefit	These delivery options provide increased effectiveness through more direct communication and control of specialists. However, no significant net benefit is anticipated.		No

6.5.2.2 Additional Control Measures

Additional Control Measures considered *Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**
Additional wildlife treatment systems	The selected options provide access to call-off contracts with selected specialist providers. The agreements ensure that these resources can be mobilised to meet the required response objectives, commensurate with the nature of environmental impact and the time available to monitor hydrocarbon plume trajectories. Provides response equipment and personnel by Day one. The additional cost in having a dedicated oiled wildlife response (equipment and personnel) in place is disproportionate to environmental benefit. These selected delivery options provide capacity to carry out an oiled wildlife response if contact is predicted; and to scale up the response if required to treat widespread contamination. Current capability meets the needs required and there is no additional environmental benefit in adopting the improvements.	Current capability meets the need with sufficient wildlife treatment available from Day one (shoreline impact is predicted after 24 hours, (Day two)). The selected options provide capacity to carry out an oiled wildlife response, if contact is predicted, and to scale up the response if required.	Additional wildlife response resources would cost $1,700 per operational site per day.	No
Additional trained wildlife responders	Current wildlife responder numbers meet the required need and additional personnel are available through existing contracts with oil spill response organisations and environmental panel contractors. The potential environmental benefit of training additional personnel is expected to be low.	Current capability meets the need with sufficient wildlife responder numbers available from Day one (shoreline impact is predicted after 24 hours, (Day two)). The selected options provide capacity to carry out an oiled wildlife response, if contact is predicted, and to scale up the response if required. Materials for holding facilities, portable pools, enclosures and rehabilitation areas would be sourced as required.	Additional wildlife response personnel cost $2,000 per person per day	No

6.5.2.3 Improved Control Measures

Improved Control Measures considered *Improved control measures are evaluated for improvements they could bring to the effectiveness of adopted control measures in terms of functionality, availability, reliability, survivability, independence and compatibility*				
Option considered	**Environmental consideration**	**Feasibility**	**Cost**	**Implemented**

Faster mobilisation time for wildlife response	Current capability meets the need. Wildlife response resources are available from Day one (shoreline impact is predicted after 24 hours (Day two)) thus response time cannot be improved and no further environmental benefit gained.	Pre-positioning vessels or equipment would not provide a significant reduction in mobilisation time for oiled wildlife response activities as current capability is available from Day one. The availability of vessels and personnel meets the response need.	Wildlife response packages to preposition at the RPA identified via the modelling would cost $700 per package per day. Additionally, as the predicted RPA is based on modelling data, this may differ with prevailing weather/met ocean conditions during an actual event.	No

6.5.3 Selected control measures

Following review of alternative, additional and improved control measures, the following controls were selected for implementation for the PAP.

- Alternative
  - None selected
- Additional
  - None selected
- Improved
  - None selected

6.6 Scientific Monitoring – ALARP Assessment

Alternative, Additional and Improved options have been identified and assessed against the base capability described in Section 5 with those that have been selected for implementation highlighted in green. Items highlighted in red have been considered and rejected on the basis that they are not feasible, the costs are clearly disproportionate to the environmental benefit, and/or the option is not reasonably practical. Control measures where there is not a clear justification for their inclusion or exclusion may be subject to a detailed ALARP assessment.

6.6.1 Existing Capability – Scientific Monitoring

Woodside's existing level of capability is based on internal and third-party resources that are available 24 hours, 7 days per week. The capability presented below is displayed as ranges to incorporate operational factors such as weather, crew/vessel/aircraft/vehicle location and duties, survey or classification society inspection requirements, overflight/port/quarantine permits and inspections, crew/pilot duty and fatigue hours, re-fueling/re-stocking provisions, and other similar logistic and operational limitation that are beyond Woodside's direct control.

6.6.2 Scientific Monitoring – Control Measure Options Analysis

Table 6-2: Scientific Monitoring – Control Measure Options considered – A. Alternative control measures

Evaluate Alternative, Additional and Improved Control Measures					
Alternative Control Measures considered *Alternative, including potentially more effective and/or novel control measures are evaluated as replacements for an adopted control*					
Ref	Control Measure Category	Option considered	Implemented	Environmental Consideration	Feasibility / Cost
SM01	System	Analytical laboratory facilities closer to the likely spill affected area	No	SM01 water quality monitoring requires water samples to be transported to NATA rated laboratories in Perth or over to the East coast. Consider the benefit of laboratory access and transportation times to deliver water samples and complete lab analysis. There is a time lag from collection of water samples to being in receipt of results and confirming hydrocarbon contact to sensitive receptors. The environmental consideration of having access to suitable laboratory facilities in Karratha to carry out the hydrocarbon analysis would provide faster turnaround in reporting of results only by a matter of days (as per the time to transport samples to laboratories).	Laboratory facilities and staff available at locations closer to the spill affected area can reduce reporting times only by a limited amount (days) with associated high costs of maintaining capability and no additional environmental benefit.
SM01	System	Dedicated contracted SMP vessel (exclusive to Woodside)	No	Would provide faster mobilisation time of scientific monitoring resources, environmental benefit associated with faster mobilisation time would be minor compared to selected options.	Chartering and equipping additional vessels on standby for scientific monitoring has been considered. The option is reasonably practicable but the sacrifice (charter costs and organisational complexity) is significant, particularly when compared with the anticipated availability of vessels and resources within in the required timeframes. The selected delivery provides capability to meet the scientific monitoring objectives, including collection of pre-emptive data where baseline knowledge gaps are identified for receptor locations where spill predictions of time to contact are >10 days. The effectiveness of this alternative control (weather dependency, availability and survivability) is rated as very low Employing a dedicated response vessel is considered to have a negligible net benefit.

Table 6-3: Scientific Monitoring - Control Measure Options considered – B. Additional control measures

Additional Control Measures considered *Additional control measures are evaluated in terms of them reducing an environmental impact or an environmental risk when added to the existing suite of control measures*					
Ref	**Control Measure Category**	**Option considered**	**Implemented**	**Environmental Consideration**	**Feasibility / Cost**
SM01	System	Determine baseline data needs and provide implementation plan in the event of an unplanned hydrocarbon release	Yes	Address resourcing needs to collect post spill (pre-contact) baseline data as spill expands in the event of a diesel spill incident from the PAP activities	Woodside relies on existing environmental baseline for receptors which have predicted hydrocarbon contact (above environment threshold) <10 days and acquiring pre-emptive data in the event of a loss of well control from the PAP activities based on receptors predicted to have hydrocarbon contact >10 days. Ensure there is appropriate baseline for key receptors for all geographic locations that are potentially impacted <10 days of spill event, where practicable. Address resourcing needs to collect pre-emptive baseline as spill expands in the event of a diesel spill incident from the PAP activities.

6.6.3 Improved Control Measures

Improved Control Measures considered – No reasonably practicable improved Control Measures identified.

6.6.4 Selected Control Measures

Following review of alternative, additional and improved control measures, the following controls were selected for implementation for the PAP.

- Alternative
  - None selected
- Additional
  - Determine baseline data needs and activate SMPs for any identified PBAs in the event of an unplanned hydrocarbon release
- Improved
  - None Selected

6.6.5 Operational Plan

Key actions from the Scientific Monitoring Program Operational Plan for implementing the response are outlined in Table 6-4.

Table 6-4: Scientific monitoring program operational plan actions

Responsibility	Action
Activation	
Perth ICC Planning (ICC Planning – Environment Unit)	Mobilise Chief Environmental Scientist or SMP Lead/Manager (via FRSP) and SMP Coordinator to the ICC Planning function.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager and SMP Coordinator)	Constantly assess all outputs from OM01, OM02 and OM03 (Section 5 and **ANNEX B** to determine receptor locations and receptors at risk. Confirm sensitive receptors likely to be exposed to hydrocarbons, timeframes to specific receptor locations and which SMPs are triggered. Review baseline data for receptors at risk.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager and SMP Coordinator)	SMP co-ordinator stand up SMP standby contractor as the SMP contractor. Stand up subject matter experts, if required.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager SMP Coordinator, SMP standby contractor SMP manager)	Establish if, and where, pre-contact baseline data acquisition is required. Determine practicable baseline acquisition program based on predicted timescales to contact and anticipated SMP mobilisation times. Determine scope for preliminary post-contact surveys during the Response Phase. Determine which SMP activities are required at each location based on the identified receptor sensitivities.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager, SMP Coordinator, SMP standby contractor SMP manager)	If response phase data acquisition is required, stand up the contractor SMP teams for data acquisition and instruct them to standby awaiting further details for mobilisation from the IMT.
Perth ICC Planning (ICC Planning – Environment Unit)	SMP contractor, SMP standby contractor to prepare the Field Implementation Plan. Prepare and obtain sign-off of the Response Phase SMP work plan and Field Implementation Plan.

Responsibility	Action
(SMP Lead/Manager, SMP Coordinator, SMP standby contactor SMP manager)	Update the IAP.
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager, SMP Coordinator SMP standby contactor SMP manager)	Liaise with ICC Logistics, and determine the status and availability of aircraft, vessels and road transportation available to transport survey personnel and equipment to point of departure. Engage with SMP standby contactor SMP Manager and ICC Logistics to establish mobilisation plan, secure logistics resources and establish ongoing logistical support operations, including: • Vessels, vehicles and other logistics resources • Vessel fit-out specifications (as detailed in the SMP Operational Plan) • Equipment storage and pick-up locations • Personnel pick-up/airport departure locations • Ports of departure • Land based operational centres and forward operations bases accommodation and food requirements
Perth ICC Planning (ICC Planning – Environment Unit) (SMP Lead/Manager, SMP Coordinator, SMP standby contactor (SMP manager)	Confirm communications procedures between Woodside SMP team, SMP standby contactor SMP Manager, SMP Team Leads and Operations Point Coordinator.
Mobilisation	
Perth ICC Logistics	Engage vessels and vehicles and arrange fitting out as specified by the mobilisation Plan Confirm vessel departure windows and communicate with the Jacob's SMP Manager. Agree SMP mobilisation timeline and induction procedures with the Division and Sector Command Point(s).
Perth ICC Logistics	Coordinate with SMP standby contactor SMP Manager to mobilise teams and equipment according to the logistics plan and Sector induction procedures.
SMP Survey Team Leads	SMP Survey Team Leader(s) coordinate on-ground/on-vessel mobilisations and support services with the Sector Command point(s).

6.6.6 ALARP and Acceptability Summary

Table 6-5: ALARP and Acceptability Summary

ALARP and Acceptability Summary		
Scientific Monitoring		
ALARP Summary	X	All known reasonably practicable control measures have been adopted
		No additional, alternative and improved control measures would provide further benefit
		No reasonably practical additional, alternative, and/or improved control measure exists
	The resulting scientific monitoring capability has been assessed against the credible spill scenarios. The range of techniques provide an ongoing approach to monitoring operations to assess and evaluate the scale and extent of impacts. All known reasonably practicable control measures have been adopted with the cost and organisational complexity of these options determined to be Moderate and the overall delivery effectiveness considered Medium. The SMP's main objectives can be met, with the addition of alternative control measures to provide further benefit.	

Acceptability Summary	• The control measures selected for implementation manage the potential impacts and risks to ALARP. • In the event of a hydrocarbon spill for the PAP, the control measures selected, meet or exceed the requirements of Woodside Management System and industry best-practice. • The level of impact and risk to the environment has been considered with regard to the principles of Environmentally Sustainable Development (ESD); and risks and impacts from a range of identified scenarios were assessed in detail. The control measures described consider the conservation of biological and ecological diversity, through both the selection of control measures and the management of their performance. The control measures have been developed to account for the worst credible case scenarios, and uncertainty has not been used as a reason for postponing control measures.
On the basis from the impact assessment above and in Section 6.7.2 of the EP, Woodside considers the adopted controls discussed manage the impacts and risks associated with implementing scientific monitoring activities to a level that is ALARP and acceptable.	

7 ENVIRONMENTAL RISK ASSESSMENT OF SELECTED RESPONSE TECHNIQUES

The implementation of response techniques may modify the impacts and risks identified in the EP and response activities can introduce additional impacts and risks from response operations themselves. Therefore, it is necessary to complete an assessment to ensure these impacts and risks have been considered and specific measures are put in place to continually review and manage these further impacts and risks to ALARP and Acceptable levels. A simplified assessment process has been used to complete this task which covers the identification, analysis, evaluation and treatment of impacts and risks introduced by responding to the event.

7.1.1 Identification of impacts and risks from implementing response techniques

Each of the control measures can modify the impacts and risks identified in the EP. These impacts and risks have been previously assessed within the scope of the EP. Refer to the EP for details regarding how these risks are being managed. They are not discussed further in this document.

- Atmospheric emissions
- Routine and non-routine discharges
- Physical presence, proximity to other vessels (shipping and fisheries)
- Routine acoustic emissions vessels
- Lighting for night work/navigational safety
- Invasive marine species
- Collision with marine fauna
- Disturbance to Seabed

Additional impacts and risks associated with the control measures not included within the scope of the EP include:

- Vessel operations and anchoring
- Presence of personnel on the shoreline
- Increase in entrained hydrocarbons
- Toxicity of dispersant
- Human presence (manual cleaning)
- Vegetation cutting
- Additional stress or injury caused to wildlife
- Secondary contamination from the management of waste

7.1.2 Analysis of impacts and risks from implementing response techniques

The table below compares the adopted control measures for this activity against the environmental values that can be affected when they are implemented.

Table 7-1: Analysis of risks and impacts

	Environmental Value						
	Soil & Groundwater	Marine Sediment Quality	Water Quality	Air Quality	Ecosystems/ Habitat	Species	Socio-Economic
Monitor and evaluate		✓	✓		✓	✓	
Shoreline Clean-up	✓	✓	✓		✓	✓	✓
Oiled Wildlife Response					✓	✓	
Scientific Monitoring	✓	✓	✓	✓	✓	✓	✓
Waste Management	✓	✓		✓	✓	✓	✓

7.1.3 Evaluation of impacts and risks from implementing response techniques

Vessel operations and anchoring

During the implementation of response techniques, where water depths allow, it is possible that response vessels will be required to anchor (e.g. during shoreline surveys). The use of vessel anchoring will be minimal and likely to occur when the impacted shoreline is inaccessible via road. Anchoring in the nearshore environment of sensitive receptor locations will have the potential to impact coral reefs, seagrass beds and other benthic communities in these areas. Recovery of benthic communities from anchor damage depends on the size of anchor and frequency of anchoring. Impacts would be highly localised (restricted to the footprint of the vessel anchor and chain) and temporary, with full recovery expected.

Presence of personnel on the shoreline

Presence of personnel on the shoreline during shoreline operations could potentially result in disturbance to wildlife and habitats. During the implementation of response techniques, it is possible that personnel may have minimal, localised impacts on habitats, wildlife and coastlines. The impacts associated with human presence on shorelines during shoreline surveys may include:

- Damage to vegetation/habitat to gain access to areas of shoreline oiling;
- Damage or disturbance to wildlife during shoreline surveys;
- Removal of surface layers of intertidal sediments (potential habitat depletion); and
- Excessive removal of substrate causing erosion and instability of localised areas of the shoreline.

Human Presence

Human presence for manual clean-up operations may lead to the compaction of sediments and damage to the existing environment especially in sensitive locations such as mangroves and turtle nesting beaches. However, any impacts are expected to be localised with full recovery expected.

Waste Generation

Implementing the selected response techniques will result in the generation of the following waste streams that will require management and disposal:

- Liquids (recovered oil/water mixture), recovered from containment and recovery and shoreline clean-up operations
- Semi-solids/solids (oily solids), collected during containment and recovery and shoreline clean-up operations
- Debris (e.g. seaweed, sand, woods, plastics), collected during containment and recovery and shoreline clean-up operations and oiled wildlife response.

If not managed and disposed of correctly, wastes generated during the response have the potential for secondary contamination similar to that described above, impacts to wildlife through contact with or ingestion of waste materials and contamination risks if not disposed of correctly onshore.

Cutting back vegetation could allow additional oil to penetrate the substrate and may also lead to localised habitat loss. However, any loss is expected to be localised in nature and lead to an overall net environmental benefit associated with the response by reducing exposure of wildlife to oiling.

Additional stress or injury caused to wildlife

Additional stress or injury to wildlife could be caused through the following phases of a response:

- Capturing wildlife
- Transporting wildlife
- Stabilisation of wildlife
- Cleaning and rinsing of oiled wildlife
- Rehabilitation (e.g. diet, cage size, housing density)
- Release of treated wildlife

Inefficient capture techniques have the potential to cause undue stress, exhaustion or injury to wildlife, additionally pre-emptive capture could cause undue stress and impacts to wildlife when there are uncertainties in the forecast trajectory of the spill. During the transportation and stabilisation phases there is the potential for additional thermoregulation stress on captured wildlife. Additionally, during the cleaning process, it is important personnel undertaking the tasks are familiar with the relevant techniques to ensure that further injury and the removal of water proofing feathers are managed and mitigated. Finally, during the release phase it’s important that wildlife is not released back into a contaminated environment.

7.1.4 Treatment of impacts and risks from implementing response techniques

In respect of the impacts and risks assessed the following treatment measures have been adopted. It must be recognised that this environmental assessment is seeking to identify how to maintain the level of impact and risks at levels that are ALARP and of an acceptable level rather than exploring further impact and risk reduction. It is for this reason that the treatment measures identified in this assessment will be captured in Operational Plans, Tactical Response Plans, and/or FSRPs.

Vessel operations and access in the nearshore environment

- If vessels are required for access, anchoring locations will be selected to minimise disturbance to benthic primary producer habitats. Where existing fixed anchoring points are not available, locations will be selected to minimise impact to nearshore benthic environments with a preference for areas of sandy seabed where they can be identified (PS 10.1)
- Shallow draft vessels will be used to access remote shorelines to minimise the impacts associated with seabed disturbance on approach to the shorelines (PS 10.2).

Presence of personnel on the shoreline

- Vehicular access will be restricted on dunes, turtle nesting beaches and in mangroves (PS 10.3).
- Shoreline access route (foot, car, vessel and helicopter) with the least environmental impact identified will be selected by a specialist in SCAT operations (PS 10.4).
- Trained unit leaders will brief personnel prior to operations of the environmental risks of presence of personnel on the shoreline (PS 10.5).

Waste Generation

- All shorelines zoned and marked before clean-up operations commence to prevent secondary contamination and minimise the mixing of clean and oiled sediment and shoreline substrates (PS 7.5).

Additional stress or injury caused to wildlife

- Vessels used in hazing/pre-emptive capture will approach fauna at slows speeds to ensure animals are not directed towards the hydrocarbons (PS 12.4).
- Oiled wildlife operations would be implemented with advice and assistance from the Oiled Wildlife Advisor from the DBCA and in accordance with the processes and methodologies described in the WA OWRP and the relevant regional plan (PS 13.3).

8 ALARP CONCLUSION

An analysis of alternative, additional and improved control measures has been undertaken to determine their reasonableness and practicability. The tables in Section 6 document the considerations made in this evaluation. Where the costs of an alternative, additional, or improved control measure have been determined to be clearly disproportionate to the environmental benefit gained from its adoption it has been rejected. Where this is not considered to be the case the control measure has been adopted.

The risks from a hydrocarbon spill have been reduced to ALARP because:

- Woodside has a significant hydrocarbon spill response capability to respond to the WCCS through the control measures identified.
- New and modified impacts and risks associated with implementing response techniques have been considered and will not increase the risks associated with the activity.
- A consideration of alternative, additional, and improved control measures identified any other control measures that delivered proportionate environmental benefit compared to the cost of adoption for this activity ensuring that:
    - All known, reasonably practicable control measures have been adopted.
    - No additional, reasonably practicable alternative and/or improved control measures would provide further environmental benefit.
    - No reasonably practical additional, alternative, and/or improved control measure exists.
- A structured process for considering alternative, additional, and improved control measures was completed for each control measure.
- The evaluation was undertaken based on the outputs of the WCCS so that the capability in place is sufficient for all other scenario from this activity.
- The likelihood of the WCCS spill has been ignored in evaluating what was reasonably practicable.

9 ACCEPTABILITY CONCLUSION

Following the ALARP evaluation process, Woodside deems the hydrocarbon spill risks and impacts to have been reduced to an acceptable level by meeting all of the following criteria:

- Techniques are consistent with Woodside's processes and relevant internal requirements including policies, culture, processes, standards, structures and systems.
- Levels of risk/ impact are deemed acceptable by relevant persons (external stakeholders) and are aligned with the uniqueness of, and/or the level of protection assigned to the environment, its sensitivity to pressures introduced by the activity, and the proximity of activities to sensitive receptors, and have been aligned with Part 3 of the EPBC Act.
- Selected control measures meet requirements of legislation and conventions to which Australia is a signatory (e.g. MARPOL, the World Heritage Convention, the Ramsar Convention, and the Biodiversity Convention etc.). In addition to these, other non-legislative requirements met include:
    - Australian IUCN reserve management principles for Commonwealth marine protected areas and bioregional marine plans.
    - National Water Quality Management Strategy and supporting guidelines for marine water quality).
    - Conditions of approval set under other legislation.
    - National and international requirements for managing pollution from ships.
    - National biosecurity requirements.
- Industry standards, best practices and widely adopted standards and other published materials have been used and referenced when defining acceptable levels. Where these are inconsistent with mandatory/ legislative regulations, explanation has been provided for the proposed deviation. Any deviation produces the same or a better level of environmental performance (or outcome).

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11 GLOSSARY & ABBREVIATIONS

11.1 Glossary

Term	Description / Definition
ALARP	Demonstration through reasoned and supported arguments that there are no other practicable options that could reasonably be adopted to reduce risks further.
Availability	The availability of a control measure is the percentage of time that it is capable of performing its function (operating time plus standby time) divided by the total period (whether in service or not). In other words, it is the probability that the control has not failed or is undergoing a maintenance or repair function when it needs to be used.
Control	The means by which risk from events is eliminated or minimised.
Control effectiveness	A measure of how well the control measures perform their required function.
Control measure (risk control measure)	The features that eliminate, prevent, reduce or mitigate the risk to environment associated with the PAP.
Credible spill scenario	A spill considered by Woodside as representative of maximum volume and characteristics of a spill that could occur as part of the PAP.
Dependency	The degree of reliance on other systems in order for the control measure to be able to perform its intended function.
Environment that May be Affected	The summary of quantitative modelling where the marine environment could be exposed to hydrocarbons levels exceeding hydrocarbon threshold concentrations.
Incident	An event where a release of energy resulted in or had (with) the potential to cause injury, ill health, damage to the environment, damage to equipment or assets or company reputation.
Major Environment Event	The events with potential environment, reputation, social or cultural consequences of category C or higher (as per Woodside's operational risk matrix) which are evaluated against credible worst-case scenarios which may occur when all controls are absent or have failed.
Performance outcome	A statement of the overall goal or outcome to be achieved by a control measure
Performance standard	The parameters against which [risk] controls are assessed to ensure they reduce risk to ALARP. A statement of the key requirements (indicators) that the control measure has to achieve in order to perform as intended in relation to its functionality, availability, reliability, survivability and dependencies.
Preparedness	Measures taken before an incident in order to improve the effectiveness of a response
Reasonably practicable	... a computation ... made by the owner, in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) [showing whether or not] that there is a gross disproportion between them ... made by the owner at a point of time anterior to the accident. (Judgement: Edwards v National Coal Board [1949])
Receptors at risk	Physical, biological and social resources identified as at risk from hydrocarbon contact using oil spill modelling predictions.
Receptor areas	Geographically referenced areas such as bays, islands, coastlines and/or protected area (WHA, Commonwealth or State marine reserve or park) containing one or more receptor type, e.g., Exmouth

Term	Description / Definition
Receptor Sensitivities	This is a classification scheme to categorise receptor sensitivity to an oil spill. The Environmental Sensitivity Index (ESI) is a numerical classification of the relative sensitivity of a particular environment (particularly different shoreline types) to an oil spill. Refer to the Woodside Oil Pollution Emergency Arrangements (Australia) for more details.
Regulator	NOPSEMA are the Environment Regulator under the Environment Regulations.
Reliability	The probability that at any point in time a control measure will operate correctly for a further specified length of time.
Response technique	The key priorities and objectives to be achieved by the response plan Measures taken in response to an event to reduce or prevent adverse consequences.
Survivability	Whether or not a control measure is able to survive a potentially damaging event is relevant for all control measures that are required to function after an incident has occurred.
Threshold	Hydrocarbon threshold concentrations applied to the risk assessment to evaluate hydrocarbon spills. These are defined as: surface hydrocarbon concentration – ≥10 g/m^2, dissolved – ≥100 ppb and entrained hydrocarbon concentrations – ≥500 ppb.
Zone of Application	The zone in which Woodside may elect to apply dispersant. The zone is determined based on a range of considerations, such as hydrocarbon characteristics, weathering and metocean conditions. The zone is a key consideration in the NEBA for dispersant use.

11.2 Abbreviations

Abbreviation	Meaning
ADIOS	Automated Data Inquiry for Oil Spills
AIIMS	Australasian Inter-Service Incident Management System
ALARP	As Low As Reasonably Practicable
AMOSC	Australian Marine Oil Spill Centre
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council Agriculture and Resource Management Council of Australia and New Zealand
APASA	Asia Pacific ASA
BAOAC	Bonn Agreement Oil Appearance Code
BOP	Blowout Preventer
CAR	Containment and Recovery
CICC	Corporate Incident Coordination Centre
DM	Duty Manager
DoT	Western Australia Department of Transport
DBCA	Western Australia Department of Biodiversity, Conservation and Attractions (former Western Australian Department of Parks and Wildlife)
D&C	Drilling and Completions
EMBA	Environment that May Be Affected
EMSA	European Maritime Safety Agency
EP	Environment Plan
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
Environment Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
ESI	Environmental Sensitivity Index
ESD	Emergency Shut Down
ESP	Environmental Services Panel
FPSO	Floating Production Storage Offloading
FSRP	First Strike Response Plan
FWADC	Fixed Wing Aerial Dispersant Capability
GIS	Geographic Information System
GPS	Global Positioning System
HSEQ	Health Safety Environment and Quality
HSP	Hydrocarbon Spill Preparedness
IAP	Incident Action Plan
ICC	Incident Coordination Centre
ICE	Internal Control Environment
IGEM	Industry-Government Environmental Meta-database
IMS	Incident Management System

Abbreviation	Meaning
IMT	Incident Management Team
IPIECA	International Petroleum Industry Environment Conservation Association
ITOPF	International Tanker Owners Pollution Federation
IUCN	International Union for Conservation of Nature
KBSF	King Bay Supply Facility
KICC	Karratha Incident Coordination Centre
KSAT	Kongsberg Satellite
ME	Monitor and Evaluate
MODU	Mobile Offshore Drilling Unit
MoU	Memorandum of Understanding
NEBA	Net Environmental Benefit Analysis
NOAA	National Oceanic and Atmospheric Administration
NRT	National Response Team
OILMAP	Oil Spill Model and Response System
OPEA	Oil Pollution Emergency Arrangements
OPEP	Oil Pollution Emergency Plan
OPGGSA	Offshore Petroleum and Greenhouse Gas Storage Act
OSMP	Operational and Scientific Monitoring Program
OSRL	Oil Spill Response Limited
OSRO	Oil Spill Response Organisations
OSTM	Oil Spill Trajectory Modelling
OWR	Oiled Wildlife Response
OWRP	Oiled Wildlife Response Plan (WA)
OWROP	Regional Oiled Wildlife Response Operational Plan
PAP	Petroleum Activities Program
PEARLS	People, Environment, Asset, Reputation, Livelihood and Services
PBA	Pre-emptive Baseline Areas
PPA	Priority Protection Area
PPB	Parts per billion
PPM	Parts per million
ROV	Remotely Operated Vehicle(s)
RPA	Response Protection Area
RUZ	Recreational Use Zone
S&EM	Security and Emergency Management
SCAT	Shoreline Contamination Assessment Techniques
SDA	Surface Dispersant Application
SHC	Shoreline Clean-up
SIMAP	Integrated Oil Spill Impact Model System
SSDI	Subsea Dispersant Injection

Abbreviation	Meaning
SFRT	Subsea First Response Toolkit
SMP	Scientific monitoring program
SOP	Standard Operating Procedure
TRP	Tactical Response Plan
WEL	Woodside Energy Limited
WHA	World Heritage Area
Woodside	Woodside Energy Limited
WCC	Woodside Communication Centre
WWCI	Wild Well Control Inc
WCCS	Worst Case Credible Scenario
ZoA	Zone of Application

ANNEX A: NEBA DETAILED OUTCOMES

A NEBA has been conducted to assess the net environmental benefit of different response techniques to selected receptors in the event of an oil spill from the PAP for marine diesel (representing surface release resulting from vessel collision). The complete list of potential receptor locations within the EMBA for the PAP is included in Section 5 of the EP.

The locations utilised for the NEBA were limited to the identified RPAs of the PAP identified from modelling (see Section 0 for outline of selection).

These include receptors that have potential for the following:

- Shoreline accumulation (>100 g/m^2) at any time.

The detailed NEBA assessment outcomes are shown below. The North-west Australia 4D Marine Seismic Survey Pre-operational NEBA contains the full assessments.

Table A-1: NEBA assessment technique recommendations for marine diesel (surface release from vessel collision)

Receptor	Monitor and Evaluate	Source Control via Vessel SOPEP	Containment and Recovery	In-situ burning	Dispersant application: >20 m water depth and >10 km from shore/reefs	Mechanical dispersion	Shoreline protection	Shoreline clean-up (manual)	Shoreline clean-up (mechanical)	Shoreline clean-up (chemical)	Oiled Wildlife Response
Ningaloo Coast North and WHA	Yes	Yes	No	No	No	No	No	Yes	Yes	No	Yes

Overall assessment

Sensitive receptor (Sites identified in EP)	Monitor and Evaluate	Source Control via Vessel SOPEP	Containment and Recovery	In-situ burning	Dispersant application: >20 m water depth and >10 km from shore/reefs	Mechanical dispersion	Shoreline protection	Shoreline clean-up (manual)	Shoreline clean-up (mechanical)	Shoreline clean-up (chemical)	Oiled Wildlife Response
Is this response Practicable?	Yes	Yes	No	No	No	No	No	Yes	Yes	No	Yes
NEBA identifies Response potentially of Net Environmental Benefit?	Yes	Yes	No	No	No	No	No	Yes	Yes	No	Yes

NEBA Impact Ranking Classification Guidance

To reduce variability between assessments, the following ranking descriptions have been devised to guide the workshop process:

			Degree of impact	Potential duration of impact	Equivalent Woodside Corporate Risk Matrix Consequence Level
Positive	3P	Major	Likely to prevent: • behavioural impact to biological receptors • behavioural impact to socio-economic receptors e.g. changes to day-today business operations, public opinion/behaviours (e.g. avoidance of amenities such as beaches) or regulatory designations.	Decrease in duration of impact by > 5 years	N/A
	2P	Moderate	Likely to prevent: • significant impact to a single phase of reproductive cycle of biological receptors • detectable financial impact, either directly (e.g. loss of income) or indirectly (e.g. via public perception), for socio-economic receptors.	Decrease in duration of impact by 1–5 years	N/A
	1P	Minor	Likely to prevent impacts on: • significant proportion of population or breeding stages of biological receptors • socio-economic receptors such as: ○ significant impact to the sensitivity of protective designation; or ○ significant and long-term impact to business/industry.	Decrease in duration of impact by several seasons (< 1 year)	N/A
	0	Non-mitigated spill impact	**No detectable difference to unmitigated spill scenario.**		
Negative	1N	Minor	Likely to result in: • behavioural impact to biological receptors • behavioural impact to socio-economic receptors e.g. changes to day-to-day business operations, public opinion/behaviours (e.g. avoidance of amenities such as beaches), or regulatory designations. **[Note 1]**	Increase in duration of impact by several seasons (< 1 year)	Increase in risk by one sub-category, without changing category (e.g. Minor (E) to Minor (D))
	2N	Moderate	Likely to result in: • significant impact to a single phase of reproductive cycle for biological receptors; or • detectable financial impact, either directly (e.g. loss of income) or indirectly (e.g. via public perception), for socio-economic receptors. This level of negative impact is recoverable and unlikely to result in closure of business/industry in the region.	Increase in duration of impact by 1–5 years	Increase in risk by one category (e.g. Minor (D) to Moderate (C or B))
	3N	Major	Likely to result in impacts on: • significant proportion of population or breeding stages of biological receptors • socio-economic receptors resulting in either: ○ significant impact to the sensitivity of protective designation; or ○ significant and long-term impact to business/industry.	Increase in duration of impact by > 5 years or unrecoverable	Increase in risk by two categories (e.g. Minor (E) to Major (A))

Note 1: the maximum likely impact should be considered; for example, if a spill were to directly impact the behaviour that results in an impact to reproduction and/or the breeding population (such as fish failing to aggregate to spawn), then the score should be a 2 or 3 rather than a 1. Similarly, if a change in behaviour resulted in an increased risk of mortality of a population, then it should be scored as a 2 or 3.

ANNEX B: OPERATIONAL MONITORING ACTIVATION AND TERMINATION CRITERIA

Table B-1: Operational monitoring objectives, triggers and termination criteria

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
Operational Monitoring Operational Plan 1 (OM01) Predictive Modelling of Hydrocarbons to Assess Resources at Risk	OM01 focuses on the conditions that have prevailed since a spill commenced, as well as those that are forecasted in the short term (1–3 days ahead) and longer term. OM01 utilises computer-based forecasting methods to predict hydrocarbon spill movement and guide the management and execution of spill response operations to maximise the protection of environmental resources at risk. The objectives of OM01 are to: • Provide forecasting of the movement and weathering of spilled hydrocarbons • Identify resources that are potentially at risk of contamination • Provide simulations showing the outcome of alternative response options (booming patterns etc.) to inform on-going NEBA and continually assess the efficacy of available response options in order to reduce risks to ALARP	OM01 will be triggered immediately following a level 2/3 hydrocarbon spill.	The criteria for the termination of OM01 are: • The hydrocarbon discharge has ceased • Response activities have ceased • Hydrocarbon spill modelling (as verified by OM02 surveillance observations) predicts no additional natural resources will be impacted

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
Operational Monitoring Operational Plan 2 (OM02) Surveillance and reconnaissance to detect hydrocarbons and resources at risk	OM02 aims to provide regular, on-going hydrocarbon spill surveillance throughout a broad region, in the event of a spill. The objectives of OM02 are: • Verify spill modelling results and recalibrate spill trajectory models (OM01) • Understand the behaviour, weathering and fate of surface hydrocarbons • Identify environmental receptors and locations at risk or contaminated by hydrocarbons • Inform ongoing NEBA and continually assess the efficacy of available response options in order to reduce risks to ALARP • To aid in the subsequent assessment of the short- to long-term impacts and/or recovery of natural resources (assessed in SMPs) by ensuring that the visible cause and effect relationships between the hydrocarbon spill and its impacts to natural resources have been observed and recorded during the operational phase.	OM02 will be triggered immediately following a level 2/3 hydrocarbon spill.	The termination triggers for the OM02 are: • 72 hours has elapsed since the last confirmed observation of surface hydrocarbons • Latest hydrocarbon spill modelling results (OM01) do not predict surface exposures at visible levels
Operational Monitoring Operational Plan 3 (OM03) Monitoring of hydrocarbon presence, properties, behaviour and weathering in water	OM03 will measure surface, entrained and dissolved hydrocarbons in the water column to inform decision-making for spill response activities. The specific objectives of OM03 are as follows: • Detect and monitor for the presence, quantity, properties, behaviour and weathering of surface, entrained and dissolved hydrocarbons • Verify predictions made by OM01 and observations made by OM02 about the presence and extent of hydrocarbon contamination Data collected in OM03 will also be used for the purpose of longer-term water quality monitoring during SM01.	OM03 will be triggered immediately following a level 2/3 hydrocarbon spill.	The criteria for the termination of OM03 are as follows: • The hydrocarbon release has ceased • Response activities have ceased • Concentrations of hydrocarbons in the water are below available ANZECC/ ARMCANZ (2000) trigger values for 99% species protection.

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
Operational Monitoring Operational Plan 4 (OM04) Pre-emptive assessment of sensitive receptors at risk	OM04 aims to undertake a rapid assessment of the presence, extent and current status of shoreline sensitive receptors prior to contact from the hydrocarbon spill, by providing categorical or semi-quantitative information on the characteristics of resources at risk. The primary objective of OM04 is to confirm understanding of the status and characteristics of environmental resources predicted by OM01 and OM02 to be at risk, to further assist in making decisions on the selection of appropriate response actions and prioritisation of resources. Indirectly, qualitative/semi-quantitative pre-contact information collected by OM04 on the status of environmental resources may also aid in the verification of environmental baseline data and provide context for the assessment of environmental impacts, as determined through subsequent SMPs.	Triggers for commencing OM04 include: • Contact of a sensitive habitat or shoreline is predicted by OM01, OM02 and/or OM03 • The pre-emptive assessment methods can be implemented before contact from hydrocarbons (once a receptor has been contacted by hydrocarbons it will be assessed under OM05)	The criteria for the termination of OM04 at any given location are: • Locations predicted to be contacted by hydrocarbons have been contacted • The location has not been contacted by hydrocarbons and is no longer predicted to be contacted by hydrocarbons (resources should be reallocated as appropriate)

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
Operational monitoring operational plan 5 (OM05) Monitoring of contaminated resources	OM05 aims to implement surveys to assess the condition of fauna and habitats contacted by hydrocarbons at sensitive habitat and shoreline locations. The primary objectives of OM05 are: • Record evidence of oiled fauna (mortalities, sub-lethal impacts, number, extent, location) and habitats (mortalities, sub-lethal impacts, type, extent of cover, area, hydrocarbon character, thickness, mass and content) throughout the response and clean-up at locations contacted by hydrocarbons to inform and prioritise clean-up efforts and resources, while minimising the potential impacts of these activities. Indirectly, the information collected by OM05 may also support the assessment of environmental impacts, as determined through subsequent SMPs.	OM05 will be triggered when a sensitive habitat or shoreline is predicted to be contacted by hydrocarbons by OM01, OM02 and/or OM03.	The criteria for the termination of OM05 at any given location are: • No additional response or clean-up of fauna or habitats is predicted • Spill response and clean-up activities have ceased OM05 survey sites established at sensitive habitat and shoreline locations will continue to be monitored during SM02. The formal transition from OM05 to SM02 will begin on cessation of spill response and clean-up activities.

ANNEX C: OIL SPILL SCIENTIFIC MONITORING PROGRAM

Oil Spill Environmental Monitoring

The following provides some further detail on Woodside's oil spill scientific monitoring Program and includes the following:

- The organisation, roles and responsibilities of the Woodside oil spill scientific monitoring team and external resourcing.
- A summary table of the ten scientific monitoring programs as per the specific focus receptor, objectives, activation triggers and termination criteria.
- Details on the oil spill environmental monitoring activation and termination decision-making processes.
- Baseline knowledge and environmental studies knowledge access via geo-spatial metadata databases.
- An outline of the reporting requirements for oil spill scientific monitoring programs.

Oil Spill Scientific Monitoring – Delivery Team Roles and Responsibilities

Woodside Oil Spill Scientific Monitoring Delivery Team

The Woodside science team are responsible for the delivery of the oil spill scientific monitoring. The roles and responsibilities of the Woodside scientific monitoring delivery team are presented in Table C-1 and the organisational structure and Incident Control Centre (ICC) linkage provided in Figure C-1.

Woodside Oil Spill Scientific monitoring program - External Resourcing

In the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors, scientific monitoring personnel and scientific equipment to implement the appropriate SMPs will be provided by service providers who hold a standby contract for SMP (SMP Standby Contractor) via the Woodside Environmental Services Panel (ESP). In the event that additional resources are required other consultancy capacity within the Woodside ESP will be used (as needed and may extend to specialist contractors, such as research agencies engaged in long-term marine monitoring programs). In consultation with the SMP Standby Contractor and/or specialist contractors, the selection, field sampling and approach of the SMPs will be determined by the nature and scale of the spill.

Table C-1: Woodside and Environmental Service Provider – Oil Spill Scientific Monitoring Program Delivery Team Key Roles and Responsibilities

Role	Location	Responsibility
Woodside Roles		
SMP Lead/Manager	Onshore (Perth)	• Approves activated the SMPs based on operational monitoring data provided by the Planning Function • Provides advice to the ICC in relation to scientific monitoring • Provides technical advice regarding the implementation of scientific monitoring • Approves detailed sampling plans prepared for SMPs • Directs liaison between statutory authorities, advisors and government agencies in relation to SMPs
SMP Co-ordinator	Onshore (Perth)	• Activates the SMPs based on operational monitoring data provided by the Planning Function • Sits in the Planning function of the ICC • Liaises with other ICC functions to deliver required logistics, resources and operational support from Woodside to support the Environmental Service Provider in delivering on the SMPs. Acts as the conduit for advice from the SMP Lead/Manager to the Environmental Service Provider • Manages the Environmental Service Provider's implementation of the SMPs • Liaises with the Environmental Service Provider on delivery of the SMPs • Arranges all contractual matters, on behalf of Woodside, associated with the Environmental Service Provider's delivery of the SMPs

Role	Location	Responsibility
Environmental Service Provider Roles		
SMP standby contractor SMP Duty Manager/Project Manager	Onshore (Perth)	• Coordinates the delivery of the SMPs • Provides costings, schedule and progress updates for delivery of SMPs • Determines the structure of the Environmental Service Provider's team to necessitate delivery of the SMPs • Verifies that HSE Plans, detailed sampling plans and other relevant deliverables are developed and implemented for delivery of the SMPs • Directs field teams to deliver SMPs • Arranges all contractual matters, on behalf of Environmental Service Provider, associated with the delivery of the SMPs to Woodside • Manages sub-consultant delivery to Woodside • Provides required personnel and equipment to deliver the SMPs
SMP Field Teams	Offshore – Monitoring Locations	• Delivers the SMPs in the field consistent with the detailed sampling plans and HSE requirements, within time and budget • Early communication of time, budget, HSE risks associated with delivery of the SMPs to the Environmental Service Provider – Project Manager • Provides start up, progress and termination updates to the Environmental Service Provider – Project Manager (will be led in-field by a party chief)

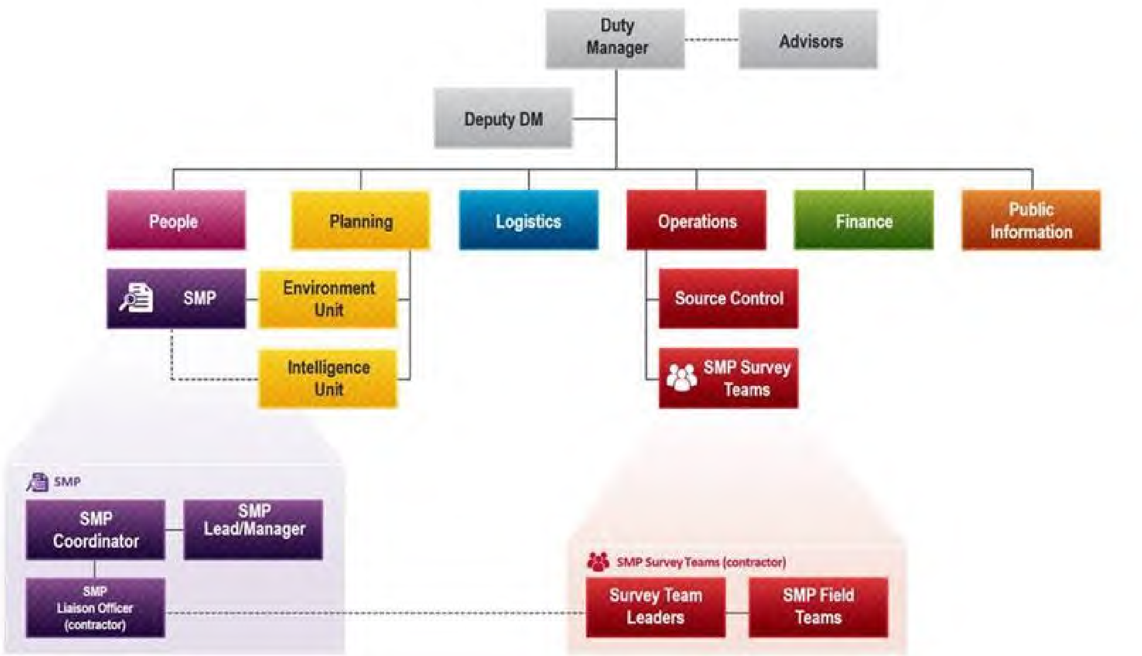

Figure C-1: Woodside Oil Spill Scientific Monitoring Program Delivery Team and Linkage to Incident Control Centre (ICC) organisational structure.

Table C-2: Oil Spill Environmental Monitoring: Scientific Monitoring Program - Objectives, Activation Triggers and Termination Criteria

Scientific monitoring Program (SMP)	Objectives	Activation Triggers	Termination Criteria
Scientific monitoring program 1 (SM01) **Assessment of Hydrocarbons in Marine Waters**	SM01 will detect and monitor the presence, extent, persistence and properties of hydrocarbons in marine waters following the spill and the response. The specific objectives of SM01 are as follows: • Assess and document the extent, severity and persistence of hydrocarbon contamination with reference to observations made during surveillance activities and / or in-water measurements made during operational monitoring; and • Provide information that may be used to interpret potential cause and effect drivers for environmental impacts recorded for sensitive receptors monitored under other SMPs.	SM01 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors	SM01 will be terminated when: • Operational monitoring data relating to observations and / or measurements of hydrocarbons on and in water have been compiled, analysed and reported; and • The report provides details of the extent, severity and persistence of hydrocarbons which can be used for analysis of impacts recorded for sensitive receptors monitored under other SMPs. SMP monitoring of sensitive receptor sites: • Concentrations of hydrocarbons in water samples are below ANZECC/ ARMCANZ (2018[5]) default guideline values (DGVs) for biological disturbance; and • Details of the extent, severity and persistence of hydrocarbons from concentrations recorded in water have been documented at sensitive receptor sites monitored under other SMPs.
Scientific monitoring program 2 (SM02) **Assessment of the Presence, Quantity and Character of Hydrocarbons in Marine Sediments**	SM02 will detect and monitor the presence, extent, persistence and properties of hydrocarbons in marine sediments following the spill and the response. The specific objectives of SM02 are as follows: • Determine the extent, severity and persistence of hydrocarbons in marine sediments across selected sites where hydrocarbons were observed or recorded during operational monitoring; and • Provide information that may be used to interpret potential cause and effect drivers for environmental impacts recorded for sensitive receptors monitored under other SMPs.	SM02 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • Response activities have ceased; and • Operational monitoring results made during the response phase indicate that shoreline, intertidal or sub-tidal sediments have been exposed to surface, entrained or dissolved hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation).	SM02 will be terminated once pre-spill condition is reached and agreed upon as per the SMP termination criteria process and include consideration of: • Concentrations of hydrocarbons in sediment samples are below ANZECC/ ARMCANZ (2013[6]) ISQG low-level trigger values for biological disturbance; and • Details of the extent, severity and persistence of hydrocarbons from concentrations recorded in sediments have been documented.
Scientific monitoring program 3 (SM03) **Assessment of Impacts and Recovery of Subtidal and Intertidal Benthos**	The objectives of SM03 are: • Characterize the status of intertidal and subtidal benthic habitats and quantify any impacts to functional groups, abundance and density that may be a result of the spill; and • Determine the impact of the hydrocarbon spill and subsequent recovery (including impacts associated with the implementation of response options). Categories of intertidal and subtidal habitats that may be monitored include: • Coral reefs • Seagrass • Macro-algae • Filter-feeders SM03 will be supported by sediment contamination records (SM02) and characteristics of the spill derived from OMPs.	SM03 will be activated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • As part of a pre-emptive assessment of PBAs of receptor locations identified by time to hydrocarbon contact >10 days, to target receptors and sites where it is possible to acquire pre-hydrocarbon contact baseline; and • Operational monitoring identified shoreline potential contact of hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) for subtidal and intertidal benthic habitat.	SM03 will be terminated once pre-spill condition is reached and agreed upon as per the SMP termination criteria process and include consideration of: • Overall impacts to benthic habitats from hydrocarbon exposure have been quantified. • Recovery of impacted benthic habitats has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 4 (SM04) **Assessment of Impacts and Recovery of Mangroves / Saltmarsh**	The objectives of SM04 are: • Characterize the status of mangroves (and associated salt marsh habitat) at shorelines exposed/contacted by spilled hydrocarbons;	SM04 will be activated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows:	SM04 will be terminated once pre-spill condition is reached and agreed upon as per the SMP termination criteria process and include consideration of:

[5] http://www.waterquality.gov.au/anz-guidelines, accessed 29th April 2019
[6] Simpson SL, Batley GB and Chariton AA (2013). Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines. CSIRO and Water Science Report 08/07. Land and Water, pp. 132.

Scientific monitoring Program (SMP)	Objectives	Activation Triggers	Termination Criteria
	• Quantify any impacts to species (abundance and density) and mangrove/saltmarsh community structure; and • Determine and monitor the impact of the hydrocarbon spill and potential subsequent recovery (including impacts associated with the implementation of response options). SM03 will be supported by sediment sampling undertaken in SM02 and characteristics of the spill derived from OMPs.	• As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days; and • Operational monitoring identified shoreline potential contact of hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) for mangrove/saltmarsh habitat.	• Impacts to mangrove and saltmarsh habitat from hydrocarbon exposure have been quantified. • Recovery of impacted mangrove/saltmarsh habitat has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 5 (SM05) **Assessment of Impacts and Recovery of Seabird and Shorebird Populations**	The Objectives of SM05 are to: • Collate and quantify impacts to avian wildlife from results recorded during OM02 and OM05 (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population level; and • Undertake monitoring to quantify and assess impacts of hydrocarbon exposure to seabirds and shorebird populations at targeted breeding colonies / staging sites / important coastal wetlands where hydrocarbon contact was recorded.	SM05 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days; • Operational monitoring predicts shoreline contact of hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) at important bird colonies / staging sites / important coastal wetland locations; or • Records of dead, oiled or injured bird species made during the hydrocarbon spill or response.	SM05 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Impacts to seabird and shorebird populations from hydrocarbon exposure have been quantified. • Recovery of impacted seabird and shorebird populations has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 6 (SM06) **Assessment of Impacts and Recovery of Nesting Marine Turtle Populations**	The objectives of SM06 are to: • To quantify impacts of hydrocarbon exposure or contact on marine turtle nesting populations (including impacts associated with the implementation of response options); • Collate and quantify impacts to adult and hatchling marine turtles from results recorded during OM02 and OM05 (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population levels (including impacts associated with the implementation of response options); .and • Undertake monitoring to quantify and assess impacts of hydrocarbon exposure to nesting marine turtle populations at known rookeries (including impacts associated with the implementation of response options).	SM06 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring has: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days; • Predicted shoreline contact of hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) at known marine turtle rookery locations; or • Records of dead, oiled or injured marine turtle species made during the hydrocarbon spill or response.	SM06 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Impacts to nesting marine turtle populations from hydrocarbon exposure have been quantified. • Recovery of impacted nesting marine turtle populations has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 7 (SM07) **Assessment of Impacts to Pinniped Colonies including Haul-out Site Populations**	The objectives of SM07 are to: • Quantify impacts on pinniped colonies and haul-out sites as a result of hydrocarbon exposure/contact. • Collate and quantify impacts to pinniped populations from results recorded during OM02 and OM05 (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population levels.	SM07 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring has: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days; • Identified shoreline contact of hydrocarbons ((at or above 0.5 g/m^2 surface, ≥5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) at known pinniped colony or haul-out site(s) (i.e. most northern site is the Houtman Abrolhos Islands); or • Records of dead, oiled or injured pinniped species made during the hydrocarbon spill or response.	SM07 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Impacts to pinniped populations from hydrocarbon exposure have been quantified. • Recovery of pinniped populations has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 8 (SM08) **Desk-Based Assessment of Impacts to Other Non-Avian Marine Megafauna**	The objective of SM08 is to provide a desk-based assessment which collates the results of OM02 and OM05 where observations relate to the mortality, stranding or oiling of mobile marine megafauna species not addressed in SM06 or SM07, including: • Cetaceans; • Dugongs;	SM08 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring reports records of dead, oiled or injured non-avian marine megafauna during the spill/ response phase.	SM08 will be terminated when the results of the post-spill monitoring have quantified impacts to non-avian megafauna.

Scientific monitoring Program (SMP)	Objectives	Activation Triggers	Termination Criteria
	• Whale sharks and other shark and ray populations; • Sea snakes; and • Crocodiles. The desk-based assessment will include population analysis to infer potential impacts to marine megafauna species populations.		• Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 9 (SM09) **Assessment of Impacts and Recovery of Marine Fish associated with SM03 habitats**	The objectives of SM09 are: • Characterise the status of resident fish populations associated with habitats monitored in SM03 exposed/contacted by spilled hydrocarbons; • Quantify any impacts to species (abundance, richness and density) and resident fish population structure (representative functional trophic groups); and • Determine and monitor the impact of the hydrocarbon spill and potential subsequent recovery (including impacts associated with the implementation of response options).	SM09 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented with SMO3.	SM09 will be undertaken and terminated concurrent with monitoring undertaken for SM03, as per the SMP termination criteria process • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 10 (SM10) **SM10 - Assessment of physiological impacts important fish and shellfish species (fish health and seafood quality/safety) and recovery**	SM10 aims to assess any physiological impacts to important commercial fish and shellfish species (assessment of fish health) and if applicable, seafood quality/safety. Monitoring will be designed to sample key commercial fish and shellfish species and analyse tissues to identify fish health indicators and biomarkers, for example: • Liver Detoxification Enzymes (ethoxyresorufin-O-deethylase (EROD) activity • PAH Biliary Metabolites • Oxidative DNA Damage • Serum SDH • Other physiological parameters, such as condition factor (CF), liver somatic index (LSI), gonado-somatic index (GSI) and gonad histology, total weight, length, condition, parasites, egg development, testes development, abnormalities. Seafood tainting may be included (where appropriate) using applicable sensory tests to objectively assess targeted finfish and shellfish species for hydrocarbon contamination. Results will be used to make inferences on the health of commercial fisheries and the potential magnitude of impacts to fishing industries.	SM10 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring (OM01, OM02 and OM05) indicates the following: • The hydrocarbon spill will or has intersected with active commercial fisheries or aquaculture activities. • Commercially targeted finfish and/or shellfish mortality has been observed/recorded. • Commercial fishing or aquaculture areas have been exposed to hydrocarbons (≥0.5 g/m^2 surface and ≥5 ppb for entrained/dissolved hydrocarbons); and • Taste, odour or appearance of seafood presenting a potential human health risk is observed.	SM10 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Physiological impacts to important commercial fish and shellfish species from hydrocarbon exposure have been quantified. • Recovery of important commercial fish and shellfish species from hydrocarbon exposure has been evaluated. • Impacts to seafood quality/safety (if applicable) have been assessed and information provided to the relevant stakeholders and regulators for the management of any impacted fisheries. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.

Activation Triggers and Termination Criteria

Scientific monitoring program Activation

The Woodside oil spill scientific monitoring team will be stood up immediately with the occurrence of a hydrocarbon spill (actual or suspected) Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors via the FSRP for the PAP. The presence of any level of hydrocarbons in the marine environment triggers the activation of the oil spill scientific monitoring program (SMP). This is to ensure the full range of eventualities relating to the environmental, socio-economic and health consequences of the spill are considered in the planning and execution of the SMP. The activation process also takes into consideration the management objectives, species recovery plans, conservation advices and conservations plans for any World Heritage Area (WHA), AMPs, State Marine Parks, other protected area designations (e.g., State nature reserves) and Matters of National Environmental Significance (including listed species under part 3 of the EPBC Act) potentially exposed to hydrocarbons. With the first 24-48 hours of a spill event, such information will be sourced and evaluated as part of the SMP planning process guided by Appendix D (identified receptors vulnerable to hydrocarbon contact), the information presented in the Existing Environment section of the EP as well as other information sources such as the Woodside Baseline Environmental Studies Database.

The starting point for decision-making on what SMPs are activated and spatial extent of monitoring activities will be based on the predictive modelling results (OM01) in the first 24-48 hours until more information is made available from other operational monitoring activities such as aerial surveillance and shoreline surveys. Pre-emptive Baseline Areas (WHA, AMPs and State Marine Parks encompassing key ecological and socio-economic values) are a key focus of the SMP activation decision-making process, particularly, in the early spill event/response phase. As the operational monitoring progresses and further situational awareness information becomes available, it will be possible to understand the nature and scale of the spill. The SMP activation and implementation decision-making will be revisited on a daily basis to account for the updates on spill information. One of the priority focus areas in the early phase of the incident will be to identify and execute pre-emptive SMP assessments at key receptor locations, as required. The SMP activation and implementation decision tree is presented in Figure C-2.

Scientific monitoring Program Termination

The basis of the termination process for the active SMPs (SMPs 1-10) will include quantification of impacts, evaluation of recovery for the receptor at risk and consultation with relevant authorities, persons and organisations. Termination of each SMP will not be considered until the results (as presented in annual SMP reports for the duration of each program) indicate that the target receptor has returned to pre-spill condition.

Once the SMP results indicate impacted receptor(s) have returned to pre-spill condition (as identified by Woodside) a termination decision-making process will be triggered and a number of steps will be undertaken as follows:

- Woodside will engage expert opinion on whether the receptor has returned to pre-spill condition (based on monitoring data). Subject Matter Expert (SMEs) will be engaged (via the Woodside SME scientific monitoring terms of reference to review program outcomes, provide expert advice and recommendations for the duration of each SMP.
- Where expert opinion agrees that the receptor has returned to pre-spill condition, findings will then be presented to the relevant authorities, persons and organisations (as defined by the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulation 11A). Stakeholder identification, planning and engagement will be managed by Woodside's Reputation Functional Support Team (FST) and follow the stakeholder management FST guidelines. These guidelines outline the FST roles and responsibilities, competencies, stakeholder communications and planning processes. An assessment of the merits of any objection to termination will be documented in the SMP final report.
- Woodside will decide on termination of SMP based on expert opinion and merits of any stakeholder objections. The final report following termination will include: monitoring results, expert opinion and stakeholder consultation including merits of any objections.

- Termination of SMPs will also consider applicable management objectives, species recovery plans, conservation advices and conservations plans for any World Heritage Area (WHA), AMPs, State Marine Parks, other protected area designations (e.g., State nature reserves) and Matters of National Environmental Significance (including listed species under part 3 of the EPBC Act).

The SMP termination decision-making process will be applied to each active SMP and an iterative process of decision steps continued until each SMP has been terminated (refer to decision-tree diagram for SMP termination criteria, Figure C-3).

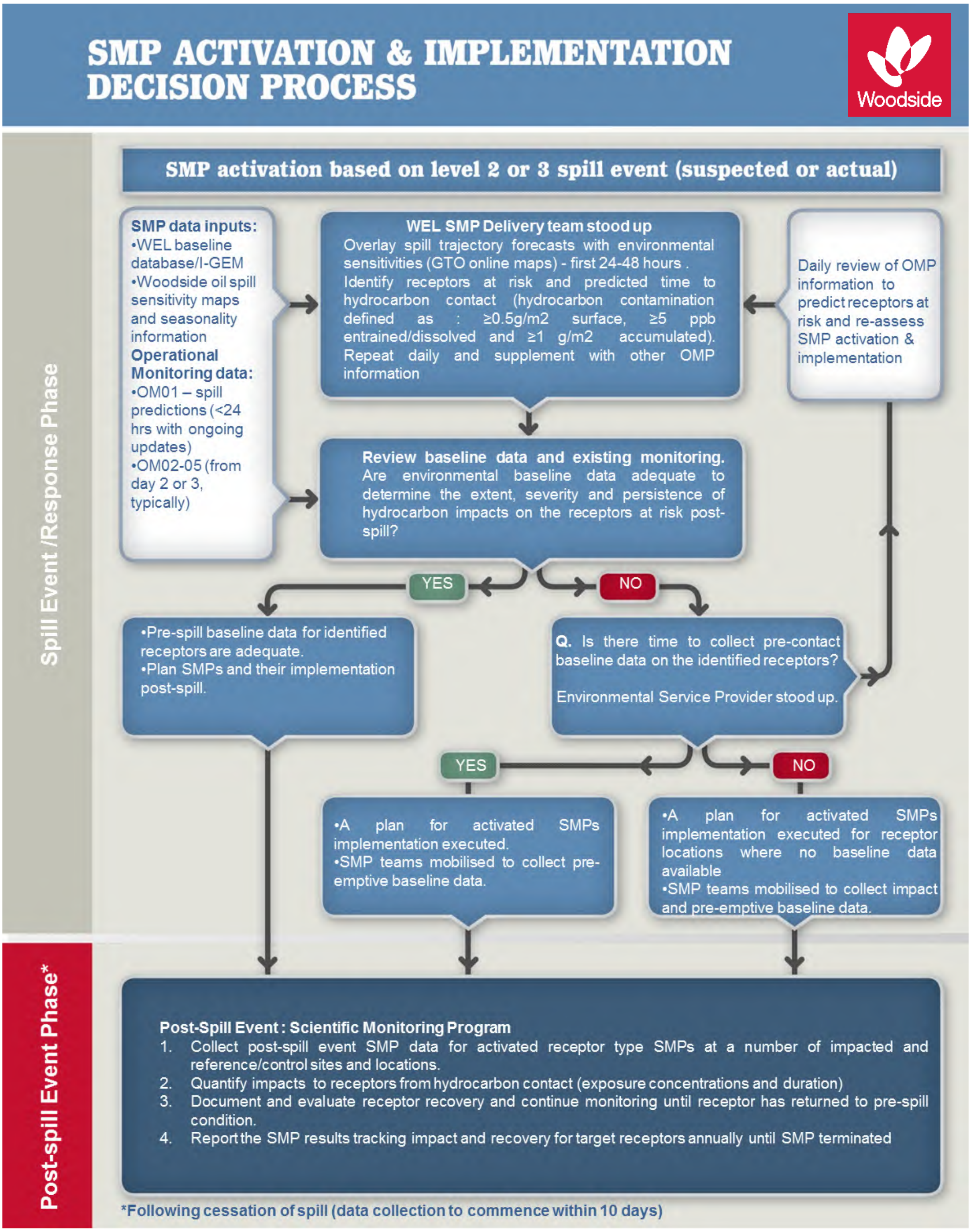

Figure C-2: Activation and Implementation Decision-tree for Oil Spill Environmental Monitoring

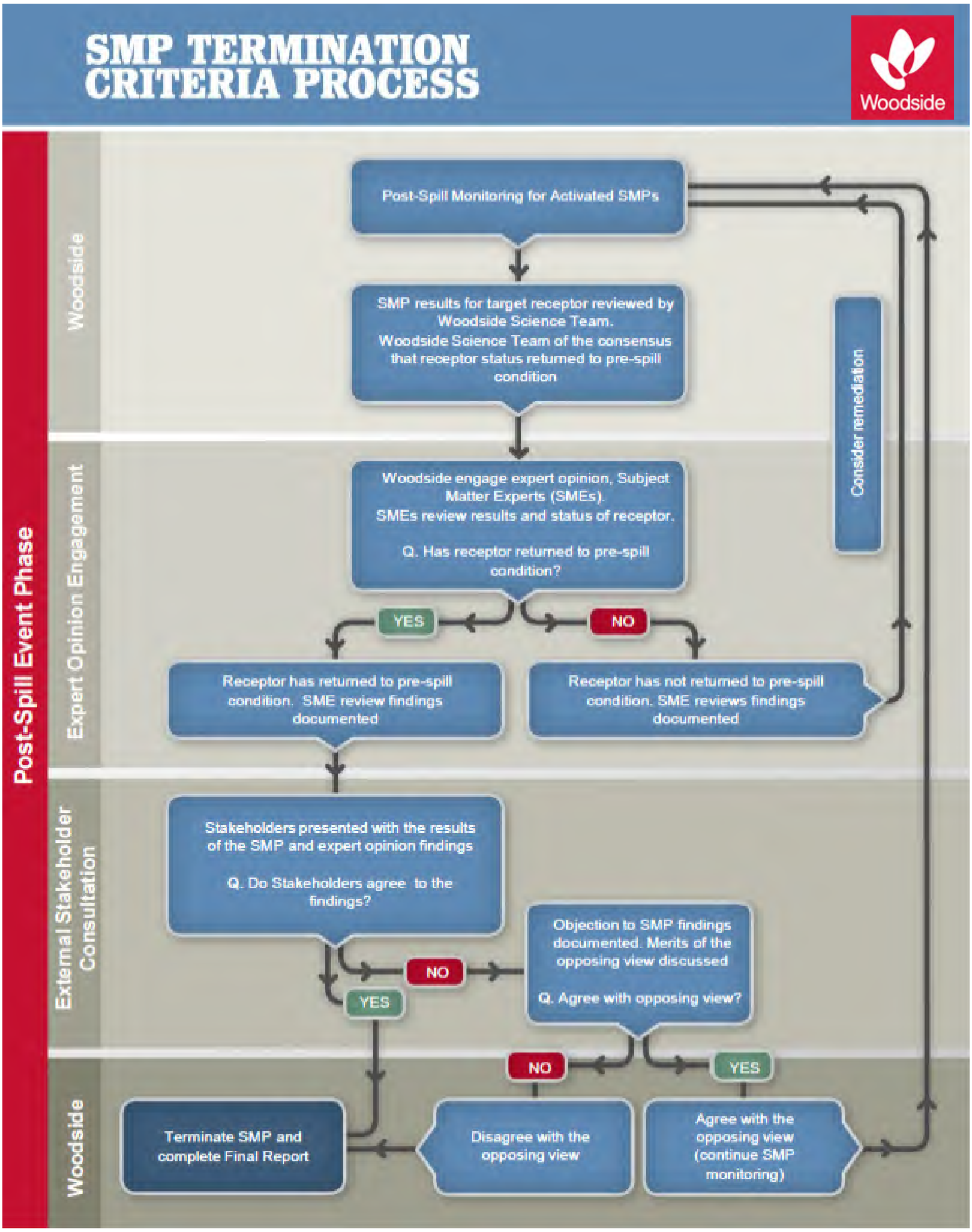

Figure C-3: Termination Criteria Decision-tree for Oil Spill Environmental Monitoring

Receptors at Risk and Baseline Knowledge

In order to assess the baseline studies available and suitability for oil spill scientific monitoring, Woodside maintains knowledge of environmental baseline studies through the upkeep and use of its Environmental Knowledge Management System.

Woodside's Environmental Knowledge Management System is a centralised platform for scientific information on the existing environment, marine biodiversity, Woodside environmental studies, key environmental impact topics, key literature and web-based resources. The system comprises a number of data directories and an environmental baseline database, as well as folders within the 'Corporate Environment' server space. The environmental baseline database was set up to support Woodside's SMP preparedness and as a SMP resource in the event of an unplanned hydrocarbon spill. The environmental baseline database is subject to updates including annual reviews completed as part of SMP standby contract. This database is accessed pre-PAP to identify Pre-emptive Baseline Areas (PBAs) where hydrocarbon contact is predicted to occur <10 days.

In addition to Woodside's Environmental Knowledge Management System, it is acknowledged that many relevant baseline datasets are held by other organisations (e.g. other oil and gas operators, government agencies, state and federal research institutions and non-governmental organisations). In order to understand the present status of environmental baseline studies a spatial environmental metadata database for Western Australia (Industry-Government Environmental Meta-database, IGEM) was established. IGEM is a collaboration comprising oil and gas operators (including Woodside), government and research agencies and other organisations. The key objective of IGEM is for participating organisations to have the ability to identify quantitative marine baseline datasets available for species and habitats via a geo-spatially referenced metadata database. It provides members the ability to enter, view and filter metadata records on baseline studies as well as customise and generate report outputs. IGEM aims to provide a foundational baseline framework so industry and government can access the same knowledge base to understand baseline data in the event of an unplanned hydrocarbon release.

In the event of an unplanned hydrocarbon release, Woodside intends to interrogate the information on baseline studies status as held by the various databases (e.g. Woodside Environmental Knowledge Management System, IGEM and other sources of existing baseline data) to identify Pre-emptive Baseline Areas (PBAs), i.e., receptors at risk where hydrocarbon contact is predicted to be >10 days, and baseline data can be collected before hydrocarbon contact.

Reporting

For the scientific monitoring program relevant regulators will be provided with:

- Annual reports summarising the SMPs deployed and active, data collection activities and available findings; and
- Final reports for each SMP summarising the quantitative assessment of environmental impacts and recovery of the receptor once returned to pre-spill condition and termination of the monitoring program.

The reporting requirements of the scientific monitoring program will be specific to the individual SMPs deployed and terms of responsibilities, report templates, schedule, QA/QC and peer-review will be agreed with the contractors engaged to conduct the SMPs. Compliance and auditing mechanisms will be incorporated into the reporting terms.

ANNEX D: MONITORING PROGRAM AND BASELINE STUDIES FOR THE PAP

Table D-1: Oil Spill Environmental Monitoring – scientific monitoring program scope for the PAP based on Spill Scenario EMBAs

Receptors to be Monitored	Receptor Areas - Potential Impact and Reference Scientific Monitoring Sites (marked X)																																								
	Applicable SMP	Kimberley AMP	Agro-Rowley Terrace AMP	Montebello AMP	Dampier AMP	Carnarvon Canyon AMP	Ningaloo AMP	Gascoyne AMP	Shark Bay Open Ocean (including AMP)	Abrolhos AMP	Jurien AMP	Two Rocks AMP	Perth Canyon AMP	Geographe AMP	South-west Corner AMP	Ashmore Reef and AMP	Seringapatam Reef	Scott Reef (North and South)	Mermaid Reef and AMP	Clerke Reef and State Marine Park	Imperieuse Reef and State Marine Park	Rankin Bank	Glomar Shoals	Rowley Shoals (including Sate Maine Park)	Fantome Shoals	Adele Island	Lacepede Islands	Montebello Islands (including State Marine Park)	Lowendal Islands (including State Nature Reserve)	Barrow Island (including State Nature Reserves, State Marine Park and Marine Management Area)	Muiron Islands (WHA, State Marine Park)	Pilbara Islands - Southern Island Group (Serrurier, Thevenard and Bessieres Islands - State Nature Reserves)	Pilbara Islands - Northern Island Group (Sandy Island Passage Islands - State nature reserves)	Abrolhos Islands	Kimberley Coast	Dampier Peninsula	Northern Pilbara Shoreline	Ningaloo Coast (North/North West Cape, Middle and South) (WHP, and State Marine Park)	Shark Bay - Open Ocean Coast	Shark Bay WHP	Ngari Capes State Marine Park
Habitat																																									
Water Quality	SM01	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marine Sediment Quality	SM02	X		X		X		X	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Coral Reef	SM03	X		X												X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	
Seagrass / Macro-Algae	SM03	X									X					X	X	X									X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Deeper Water Filter Feeders	SM03	X			X	X	X							X	X		X	X	X	X	X	X	X	X	X						X							X			
Mangroves and Saltmarsh	SM04																											X						X	X	X	X	X		X	
Species																																									
Sea Birds and Migratory Shorebirds (significant colonies / staging sites / coastal wetlands)	SM05	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marine Turtles (significant nesting beaches)	SM06	X	X	X	X		X	X	X							X	X	X	X	X	X						X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Pinnipeds (significant colonies / haul-out sites)	SM07									X	X	X			X																										X
Cetaceans - Migratory Whales	SM08	X	X	X	X		X	X	X	X	X	X	X	X	X			X									X	X	X	X	X			X	X	X		X		X	X
Oceanic and Coastal Cetaceans	SM08	X	X	X	X		X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dugongs	SM08	X							X							X												X	X	X	X	X	X		X	X	X	X	X	X	
Sea Snakes	SM08	X		X	X			X	X	X						X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Whale Sharks	SM08			X			X	X										X										X	X	X	X							X			
Other Shark and Ray Populations	SM08, SM09	X	X	X	X		X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fish Assemblages	SM09	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Socio-economic																																									
Fisheries - Commercial	SM10		X	X	X	X	X	X	X	X	X	X										X	X	X	X			X	X	X		X	X	X	X	X	X	X	X	X	X
Fisheries - Traditional	SM10															X	X	X									X													X	
Tourism (incl. recreational fishing)	SM10	X		X			X	X	X		X			X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X

(dark red)	Receptor areas identified as Pre-emptive Baseline Areas (based on criteria of surface contact and/or entrained hydrocarbon contact ≤10 days (Offshore Australian Marine Parks contacted by hydrocarbons in this timeframe also noted)
(light red)	Receptor areas identified as Pre-Emptive Basline Areas in the response phase >10 days (based on criteria of surface contact and/or entrained hydrocarbon contact >10 days)
(white)	Receptor areas that may be identified as impact or reference sites in the event of major hydrocarbon release and would be identified as part of the SMP planning process

Table D-2: Baseline Studies for the SMPs applicable to identified Pre-emptive Baseline Areas for the PAP

Major Baseline	Proposed Scientific monitoring operational plan and Methodology	Ningaloo (WHA, AMP, State Marine Park)	Montebello AMP
Benthic Habitat (Coral Reef)	**SM03** Quantitative assessment using image capture using either diver held camera or towed video. Post analysis into broad groups based on taxonomy and morphology.	**Studies:**	
		1. AIMS/DBCA 2014 Baseline Ningaloo and Muiron Islands Survey – repeat and expansion on the LTM (Co-funded survey: Woodside and AIMS). 2. AIMS Long Term Monitoring (LTM) Ningaloo Reef programme: 1995 and 2002. 3. DBCA LTM Ningaloo Reef programme: 1991, 1994, 1998, 1999, 2001, 2005, 2006, 2010, 2011, 2012 and 2015. 4. (WAMSI LTM Study:) Ningaloo Research node: 2009 -10 over the length of Ningaloo reef system (with a focus on coral and fish recruitment). 5. Ningaloo Outlook (CSIRO) - Shallow and Deep Reefs Program (2015). 6. Ningaloo Collaboration Cluster: Habitats of the Ningaloo Reef and adjacent coastal areas determined through hyperspectral imagery. 7. Australian Institute of Marine Science – CReefs: Ningaloo Reef Biodiversity Expeditions (2008-2010). 8. Le Nohaic et al. 2017. Marine heatwave causes unprecedented Regional Mass Bleaching in NW Australia Coral Bay Location.	Coral Reefs & Filter Feeders 1. Montebello Marine Park, 2019, Identification and qualitative descriptions of benthic habitat. 2. Montebello Australian Marine Parks – 2019 – Baseline survey on benthic habitats Pluto Trunkline within Montebello Marine Park – Monitoring marine communities.
		Methods:	
		1. LTM sites, transects, diver-based video quadrat. 2. LTM transects, diver based (video) photo quadrat. 3. Video point intercept transects recorded by towed video or diver hand-held video camera. 4. Video transects. 5. LTM transects, diver based (video) photo quadrat. 6. LTM transects, diver based (video) photo quadrat. 7. LTM transects, diver based (video) photo quadrats, specimen collection. 8. Intertidal walks and snorkelling transects with photo quadrats. In situ water temperature loggers deployed for survey period.	1.ROV Transects. 2. Benthic habitat mapping, multibeam acoustic swathing. 3. ROV video.
		References and Data:	
		1. AIMS 2014. DATAHOLDER: AIMS. 2. AIMS unpublished data. DATAHOLDER: AIMS. 3. DBCA unpublished data. DATAHOLDER: DBCA. 4. Depczynski et al. 2011. DATAHOLDER: AIMS, DBCA and WAMSI. 5. CSIRO 2015. Damian Thompson (shallow reefs) and Russell Babcock (Deep reefs). 6. Murdoch University - Kobryn et al 2011 and Keulen and Langdon 2011. 7. AIMS (2010) - http://www.aims.gov.au/creefs 8. Verna Shoepf at UWA and Western Australian Marine Science Institution, Perth, email: verena.schoepf@uwa.edu.au).	1. Advisian 2019. 2. Keesing 2019. 3. McLean et al. 2019.
Benthic Habitat (Seagrass and Macro-algae)	**SM03** Quantitative assessment using image capture using either diver held camera or towed video. Post analysis into broad groups based on taxonomy and morphology.	**Studies:**	
		1. Quantitative descriptions of Ningaloo sanctuary zones habitats types including lagoon and offshore areas – Cassata and Collins (2008). 2. CSIRO/BHP Ningaloo Outlook Program. 3. Ningaloo Collaboration Cluster: Habitats of the Ningaloo Reef and adjacent coastal areas determined through hyperspectral imagery. 4. Australian Institute of Marine Science – CReefs: Ningaloo Reef Biodiversity Expeditions (2008-2010).	N/A – see table D – 1
		Methods:	
		1. Video transects to ground truth aerial photographs and satellite imagery. 2. Diver video transects. 3. LTM transects, diver based (video) photo quadrat. 4. LTM transects, diver based (video) photo quadrats, specimen collection.	N/A – see table D – 1
		References and Data:	

Major Baseline	Proposed Scientific monitoring operational plan and Methodology	Ningaloo (WHA, AMP, State Marine Park)	Montebello AMP
		1. Cassata and Collins 2008. DATAHOLDER: Curtin University – Applied Geology. 2. CSIRO Damian Thompson - Damian.Thomson@csiro.au 3. Murdoch University - Kobryn et al 2011 and Keulen and Langdon 2011. 4. AIMS (2010) - http://www.aims.gov.au/creefs	N/A – see table D – 1
Benthic Habitat (Deeper Water Filter Feeders)	**SM03** Quantitative assessment using image capture using towed video. Post analysis into broad groups based on taxonomy and morphology.	**Studies:**	
		1. WAMSI 2007 deep-water Ningaloo benthic communities study, Colquhoun and Heyward (2008). 2. CSIRO/BHP Ningaloo Outlook Program - Deep reef themes.	N/A – see table D – 1
		Methods:	
		1. Towed video and benthic sled (specimen sampling). 2. Sidescan sonar and AUV transects.	N/A – see table D – 1
		References and Data:	
		1. Colquhoun and Heyward (eds) 2008.DATAHOLDER: WAMSI, AIMS. 2. Russell Babcock (Deep reefs) - Russ.Babcock@csiro.au	N/A – see table D – 1
Mangroves and Saltmarsh	**SM04** Aerial photography and satellite imagery will be used in conjunction with field surveys to map the range and distribution of mangrove communities.	**Studies**	
		1. Woodside hold Rapid Eye imagery of the Ningaloo Reef and coastal area. 2. Hyperspectral survey (2006) of Ningaloo Reef and coastal area (not yet analysed for Mangroves). 3. North West Cape sensitivity mapping 2012 included Mangrove Bay. 4. Global mangrove distribution as mapped by the USGS and located on UNEP's Ocean Data viewer.	N/A – see table D – 1
		Methods:	
		1. Rapid Eye imagery – High resolution satellite imagery from October/November/December 2011. 2. Remote sensing – acquisition of HyMap airborne hyperspectral imagery and ground truthing data collection. 3. Reconnaissance surveys of the shorelines of the North West Cape and Muiron Islands. 4. Remote sensing study of global mangrove coverage.	N/A – see table D – 1
		References and Data:	
		1. AAM 2012. DATAHOLDER: Woodside. 2. Kobryn et al. 2013. DATAHOLDER: Murdoch University, AIMS; Woodside. 3. Joint Carnarvon Basin Operators, 2012. DATAHOLDER: Woodside Apache Energy Ltd. 4. http://data.unep-wcmc.org/	N/A – see table D – 1
Seabirds	**SM05** Visual counts of breeding seabirds, nest counts, intertidal bird counts at high tide.	**Studies:**	
		1. LTM Study of marine and shoreline birds: 1970-2011. 2. LTM of shorebirds within the Ningaloo coastline (Shorebirds 2020). Available through Birdlife. 3. Exmouth Sub-basin Marine Avifauna Monitoring Program (Quadrant Energy/Santos). 4. Integrated Shearwater Monitoring Program (1994-2016). 5. Seabird and Shorebird baseline studies, Ningaloo Region – Report on January 2018 bird surveys. 6.FieldReport – Wedge-tailed shearwater foraging behaviour in the Exmouth Region.	Present, in open water, no breeding habitat.
		Methods:	

Major Baseline	Proposed Scientific monitoring operational plan and Methodology	Ningaloo (WHA, AMP, State Marine Park)	Montebello AMP
		1. Counts of nesting areas, counts of intertidal zone during high tide. 2. The Shorebirds 2020 database comprises the most complete shorebird count data available in Australia. The data have been collected by volunteer counters and BirdLife Australia staff for approximately 150 roosting and feeding sites, mainly in coastal Australia. The data go back as far as 1981 for key areas. 3. The Exmouth Sub-basin Marine Avifauna Monitoring Program undertook a detailed assessment of seabird and shorebird use in the Exmouth Sub-basin. Four aerial surveys and four island surveys were conducted between February 2013 and January 2015 for this Program, inclusive of the mainland coasts, offshore islands and a 2500km2 area of ocean adjacent to the Exmouth Sub-basin. 4. Airlie and Serrurier islands, with Abutilon and Parakeelya islands (Lowendal Island group) added in 2014. 5. Shorebird counts, Shearwater Burrow Density 6. GPS and Satellite Tags	N/A
		References and Data:	
		1. Johnstone et al. 2013. DATAHOLDER: WA MUSEUM. AMOSC/DBCA (DPaW)2014. 2. BirdLife Australia Shorebirds 2020 programme (http://www.birdlife.org.au/projects/shorebirds-2020). 3. Santos (Libby Howitt) – Report 4. Santos (I-GEM, UUID: bdd428fe-cf24-4596-a822-cd578695ee16). 5. BirdLife Australia: Dataholder: BirdLife Australia. 6. UWA. Dataholder: UWA	N/A
Turtles	**SM06** Beach surveys (recording species, nests, and false crawls).	**Studies:**	
		1. Ningaloo LTM turtle program was established in 2002, with the most recent survey during the 2014-2015 season. The primary aim is to predict long-term trends in marine turtle populations along Ningaloo coast. 2. Exmouth Islands Turtle Monitoring Program. 3. Ningaloo Turtle Program Annual Report 2016-2017. 4. Turtle activity and nesting on the Muiron Islands and Ningaloo Coast (2018). 5. Field Report: Spatial and temporal use of inter-nesting habitat by sea turtles along the Murion Islands and Ningaloo Coast (2018).	Present, in open water, no nesting habitats.
		Methods:	
		1. Beach surveys, track counts, best location, mortality counts. 2.Undertaken by Astron (on behalf of Santos) to address a gap in the knowledge of turtle numbers at key locations (offshore islands within the region) that are not currently part of an existing monitoring programs (e.g. the NTP). Field surveys were conducted in October 2013 and January 2014. Surveys were conducted on 12 islands, with each island surveyed once (with the exception of Beach 8 at North Muiron Island) and all tracks counted. 3. Long term trends in marine turtle populations, nesting levels, nesting success rates. 4. On-beach monitoring and aerial surveys. 5.Satellite Tagging.	N/A
		References/Data:	
		1. Markovina, K, 2015. DATAHOLDERS: DBCA. Reports available at (http://www.ningalooturtles.org.au/media_reports.html). 2. Santos (Libby Howitt) – Report. 3. Woodside (Author Keely Markovina). 4.DBCA, DBCA Dataholder. 5.DBCA, DBCA Dataholder.	N/A
Fish	**SM09**	**Studies:**	

Major Baseline	Proposed Scientific monitoring operational plan and Methodology	Ningaloo (WHA, AMP, State Marine Park)	Montebello AMP
	Baited Remote Underwater Video Stations (BRUVS), Visual Underwater Counts (VUC), Diver Operated Video (DOV).	1. AIMS/DBCA 2014 Baseline Ningaloo Survey – repeat and expansion on the LTM (Co-funded survey: Woodside and AIMS). 2. Demersal fish populations – baseline assessment (AIMS/WAMSI). 3. DBCA study measured Species Richness, Community Composition, and Target Biomass, through UVC. BRUVS studies determining max N, Species Richness, and Biomass. 4. Pilbara Marine Conservation Partnership Stereo BRUVS drops in shallow water (~10m) in 2014 in northern region of the Ningaloo Marine Park, in shallow water (~10m) inside the lagoonal reef of the Ningaloo Marine Park in 2016, in deep water (~40m) across the length of the Ningaloo Marine Park in 2015, in shallow water outside of Ningaloo Reef from Waroora to Jurabi in 2015 and offshore of the Muiron Islands in 2015. 5. Elasmobranch faunal composition of Ningaloo Marine Park. 6. Juvenile fish recruitment surveys at Ningaloo reef. 7. Demersal fish assemblage sampling method comparison. 8. Ningaloo Outlook (CSIRO) - Shallow and Deep Reefs Program.	1. CSIRO – Fish Diversity. 2. Fish species richness and abundance.
		Methods:	
		1. UVC surveys. 2. BRUVS Study with 304 video samples at three specific depth ranges (1-10 m, 10-30 m and 30-110m). 3. UVC surveys. 4. Stereo BRUVS 5. Snorkel and Scuba surveys. 6. Underwater visual census. 7. Diver operated video. 8. Diver UVS.	1. Semi V Wing trawl net or an epibenthic sled. 2. ROV Video.
		References and Data:	
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ANNEX E: TACTICAL RESPONSE PLANS

TACTICAL RESPONSE PLANS
Exmouth
Mangrove Bay
Turquoise Bay
Yardie Creek
Muiron Islands
Jurabi to Lighthouse Beaches Exmouth
Ningaloo Reef - Refer to Mangrove/Turquoise bay and Yardie Creek
Exmouth Gulf
Shark Bay Area 1: Carnarvon to Wooramel
Shark Bay Area 2: Wooramel to Petite Point
Shark Bay Area 3: Petite Point to Dubaut Point
Shark Bay Area 4: Dubaut Point to Herald Bight
Shark Bay Area 5: Herald Bight to Eagle Bluff
Shark Bay Area 6: Eagle Bluff to Useless Loop
Shark Bay Area 7: Useless Loop to Cape Bellefin
Shark Bay Area 8: Cape Bellefin to Steep Point
Shark Bay Area 9: Western Shores of Edel Land
Shark Bay Area 10: Dirk Hartog Island
Shark Bay Area 11: Bernier and Dorre Islands
Abrohlos Islands: Pelseart Group
Abrohlos Islands: Wallabi Group
Abrohlos Islands: Easter Group
Dampier
Rankin Bank & Glomar Shoals
Barrow and Lowendal Islands
Pilbara Islands - Southern Island Group
Montebello Is - Stephenson Channel Nth
Montebello Is Champagne Bay & Chippendale channel
Montebello Is - Claret Bay
Montebello Is - Hermite/Delta Is Channel
Montebello Is - Hock Bay
Montebello Is - North & Kelvin Channel
Montebello Is - Sherry Lagoon Entrance
Withnell Bay
Holden Bay
King Bay
No Name Bay / No Name Beach
Enderby Is -Dampier
Rosemary Island - Dampier

Legendre Is - Dampier
Karratha Gas Plant
KGP to Whitnell Creek
KGP to Northern Shore
KGP Fire Pond & Estuary
KGP to No Name Creek
Broome
Sahul Shelf Submerged Banks and Shoals
Clerke Reef (Rowley Shoals)
Imperieuse Island (Rowley Shoals)
Mermaid Reef (Rowley Shoals)
Scott Reef
Oiled Wildlife Response
Exmouth
Dampier region
Shark Bay

APPENDIX E: NOPSEMA REPORTING FORMS

NOPSEMA Recordable Environmental Incident Monthly Reporting Form
https://www.nopsema.gov.au/assets/Forms/A198750.doc
Report of an accident, dangerous occurrence or environmental incident
https://www.nopsema.gov.au/assets/Forms

Recordable Environmental Incident Monthly Report

Due Date: By the 15th day of the following month.

Send completed form to: submissions@nopsema.gov.au via secure file transfer at https://securefile.nopsema.gov.au/filedrop/submissions

Reference: Regulation 26B

Please check the following boxes if applicable to this report		**Nil Incident Report:** ☐		**Final report for this activity:** ☐	
Titleholder name:		**Titleholder business address:**		**Title of environment plan for the activity:**	
Activity type: (e.g. drilling, seismic, production)		**Month, Year:**		**Facility name and type:** (e.g. MODU, Seismic Vessel, FPSO)	
Contact person:		**Email:**		**Phone:**	
Incident date	**All material facts and circumstances** (including release volumes to environment if applicable)	**Performance outcome(s) and/or standard(s) breached**	**Action taken to avoid or mitigate any adverse environmental impacts of the incident**	**Corrective action taken, or proposed, to stop, control or remedy this incident**	**Action taken, or proposed, to prevent a similar incident occurring in future**

Note 1: As at 28 February 2014, amendments to the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations changed from environmental performance objective to environmental performance outcome. If you are reporting against an EP accepted under the old Regulations please report against the environmental performance objective for that activity.

Note 2: This form may be submitted in conjunction with the 'Injuries and Fatalities – Monthly Summary Report' Form available at www.nopsema.gov.au

Privacy Notice

NOPSEMA collects your contact details for the purpose of administering the OPGGSA and associated regulations. NOPSEMA will not use or disclose your personal information for any other purpose without your consent, unless it is required or authorised by law, or relates to NOPSEMA's enforcement activities. Your personal information may be disclosed to the following organisations, entities or individuals:

- individuals who make a request under the *Freedom of Information Act 1982*
- the Australian National Audit Office and other privately-appointed auditors
- NOPSEMA's legal advisors.

NOPSEMA may occasionally be required to disclose information to overseas recipients in order to discharge its functions or exercise its powers, or to perform its necessary business activities. Information about how you can access, or seek correction to, your personal information is contained in NOPSEMA's APP Privacy Policy at www.nopsema.gov.au/privacy. If you have an enquiry or a complaint about your privacy, please contact NOPSEMA's Privacy Contact Officer on 08 6188 8700 or by email at privacy@nopsema.gov.au.

Report of an accident, dangerous occurrence or environmental incident

For instructions and general guidance in the use of this form, please see the last page.

Part 1 is required within 3 days of a notified incident.
Part 2 is required within 30 days of notified incident.

What was the date and time of the initial verbal incident notification to NOPSEMA?			
Date		**Time**	

NOTE: It is a requirement to request permission to interfere with the site of an accident or dangerous occurrence. Refer OPGGS(S)R, Reg. 2.49.

What is the date and time of this written incident report?			
Date		**Time**	

What type of incident is being reported?	*Please tick appropriate incident type*	
Accident or dangerous occurrence		Complete parts 1A, 1B & part 2
Environmental Incident		Complete parts 1A, 1C
BOTH (Accident or dangerous occurrence AND environmental incident)		Complete ALL parts (1A, 1B, 1C, 2)

Please tick all applicable (one or more categories) *To use electronically: MS Word 2007-10 – click in check box*

Categories *Please select one or more*	Accidents	Death or Serious injury	☐
		Lost time injury ≥3 days	☐
	Dangerous occurrences	Hydrocarbon release >1 kg or ≥80 L (gas or liquid)	☐
		Fire or explosion	☐
		Collision marine vessel and facility	☐
		Could have caused death, serious injury or LTI	☐
		Damage to safety-critical equipment	☐
		Unplanned event - implement ERP	☐
		Pipeline incident	☐
		Well kick >50 barrels	☐
		Other ______________________	☐
	Environmental incidents	Hydrocarbon release	☐
		Chemical release	☐
		Drilling fluid/mud release	☐
		Fauna Incident	☐
		Other ______________________	☐

Part 1A – Information required within 3 days of an accident, dangerous occurrence or environmental incident

General information – all incidents

1.	**Where did the incident occur?**	Facility / field / title name		
		Site name and location *Latitude/longitude*		
2.	**Who is the registered operator/titleholder or other person that controls the works site or activity?**	Name		
		Business address		
		Business phone no.		
3.	**When did the incident occur?**	Time and time zone		
		Date		
4.	**Did anyone witness the incident?**	Yes or no *If yes, provide details below*		
	Witness details	Witness no 1	Witness no 2	Witness no 3
	Full name			
	Phone no. (Business hours)			
	Phone no. (Home) (Mobile)			
	Email (Business) (Private)			
	Postal address			
	NB: If more witnesses, copy and insert this section (4) here , and add extra witness numbers appropriately			
5.	**Details of person submitting this information**	Name		
		Position		
		Email		
		Telephone no.		
6.	**Brief description of incident**			
7.	**Work or activity being undertaken at time of incident**			

Part 1A – Information required within 3 days of an accident, dangerous occurrence or environmental incident

General information – all incidents

8.	**What are the internal investigation arrangements?**					
9.	**Was there any loss of containment of any fluid (liquid or gas)?**	Yes or no *If Yes, provide details below*				
		Type of fluid (liquid or gas) *If hydrocarbon release please complete item no.15 as well*	Hydrocarbon *Please specify*__________________ Non-hydrocarbon *Please specify*__________________			☐ ☐
		Estimated quantity *Liquid (L), Gas (kg)*				
		Estimation details	Calculation	☐	Measurement	☐
			*Please specify*______________________			
		Composition *Percentage and description*				
		Known toxicity to people and/or environment	Toxicity to people			
			Toxicity to environment			
		How was the leak/spill detected?	F&G detection CCTV	☐ ☐	Visual Other	☐ ☐
		Did ignition occur?	No Yes	☐ ☐	Immediate Delayed	☐ ☐
			If yes, what was the likely ignition source		Hotwork Spark electrical source Spark metallic contact Hot surface Other	☐ ☐ ☐ ☐ ☐
10.	**Has the release been stopped and/or contained?**	Yes or no				
		Duration of the release *hh:mm:ss*				
		Estimated rate of release *Litres or kg per hour*				
11.	**Location of release**	What or where is the location of the release?				
		What equipment was involved in the release?				
		Is this functional location listed as safety-critical equipment?				

Part 1A – Information required within 3 days of an accident, dangerous occurrence or environmental incident

General information – all incidents

12.	**Weather conditions** *Please complete as appropriate*	Ambient temperature C°				
		Relative humidity %				
		Wind speed m/s *NB: for enclosed areas use* Air change per hour				
		Wind direction e.g. from SW				
		Significant wave height m				
		Swell m				
		Current speed m/s				
		Current direction e.g. from SW				
13.	**Hydrocarbon release details** *If hydrocarbon fluid (liquid or gas) was released, please complete this section as well*	System of hydrocarbon release	Process Drilling Subsea / Pipeline	☐ ☐ ☐	Utilities Well related Marine	☐ ☐ ☐
		Estimated inventory in the isolatable system *Litres or kg*				
		System pressure and size of piping or vessel *diameter (d in mm) length (l in m) or volume (V in L)*	Pressure MPag			
			Size Piping (d) and Piping (l) or Vessel (V)			
		Estimated equivalent hole diameter *d in mm*				

Part 1B - Complete for accidents or dangerous occurrences

Accidents and dangerous occurrences information

	Was NOPSEMA notified through the dedicated notification phone line? *Phone No. 08 6461 7090*		Yes	☐	No	☐
15.	**Action taken to make the work-site safe**	Was permission given by a NOPSEMA inspector to interfere with the site? OPGGS(S)R 2.49.	Yes	☐	No	☐
		Action taken				
		Details of any disturbance of the work site				

Part 1B - Complete for accidents or dangerous occurrences

Accidents and dangerous occurrences information

16.	**Was an emergency response initiated?**		Yes	☐	No	☐
		Type of response	Manual Automatic alarm	☐ ☐	Muster Evacuation	☐ ☐
		How effective was the emergency response?				

17.	**Was anyone killed or injured?** *Provide details below*		Yes	☐		No		☐
	Injured persons (IP)	**Casualty No 1**						
	If different from item 2. Employer name		Employer address					
	Employer phone no.		Employer email					
	IP full name							
	IP date of birth		Sex	M	☐	F	☐	
	IP residential address							
	IP phone no. (Work)		IP phone no. (Home) (Mobile)					
	IP occupation/job title		Contractor or core crew					
	Details of injury							
	Based on TOOCS (refer last page) Nature of injury	a. Intracranial injury b. Fractures c. Wounds, lacerations, amputations, internal organ damage	☐ ☐ ☐	d. Burn e. Nerve or spinal cord injury f. Joint, ligament, muscle or tendon injury g. Other ____________________	☐ ☐ ☐ ☐			
	Part of body	G1. Head or face G2. Neck G3. Trunk G4. Shoulder or arm	☐ ☐ ☐ ☐	G5. Hip or leg G6. Multiple locations G7. Internal systems G8. Other ____________________	☐ ☐ ☐ ☐			
	Mechanism of injury	G0. Falls, stepping, kneeling, sitting on object G1. Hitting object G2. Being hit or trapped	☐ ☐ ☐	G3. Exposure to sound or pressure G4. Muscular stress G5. Heat, cold or radiation G6/7 Chemical, biological substance G8. Other ____________________	☐ ☐ ☐ ☐ ☐			
	Agency of injury	1. Machinery or fixed plant 2. Mobile plant or transport 3. Powered equipment 4. Non-power equipment	☐ ☐ ☐ ☐	5/6. Chemicals, materials, substances 7. Environmental agencies 8. Human or animal agencies 9. Other ____________________	☐ ☐ ☐ ☐			

Part 1B - Complete for accidents or dangerous occurrences

Accidents and dangerous occurrences information

	Details of job being undertaken						
	Day and hour of shift	Day *e.g. 5th day of 7 (5 / 7)*		Hour *e.g. 3rd hour of 12 (3 / 12)*			
	NB: If more casualties, please copy/paste this section (19) for each additional casualty and insert here						
18.	**Was there any serious damage?** *Provide details below*		Yes	☐	No	☐	
	Details	**Item 1**	**Item 2**		**Item 3**		
	Equipment damaged						
	Extent of damage						
19.	**Will the equipment be shut down?** *Yes or No*						
	If Yes, for how long?						
	NB: If more equipment seriously damaged, please copy/paste this section as required						
20.	**Will the facility be shut down?**	Yes or no *If yes provide details below*					
	Facility shutdown	Date			dd/mm/yyyy		
		Time			24 hour clock		
		Duration			days / hours / minutes		
21.	**Immediate action taken/intended, if any, to prevent recurrence of incident.**	**Action**	**Responsible party**		**Completion date** *Actual or intended*		
22.	**What were the immediate causes of the incident?**						

Attachments

Are you attaching any documents?	Yes or no *If yes provide details below*	

No.	ID	Revision	Date	Title/description

Attachments

Are you attaching any documents?			Yes or no *If yes provide details below*	
Insert or delete rows as required				

Part 1C – Complete for environmental incidents

Environmental Impacts

23.	**What is the current environment plan for this incident?**	Environment plan		
24.	**Has the incident resulted in an impact to the environment?**	Yes or no *If yes provide details below*		
		Incident details *e.g. estimated area of impact, nature/significance of impact*		
		ENVIRONMENTAL RECEPTORS		
		Open ocean ☐ Shoreline ☐ Population centre ☐ Stakeholders ☐ Other sensitivity ☐ *e.g. conservation area, nesting beach*	Macroalgae ☐ Coral Reef ☐ Benthic invertebrates ☐ Seagrass ☐ Mangrove ☐	
		Further details		
	Details	**Environment 1**	**Environment 2**	**Environment 3**
	Location of receiving environments *Lat/Long*			
	Date & time of impact			
	Action taken to minimise exposure			
	Specify each matter protected under Part 3 of the EPBC Act impacted			
	NB: If more environments were damaged, please copy/paste this section (Item E3) and add extra data			
25.	**Are any environments at risk?** ***Including as a result of spill response measures***	Yes or no *If yes, provide details*		
		Details *e.g. zone of potential impact*		
		AT RISK ENVIRONMENTS		

Part 1C – Complete for environmental incidents

Environmental Impacts

		Open ocean	☐	Macroalgae	☐
		Shoreline	☐	Coral Reef	☐
		Population Centre	☐	Benthic Invertebrates	☐
		Stakeholders	☐	Seagrass	☐
		Other sensitivity *e.g. conservation area, nesting beach*	☐	Mangrove	☐

	Details	Environment 1	Environment 2	Environment 3
	Estimated location of 'at-risk' environments			
	Estimated impact date & time			
	Action required to minimise exposure			
	Specify each matter protected under Part 3 of the EPBC Act at risk			

NB: If more environments at risk of damage, please copy/paste this section (Item E2) and add extra data

26.	**Was an oil pollution emergency plan activated?**	Yes or no	
		If yes, what action has been implemented /planned?	
		If yes, how effective is/was the spill response?	
27.	**Was an environmental monitoring program initiated?**	Yes or no	
		If yes, what actions have been implemented and/or planned?	

28.	**Did the incident result in the death or injury of any fauna?**	Yes or no (If yes provide details of species in the table below)		
	Injured fauna	**Species 1**	**Species 2**	**Species 3**
	Species name (common or scientific name)			
	Number of individuals killed or injured	Killed: Injured:	Killed: Injured:	Killed: Injured:

NB: If more species were injured or killed, please copy/paste this section (Item E4) and add extra data

29.	**Actions taken to avoid or mitigate any adverse environmental impacts of the incident.**	**Action**	**Responsible party**	**Completion date** *Actual or intended*

NB: If more actions, please add extra rows as required

Part 1C – Complete for environmental incidents

Environmental Impacts

30.	**Corrective actions taken, or proposed, to stop, control or remedy the incident.**	**Action**	**Responsible party**	**Completion date** *Actual or intended*
	NB: If more actions, please add extra rows as required			
31.	**Actions taken, or proposed, to prevent a similar incident occurring in the future.**	**Action**	**Responsible party**	**Completion date** *Actual or intended*
	NB: If more actions, please add extra rows as required			

Attachments

Are you attaching any documents?			Yes or no *If yes provide details below*	
No.	**ID**	**Revision**	**Date**	**Title/Description**
Insert or delete rows as required				

Part 2 – Information required within 30 days of accident or dangerous occurrence

NOPSEMA acknowledges that in many circumstances an operator may not have completed an investigation within 3 days of an accident or first detection of a dangerous occurrence and agrees that these items must be provided within 30 days unless otherwise agreed, in writing with NOPSEMA. In circumstances where an investigation has been completed within 3 days, and these items are available (supplemented, as required by any attachments) this part should also be completed at that time.

32.	**Has the investigation been completed?**	Yes or no		
	Root cause analysis *What were the root causes?*	Root cause 1		
		Root cause 2		
		Root cause 3		
		Other root causes		
	Full report *Describe investigation in detail, including who conducted the investigation and in accordance with what standard/procedure with reference to attachments listed in the 'attachments table' (following) as applicable*			
33.	**Actions to prevent recurrence of same or similar incident**	**Action**	**Responsible party**	**Completion date** *Actual or intended*
	NB: Add or delete rows as appropriate			

Attachments (Insert/delete rows as required)

Are you attaching any documents?		Yes or no *If yes provide details below*		
No.	**ID**	**Revision**	**Date**	**Title/description**

Instructions and general guidance for use:

1. The use of this form is voluntary and is provided to assist operators and titleholders to comply with their obligations to give notice and provide reports of incidents to NOPSEMA under the applicable legislation.
2. Accidents, dangerous occurrences or environmental incidents can all be reported using this same form.
3. The applicable legislation for incident reporting is:
   a. Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009 [OPGGS(S)R]; and
   b. Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 [OPGGS(E)R], for facilities located in Commonwealth waters; or
   c. for facilities located in designated coastal waters, the relevant State or Territory Act and associated Regulations where there is a current conferral of powers to NOPSEMA.
4. In the context of this form an incident is a reportable incident as defined under:
   a. OPGGSA, Schedule 3, Clause 82.
   b. OPGGS(E)R, regulation 4.
5. This form should be used in conjunction with NOPSEMA Guidance Notes available on the NOPSEMA website:
   a. N-03000-GN0099 Notification and Reporting of Accidents and Dangerous Occurrences
   b. N-03000-GN0926 Notification and Reporting of Environmental Incidents
6. Part 1 requires completion for all incidents; then ALSO complete part 2 if the incident is an accident or dangerous occurrence.
7. NOPSEMA considers that a full report will contain copies of documentary material referenced and/or relied on in the course of completing this form, which may include (but not be limited to) as appropriate: witness statements, management system documents, drawings, diagrams and photographs, third party reports (audit, inspection, material analysis etc.), internal records and correspondence.
8. This form is intended to be completed electronically using Microsoft Word by completing the unshaded cells which will expand as required to accept the information required and the check boxes where relevant (NB: check boxes may appear shaded and have reduced functionality in MS Word versions prior to 2010).
9. The completed version of this form (and any attachments, where applicable) should be emailed to: submissions@nopsema.gov.au or submitted via secure file transfer at: https://securefile.nopsema.gov.au/filedrop/submissions as soon as practicable, but in any case within three days of the incident.

References

NOPSEMA website: www.nopsema.gov.au

TOOCS – Type of Occurrence Classification System.

The *Type of Occurrence Classifications System, Version 3.0* (TOOCS3.0) was developed to improve the quality and consistency of data. This system aligns with the International Classification of Diseases –Australian Modification (ICD10-AM).

http://www.safeworkaustralia.gov.au/sites/SWA/AboutSafeWorkAustralia/WhatWeDo/Publications/Documents/207/TypeOfOccurrenceClassificationSystem(TOOCS)3rdEditionRevision1.pdf

OPGGS(S)R. Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009. Select Legislative Instrument 2009 No. 382 as amended and made under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006.* Commonwealth of Australia.

OPGGS(E)R. Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. Statutory Rules 1999 No. 228 as amended and made under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006.* Commonwealth of Australia.

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- the Australian National Audit Office and other privately-appointed auditors
- other law enforcement bodies (for example, the police or the Coroner)
- NOPSEMA's legal advisors.

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APPENDIX F: STAKEHOLDER CONSULTATION

Woodside Consultation Material

Consultation with all relevant stakeholders – 1 April 2019

Woodside sent the email below and consultation Information Sheet to all relevant stakeholders.

Dear Stakeholder

Woodside is planning to conduct a series of marine seismic surveys in three areas of Commonwealth waters in North West Australia, starting in Q4 2019 pending approvals, vessel availability and weather constraints.

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

Activity overview

Activity purpose:	All of the proposed seismic surveys are over areas where Woodside has previously acquired seismic data and are termed 'time lapse' or 4D surveys. Data acquired from these surveys will be important to help inform current and future reservoir management decisions.					
Activity:	Six marine seismic surveys in three Operational Areas: o **Area A** - Pluto 4D M2 and Harmony 4D M1 surveys o **Area B** - Scarborough 4D B1 survey o **Area C** - Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys					
	Area A		**Area B**	**Area C**		
	Pluto 4D M2	**Harmony 4D M1**	**Scarborough 4D B1**	**Laverda 4D M1**	**Cimatti 4D M1**	**Vincent 4D M2**
Distance from Acquisition Area to nearest port:	163 km north-west of Dampier	160 km north-west of Dampier	357 km north-west of Dampier	49 km north-west of Exmouth	47 km north-west of Exmouth	51 km north-west of Exmouth
Approximate water depth:	41 – 1,382 m	39 – 1,195 m	961 – 1,242 m	205 – 1,198 m	183 – 1,028 m	153 – 983 m
Earliest commencement date:	Q4 2019	Q1 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020
Estimated duration	28 days	20 to 23 days	45 days	12-13 days	11 days	23 days
Vessels:	Three project vessels, comprising the seismic vessel and up to two support and chase vessels, will be required for the surveys in Areas A and B. An additional source vessel may be required for surveys in Area C.					
Exclusion Zone:	A 500 m 'safe navigation area' will be in place around the primary vessel and streamers during seismic operations.					

Survey locations

Please refer to the Consultation Information Sheet attached.

Your feedback

Your feedback on the proposed activity and our response will be included in an Environment Plan for consideration by the National Offshore Petroleum Safety and Environmental Management Authority, as is required under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please provide your views by **3 May 2019** to allow us sufficient time to inform our planning for the proposed activity. Comments can be made by email, letter or by phone.

Notification will be provided to relevant marine users closer to the time of the proposed activity.

Please note under new public transparency arrangements being implemented by NOPSEMA, the Environment Plan for this activity will be published in full following acceptance by the Authority. Please advise Woodside if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan. The information received will form part of the EP assessment however it will not be released publicly and will remain confidential to NOPSEMA throughout.

Regards

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Woodside consultation Information Sheet

Woodside

STAKEHOLDER CONSULTATION
INFORMATION SHEET

April 2019

NORTH-WEST AUSTRALIA 4D MARINE SEISMIC SURVEY

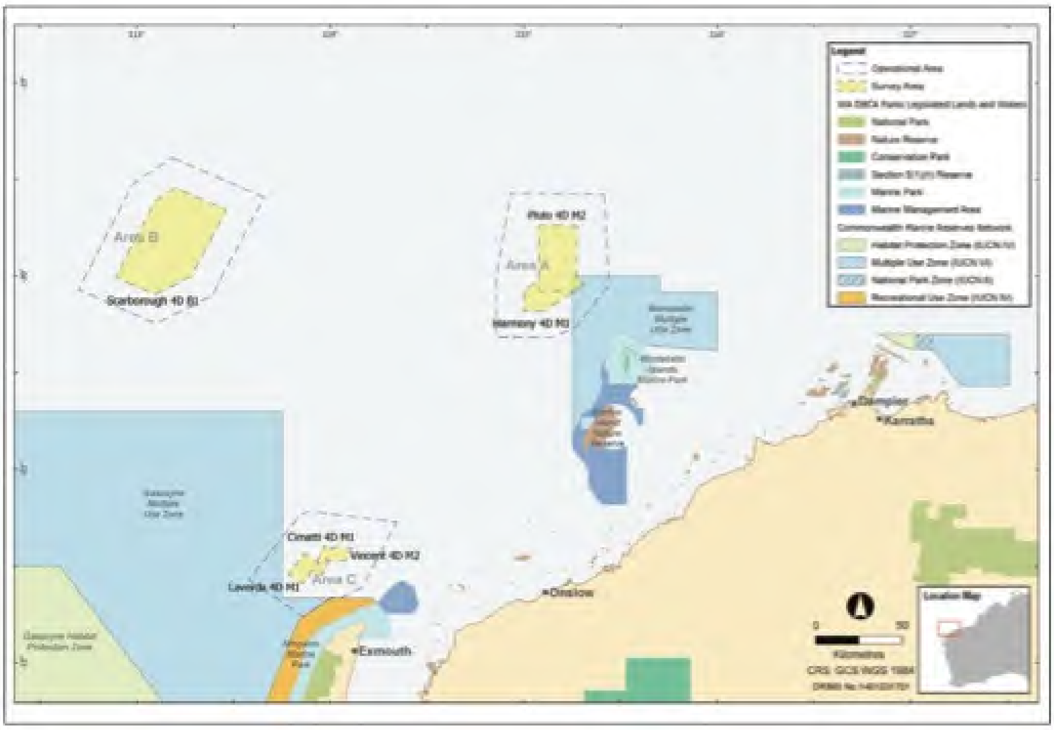
EXMOUTH PLATEAU SUB-BASIN / NORTHERN CARNARVON BASIN

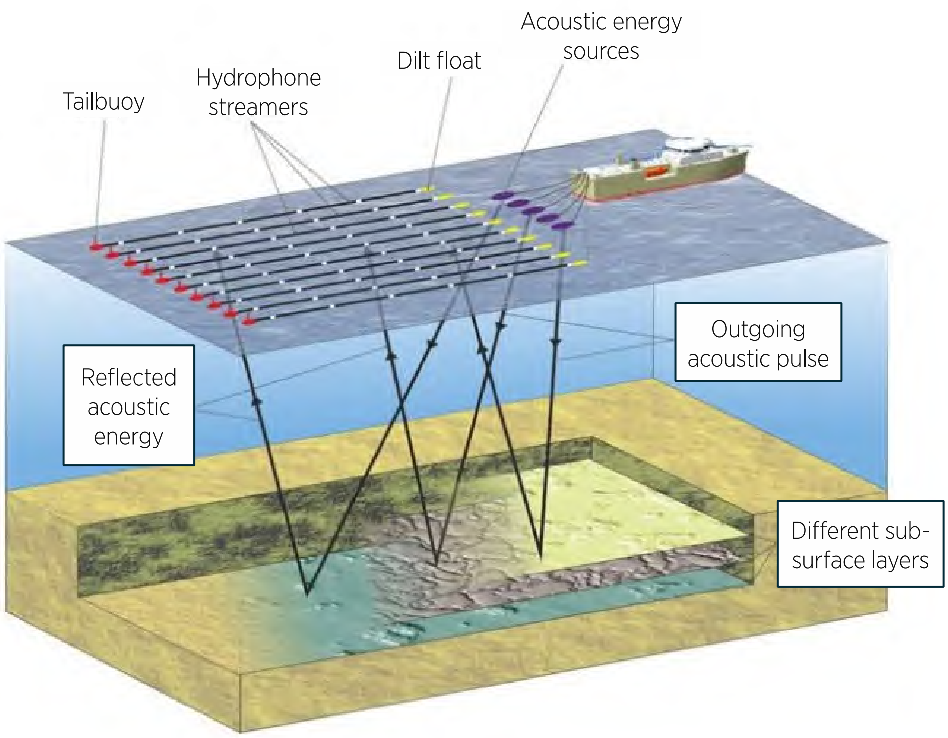
Woodside is planning to conduct a series of marine seismic surveys in three areas of Commonwealth waters in North-west Australia, starting in Q4 2019 pending approvals, vessel availability and weather constraints.

All of the proposed seismic surveys are over areas where Woodside has previously acquired seismic data and are termed 'time lapse' or 4D surveys. Data acquired from these surveys will be important to help inform current and future reservoir management decisions.

Data from surveys in Areas A and C are termed monitor surveys and will show how oil and gas reservoirs have changed as a result of hydrocarbon depletion resulting from production. This data will be acquired over the Pluto, Brunello, Vincent, Cimatti and Laverda oil and gas fields.

The survey in Area B over the Scarborough field, termed a baseline survey, will provide updated data to assist with planning for future production.





ABOUT MARINE SEISMIC SURVEYS

Marine seismic surveys use acoustic or noise pulses to image subsurface formations. This is done by transmitting sound waves that reflect off underground rock formations. The sound waves that reflect back are captured by recording sensors called hydrophones.

The information gathered by the hydrophones is collected, converted to a digital signal and relayed to data storage devices on the survey vessel. The data is typically transferred to shore via tape or disc packs and data processers using powerful computers translate the information into digital images or maps of the subsurface. Geophysicists and geologists then analyse and interpret this data to determine the presence of hydrocarbons or monitor how hydrocarbon reservoirs change over time.

During a seismic survey, standard environmental procedures are followed, including a soft start of the noise pulses, gradually increasing the intensity of the pulses while monitoring the area to be sure no whales are present.

For the period of seismic operations, marine fauna observers on board the vessel and during daylight hours continuously scan for marine life. If whales are detected within close vicinity, operations cease and are only restarted when the animals have moved away.

	Area A		Area B	Area C		
	Pluto 4D M2	Harmony 4D M1	Scarborough 4D B1	Laverda 4D M1	Cimatti 4D M1	Vincent 4D M2
Earliest commencement date	Q4 2019	Q1 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020
Estimated duration	28 days	20 to 23 days	45 days	12-13 days	11 days	23 days
Acquisition Area	780 km^2	469 km^2	2,059 km^2	144 km^2	87 km^2	82 km^2
Operational Area	3,710 km^2	2,419 km^2	5,597 km^2	1,758 km^2	1,564 km^2	1,655 km^2
Water depth in Operational area	41 – 1,382 m	39 – 1,195 m	961 – 1,242 m	205 – 1,198 m	183 – 1,028 m	153 – 983 m
Last acquired data	2015	2013	2004	2010	2010	2010
Distance from Acquisition Area to nearest port/marina	163 km north-west of Dampier	160 km north-west of Dampier	357 km north-west of Dampier	49 km north-west of Exmouth	47 km north-west of Exmouth	51 km north-west of Exmouth
Distance from Acquisition Area to nearest marine park	Overlaps north-west corner of Montebello Marine Park Multiple Use Zone	Overlaps north-west corner of Montebello Marine Park Multiple Use Zone	68 km north of Gascoyne Marine Park Multiple Use Zone	3 km east of Gascoyne Marine Park Mulitiple Use Zone	14 km north-west of Ningaloo Marine Park	21 km north of Ningaloo Marine Park

Proposed activity

The proposed surveys will be conducted by a purpose-built seismic vessel, using technical methods and procedures commonly used in Australian waters. No unique or unusual equipment or operations are proposed.

During the proposed activities, the seismic vessel will traverse a series of pre-determined sail lines within each survey Acquisition Area at a speed of approximately 7-9 km/hr. An additional buffer area, or Operational Area, is allowed for vessel manoeuvring. Bubble tests, soft starts and seismic line 'run in' and 'run out' data will be acquired in the Operational Areas.

As the vessel travels along the survey lines a series of noise pulses will be directed every 6-9 seconds down through the water column and the seabed.

The released sound will be attenuated and reflected at geological boundaries, with the reflected signals detected by sensitive microphones called 'hydrophones receivers', embedded within a number of cables, or streamers, towed behind the seismic vessel.

The reflected sound will then be processed to generate a three dimensional (3D) seismic image, providing information about the structure and composition of geological formations below the seabed.

The seismic vessel will follow as accurately as possible the previous source and receiver locations along pre-determined vessel sail lines, as acquired by previous surveys in order to show how reservoir characteristics have changed over time. This change or difference in the seismic signal is known as time-lapse or '4D' seismic.

The seismic vessel will tow between 6 to 12 solid streamers at a depth of approximately 15-18 m with a spacing between streamers of 50-100 m and a maximum streamer length of approximately 8,000 m. Survey activities will take place during the day and night.

It is anticipated that three project vessels, comprising the seismic vessel and up to two support and chase vessels will be required for the surveys in Areas A and B. An additional source vessel may be required for surveys in Area C. During this time the main seismic vessel will be used to tow streamers.

Support and chase vessels will assist with re-supply, refuelling and other support functions, as well as be on stand-by to manage potential interactions with other marine users of the area.

Communications with Mariners

A 500 m 'safe navigation area' will be in place around the primary vessel and streamers during seismic operations.

The seismic vessels will be operating within the Operational Areas determined for these activities. Marine notices will be issued prior to the start of work to alert vessels that maybe operating in waters nearby and that access to these areas may be limited.

Woodside will provide updates on vessel movements and their details during the activities at an appropriate frequency to meet relevant stakeholder needs

Survey Coordinates

Area A		
	Latitude	**Longitude**
Survey Operational Area	19°34'12.462"S	114°56'01.581"E
	20°00'11.867"S	114°51'27.323"E
	20°18'50.759"S	114°51'27.693"E
	20°19'02.669"S	115°08'49.012"E
	20°15'53.34"S	115°15'55.885"E
	20°02'46.041"S	115°26'26.19"E
	19°34'30.004"S	115°24'54.989"E

	Pluto 4D M2 survey		Harmony 4D M1 survey	
	Latitude	**Longitude**	**Latitude**	**Longitude**
Survey Acquisition Area	19°44'02.451"S	115°04'37.853"E	20°10'49.14"S	115°00'04.08"E
	20°04'37.104"S	115°04'37.946"E	20°10'53.22"S	115°06'11.94"E
	20°04'39.019"S	115°16'23.684"E	20°02'52.542"S	115°18'35.669"E
	19°44'11.842"S	115°16'28.804"E	19°58'18.234"S	115°15'08.425"E
			19°58'17.94"S	115°09'38.28"E
			20°04'29.34"S	115°00'03.6"E

Area B		
	Latitude	**Longitude**
Survey Operational Area	19°23'08.078"S	113°10'55.817"E
	19°35'25.579"S	113°39'22.485"E
	20°06'02.861"S	113°23'11.159"E
	20°14'43.528"S	113°05'50.122"E
	20°04'07.021"S	112°41'50.389"E
	19°31'10.437"S	112°58'49.251"E

	Scarborough 4D B1 survey	
	Latitude	**Longitude**
Survey Acquisition Area	19°32'26.998"S	113°11'49.708"E
	19°39'19.852"S	113°27'44.143"E
	20°00'05.432"S	113°16'44.265"E
	20°05'39.844"S	113°05'35.852"E
	20°00'16.217"S	112°53'23.022"E
	19°36'37.046"S	113°05'32.964"E

Area C		
	Latitude	**Longitude**
Survey Operational Area	21°12'56.728"S	113°53'22.29"E
	21°14'36.163"S	113°50'07.552"E
	21°34'15.565"S	113°34'45.669"E
	21°45'48.511"S	113°51'38.324"E
	21°39'48.312"S	114°00'06.655"E
	21°39'49.318"S	114°03'34.487"E
	21°36'39.407"S	114°10'00.881"E
	21°16'24.45"S	114°20'31.463"E

	Laverda 4D M1 survey		Cimatti 4D M1 survey		Vincent 4D M2 survey	
	Latitude	**Longitude**	**Latitude**	**Longitude**	**Latitude**	**Longitude**
Survey Acquisition Area	21°29'00.941"S	113°56'29.805"E	21°31'33.609"S	113°54'25.865"E	21°24'12.065"S	114°00'45.066"E
	21°35'34.453"S	113°51'22.652"E	21°23'39.518"S	113°58'00.971"E	21°28'19.742"S	113°58'24.633"E
	21°32'30.412"S	113°46'53.538"E	21°24'50.059"S	114°00'56.251"E	21°28'26.392"S	114°04'38.121"E
	21°25'57.047"S	113°52'00.747"E	21°32'45.166"S	113°57'20.863"E	21°24'18.387"S	114°06'47.17"E

Implications for Stakeholders

In support of the proposed activities, Woodside will consult relevant stakeholders whose interests, functions, and activities may be affected by the proposed activities. We will also keep other stakeholders who have identified an interest informed about our planned activities.

Woodside has undertaken an assessment to identify potential risks to the marine environment and relevant stakeholders, considering timing, duration, location and potential impacts arising from the North-west Australia 4D Marine Seismic Survey.

A number of mitigation and management measures will be implemented and are summarised below. Further details will be provided in the Environment Plan.

Summary of key risks and/or impacts and management measures.

Potential Risk and/or Impact	Mitigation and/or Management Measure
Planned Activities	
Interests of relevant stakeholders with respect to: + Defence activities + Petroleum activities + Commercial fishing activities + Shipping activities	+ Consultation with petroleum titleholders, commercial fishers and their representative organisations, and government departments and agencies to inform decision making for the proposed activity and development of the Environment Plan. + Advice to relevant stakeholders prior to the commencement of activities. + Ongoing consultation by way of updates on vessel movements during survey activities at a frequency to meet relevant stakeholder needs.
Marine fauna interactions	+ Measures will be taken to protect marine fauna and ecosystems from vessel activities and to prevent vessel collisions and groundings. + Maintaining dedicated marine fauna observers throughout the survey. + All marine fauna sightings are recorded and reported to the Department of the Environment and Energy.
Marine discharges	+ All routine marine discharges will be managed according to legislative and regulatory requirements and Woodside's Environmental Performance Standards where applicable.
Underwater noise	+ Implementation of *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Policy Statement 2.1. + Noise modelling to inform potential impacts and input to mitigation and management measures.
Vessel interaction	+ Woodside will notify relevant fishery stakeholders and Government maritime safety agencies of specific start and end dates, specific vessel-on-location dates and any exclusion zones prior to commencement of the activity. + A 500 m radius safe navigation area will be in place around the seismic vessel and streamers during seismic operations. + The seismic vessel will display appropriate day shapes and lights to indicate the vessel is towing and is therefore restricted in its ability to manoeuvre. + The streamers will tow surface tail buoys fitted with radar reflectors. + A visual and radar watch will be maintained on the project vessel bridges at all times. + Support and chase vessels will be on standby to direct any shipping traffic or commercial fishing vessels away from the seismic vessel and its towed equipment.
Waste generation	+ Waste generated on the vessels will be managed in accordance with legislative requirements and a Waste Management Plan. + Wastes will be managed and disposed of in a safe and environmentally responsible manner that prevents accidental loss to the environment. + Wastes transported onshore will be sent to appropriate recycling or disposal facilities by a licensed waste contractor.
Unplanned	
Hydrocarbon release	+ Appropriate spill response plans, equipment and materials will be in place and maintained. + Appropriate refuelling procedures and equipment will be used to prevent spills to the marine environment.
Introduction of invasive marine species	+ All vessels will be assessed and managed as appropriate to prevent the introduction of invasive marine species. + Compliance with Australian biosecurity requirements and guidance. + Contracted vessels comply with Australian ballast water requirements.

Providing feedback

Our intent is to minimise environmental and social impacts associated with the proposed activities, and we are seeking any interest or comments you may have to inform our decision making.

An Environment Plan for the proposed activity will be submitted to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) for acceptance in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

If you would like to comment on the proposed activities outlined in this information sheet, or would like additional information, please contact Woodside before COB 3 May 2019.

Please note under new public transparency arrangements being implemented by NOPSEMA, the Environment Plan for this activity will be published in full following acceptance by the Authority. Please advise Woodside if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan. The information received will form part of the EP assessment however it will not be released publicly and will remain confidential to NOPSEMA throughout.

Andrew Winter, *Corporate Affairs Adviser*
Woodside Energy Ltd
E: Feedback@woodside.com.au | **Toll free:** 1800 442 977

Please note that stakeholder feedback will be communicated to NOPSEMA as required under legislation. Woodside will communicate any material changes to the proposed activity to affected stakeholders as they arise.

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Woodside

Consultation with specific stakeholders

Woodside sent the following emails, consultation Information Sheet, activity maps and other information relevant to specific stakeholder interests.

Email to DPIRD – 19 February 2019

We are commencing the process of pulling together information to inform the development of an EP for some 4D seismic work we propose to undertake later this year.

As part of our engagement process we would like to meet with DPIRD to provide an initial overview of the proposed 4D seismic work which is planned to include 5 surveys across 4 areas (Pluto, Brunello, Scarborough, and Laverda Canyon/Cimatti).

In terms of a meeting agenda, we could provide you with an overview of the activity including proposed timing, answer any preliminary questions you may have, and seek your feedback on our proposed engagement approach.

Would you (and anyone else you consider relevant from the Department) be available for a meeting over the next couple of weeks?

From Woodside's end, I would invite a couple of people from our environment team, our geophysist and myself.

Look forward to your response.

Regards

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Email to DPIRD – 13 March 2019

As discussed, please find attached some slides for our discussion from 3-4pm on 20 March.

Any questions please let me know.

Hopefully get access to Fishcube shortly.

Thanks

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Email to WAFIC – 1 April 2019

Woodside is planning to conduct a series of marine seismic surveys in three areas of Commonwealth waters in North West Australia, starting in Q4 2019 pending approvals, vessel availability and weather constraints.

We have identified and assessed potential risks and impacts to active commercial fishers, fishing activity, the commercial fishing resource and the marine environment in the development of the proposed Environment Plan for this activity. These risks are summarised below.

Woodside has endeavoured to reduce these risks to as low as reasonably practical (ALARP) level. Please contact me if you believe we have overlooked any potential impacts to the commercial fishing industry or missed any points of importance.

An information sheet (also available on our website) and maps of State Fisheries relevant to the proposed activities are also attached.

Activity overview

Activity purpose:	All of the proposed seismic surveys are over areas where Woodside has previously acquired seismic data and are termed 'time lapse' or 4D surveys. Data acquired from these surveys will be important to help inform current and future reservoir management decisions.					
Activity:	Six marine seismic surveys in three Operational Areas: • **Area A** - Pluto 4D M2 and Harmony 4D M1 surveys • **Area B** - Scarborough 4D B1 survey • **Area C** - Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys Please refer to the Consultation Information Sheet attached for latitude and longitudes.					
State fisheries identified as relevant to the proposed activity*:	**Area A**		**Area B**	**Area C**		
	Western Australian Mackerel Fishery – Pilbara (Area 2) Pearl Oyster Managed Fishery Pilbara Line		None	Western Australian Mackerel Fishery – Pilbara (Area 2) Pearl Oyster Managed Fishery Pilbara Line		
	Pluto 4D M2	**Harmony 4D M1**	**Scarborough 4D B1**	**Laverda 4D M1**	**Cimatti 4D M1**	**Vincent 4D M2**
Distance from Acquisition Area to nearest port:	163 km NW of Dampier	160 km NW of Dampier	357 km NW of Dampier	49 km NW of Exmouth	47 km NW of Exmouth	51 km NW of Exmouth
Approximate water depth:	41 – 1,382 m	39 – 1,195 m	961 – 1,242 m	205 – 1,198 m	183 – 1,028 m	153 – 983 m
Earliest commencement date:	Q4 2019	Q1 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020
Estimated duration	28 days	20 to 23 days	45 days	12-13 days	11 days	23 days
Vessel/rig:	Three project vessels, comprising the seismic vessel and up to two support and chase vessels, will be required for the surveys in Areas					

	A and B. An additional source vessel may be required for surveys in Area C.
Exclusion Zone:	A 500 m 'safe navigation area' will be in place around the primary vessel and streamers during seismic operations.

* Fisheries have been identified on the basis of fishing licence overlap with the proposed activity area and recent fishing effort data as managed by the Department of Primary Industries and Regional Development. Individual licence holders or representative fishing organisations who have requested ongoing advice on Woodside's planned activities will also be advised.

Potential risks to commercial fishing

Potential risk	Risk description	Mitigation and/or management measures
Planned Activities		
Vessel interaction	The presence of survey vessel, towed array, support and chase vessels may preclude other marine users from access to the area.	• Woodside will notify relevant fishery stakeholders and Government maritime safety agencies of specific start and end dates, specific vessel-on-location dates and any exclusion zones prior to commencement of the activity. • A 500 m safe navigation area will be maintained around seismic vessel and towed array. • A communications protocol will be in place between the project vessels and known commercial fishing vessels within the survey operational areas, to actively manage concurrent activities. • Support and chase vessels will be on standby to direct any shipping traffic or commercial fishing vessels away from the seismic vessel and its towed equipment
Underwater noise emissions from vessels	Noise will be generated by the survey vessel, support and chase vessels. Due to the low acoustic source levels associated with MODU and vessel operations there is not likely to be any interaction or potential impact to fish hearing, feeding or spawning.	• EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans will be implemented. • Survey timing will be varied where possible to avoid the migration periods for humpback whales.
Underwater noise-emissions from seismic survey equipment	Noise will be generated by the seismic survey array. Due to the low acoustic source levels associated with MODU and vessel operations there is not	• Noise modelling to inform potential impacts • Meeting with WAFIC and interested relevant fishery licence holders in April to further discuss noise

	likely to be any interaction or potential impact to fish hearing, feeding or spawning.	modelling and mitigation and management measures.
Marine discharges	Discharges from the operation vessels include sewage, grey water, cooling water, desalination brine, deck drainage, ballast and bilge water These discharges may result in a localised short-term reduction in water quality however they will be rapidly diluted and dispersed in the water column.	• Implementation of chemical assessment and approval process
Unplanned Risks		
Hydrocarbon release	Loss of hydrocarbons to the marine environment via loss of well control or from a vessel collision resulting a tank rupture.	• In the unlikely event of an oil spill or unplanned discharge into the environment, relevant agencies and organisations will be notified as appropriate to the nature and scale of the event, as soon as practicable following the occurrence. • Oil spill response strategies will be assessed based on potential impact to identified key receptor locations and sensitivities, which includes fish spawning and nursery areas.
Invasive Marine Species	Introduction or translocation and establishment of invasive marine species to the area via vessels ballast water or biofouling.	• All vessels will be assessed and managed as appropriate to prevent the introduction of invasive marine species. • Compliance with Australian biosecurity requirements and guidance.

Your feedback
Your feedback on the proposed activity and our response will be included in an Environment Plan for consideration by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), as is required under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please provide your views by **3 May 2019** to allow us sufficient time to inform our planning for the proposed activity. Comments can be made by email, letter or by phone.

Please note under new public transparency arrangements being implemented by NOPSEMA, the Environment Plan for this activity will be published in full following acceptance by the Authority. Please advise Woodside if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan. The information received will form part of the EP assessment however it will not be released publicly and will remain confidential to NOPSEMA throughout.

Regards

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Email to WAFIC – 2 April 2019

Please find below an updated risk description for underwater noise emissions.

Regards, [Redacted]

Potential risk	Risk description	Mitigation and/or management measures
Planned Activities		
Vessel interaction	The presence of survey vessel, towed array, support and chase vessels may preclude other marine users from access to the area.	• Woodside will notify relevant fishery stakeholders and Government maritime safety agencies of specific start and end dates, specific vessel-on-location dates and any exclusion zones prior to commencement of the activity. • A 500 m safe navigation area will be maintained around seismic vessel and towed array. • A communications protocol will be in place between the project vessels and known commercial fishing vessels within the survey operational areas, to actively manage concurrent activities. • Support and chase vessels will be on standby to direct any shipping traffic or commercial fishing vessels away from the seismic vessel and its towed equipment
Underwater noise emissions from vessels	Noise will be generated by the survey vessel, support and chase vessels. Due to the low acoustic source levels associated with vessel operations there is unlikely to be any interaction or potential impact to fish hearing, feeding or spawning.	• EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans will be implemented. • Survey timing will be varied where possible to avoid the migration periods for humpback whales.
Underwater noise-emissions from seismic survey equipment	Noise will be generated by the seismic survey array. The seismic source will comprise a source array with a volume ranging from 2,650 cubic inches (in^3) to 3,150 in^3 with an operating pressure of approximately 13,800 kPa	• Noise modelling to inform potential impacts • Meeting with WAFIC in April to further discuss noise modelling and mitigation and management measures.

	(2,000psi). Acoustic propagation modelling is currently being completed to assess the potential impacts of the seismic survey source on fish, fish eggs and larvae, and benthic species such as crustaceans, bivalves, sponges and coral in line with the most recent and relevant peer reviewed literature.	
Marine discharges	Discharges from the operation vessels include sewage, grey water, cooling water, desalination brine, deck drainage, ballast and bilge water These discharges may result in a localised short-term reduction in water quality however they will be rapidly diluted and dispersed in the water column.	• Implementation of chemical assessment and approval process
Unplanned Risks		
Hydrocarbon release	Loss of hydrocarbons to the marine environment from a vessel collision resulting in a tank rupture.	• In the unlikely event of an oil spill or unplanned discharge into the environment, relevant agencies and organisations will be notified as appropriate to the nature and scale of the event, as soon as practicable following the occurrence. • Oil spill response strategies will be assessed based on potential impact to identified key receptor locations and sensitivities, which includes fish spawning and nursery areas.
Invasive Marine Species	Introduction or translocation and establishment of invasive marine species to the area via vessels ballast water or biofouling.	• All vessels will be assessed and managed as appropriate to prevent the introduction of invasive marine species. • Compliance with Australian biosecurity requirements and guidance.

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Letter to relevant State fishery licence holders – 1 April 2019

Dear Licence Holder

CONSULTATION INFORMATION – NORTH WEST AUSTRALIA MARINE SEISMIC SURVEY

Woodside is planning to conduct a series of marine seismic surveys in three areas of Commonwealth waters in North West Australia, starting in Q4 2019 pending approvals, vessel availability and weather constraints.

We have identified and assessed potential risks and impacts to active commercial fishers, fishing activity, the commercial fishing resource and the marine environment in the development of the proposed Environment Plan for this activity. These risks are enclosed.

Woodside has endeavoured to reduce these risks to as low as reasonably practical (ALARP) level. Please contact me if you believe we have overlooked any potential impacts to the commercial fishing industry or missed any points of importance.

Activity description
The activity description and potential risks to commercial fishing are enclosed in Appendix A and B.

Your feedback
Your feedback on the proposed activity and our response will be included in an Environment Plan for consideration by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), as is required under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth).

Under new public transparency arrangements being implemented by NOPSEMA, the Environment Plan for this activity will be published in full following acceptance by the Authority. Please advise Woodside if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan, which will remain confidential to NOPSEMA.

Please provide your views by 3 May 2019 to allow us sufficient time to inform our planning for the proposed activity. Comments can be made by email, letter or by phone.

Appendix A – Activity Description – North West Australia Marine Seismic Survey

Activity purpose:	All of the proposed seismic surveys are over areas where Woodside has previously acquired seismic data and are termed 'time lapse' or 4D surveys. Data acquired from these surveys will be important to help inform current and future reservoir management decisions.					
Activity:	Six marine seismic surveys in three Operational Areas: - **Area A** - Pluto 4D M2 and Harmony 4D M1 surveys - **Area B** - Scarborough 4D B1 survey - **Area C** - Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys					
State fisheries identified as relevant to the proposed activity*:	**Area A**		**Area B**	**Area C**		
	Western Australian Mackerel Fishery – Pilbara (Area 2) Pearl Oyster Managed Fishery Pilbara Line		None	Western Australian Mackerel Fishery – Pilbara (Area 2) Pearl Oyster Managed Fishery Pilbara Line		
	Pluto 4D M2	**Harmony 4D M1**	**Scarborough 4D B1**	**Laverda 4D M1**	**Cimatti 4D M1**	**Vincent 4D M2**
Distance from Acquisition Area to nearest port:	163 km NW of Dampier	160 km NW of Dampier	357 km NW of Dampier	49 km NW of Exmouth	47 km NW of Exmouth	51 km NW of Exmouth
Approximate water depth:	41 – 1,382 m	39 – 1,195 m	961 – 1,242 m	205 – 1,198 m	183 – 1,028 m	153 – 983 m
Earliest commencement date:	Q4 2019	Q1 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020
Estimated duration	28 days	20 to 23 days	45 days	12-13 days	11 days	23 days
Vessel/rig:	Three project vessels, comprising the seismic vessel and up to two support and chase vessels, will be required for the surveys in Areas A and B. An additional source vessel may be required for surveys in Area C.					
Exclusion Zone:	A 500 m 'safe navigation area' will be in place around the primary vessel and streamers during seismic operations.					

* Fisheries have been identified on the basis of fishing licence overlap with the proposed activity area and recent fishing effort data as managed by the Department of Primary Industries and Regional Development. Individual licence holders or representative fishing organisations who have requested ongoing advice on Woodside's planned activities will also be advised.

Appendix B – Potential risks to commercial fishing

Potential risk	Risk description	Mitigation and/or management measures
Planned Activities		
Vessel interaction	The presence of survey vessel, towed array, support and chase vessels may preclude other marine users from access to the area.	- Woodside will notify relevant fishery stakeholders and Government maritime safety agencies of specific start and end dates, specific vessel-on-location dates and any exclusion zones prior to commencement of the activity. - A 500 m safe navigation area will be maintained around seismic vessel and towed array. - A communications protocol will be in place between the project vessels and known commercial fishing vessels within the survey operational areas, to actively manage concurrent activities. - Support and chase vessels will be on standby to direct any shipping traffic or commercial fishing vessels away from the seismic vessel and its towed equipment
Underwater noise emissions from vessels	Noise will be generated by the survey vessel, support and chase vessels. Due to the low acoustic source levels associated with vessel operations there is unlikely to be any interaction or potential impact to fish hearing, feeding or spawning.	- EPBC Regulations 2000 – Part 8 Division 8.1 Interacting with cetaceans will be implemented. - Survey timing will be varied where possible to avoid the migration periods for humpback whales.
Underwater noise-emissions from seismic survey equipment	Noise will be generated by the seismic survey array. The seismic source will comprise a source array with a volume ranging from 2,650 cubic inches (in^3) to 3,150 in^3 with an operating pressure of approximately 13,800 kPa (2,000psi). Acoustic propagation modelling is currently being completed to assess the potential impacts of the seismic survey source on fish, fish eggs and larvae, and benthic species such as crustaceans, bivalves, sponges and coral in line with the most recent and relevant peer reviewed literature.	- Noise modelling to inform potential impacts - Meeting with WAFIC in April to further discuss noise modelling and mitigation and management measures.

Email to Exmouth Community Reference Group – 2 April 2019

Woodside sent the email below and consultation Information Sheet below to members of the Exmouth Community Reference Group, a long-standing forum established by Woodside in 2002 to inform local community, industry and government stakeholders about its current and planned activities.

Dear Exmouth Community Reference Group

Woodside is planning to conduct a series of marine seismic surveys in three areas of Commonwealth waters in North West Australia, starting in Q4 2019 pending approvals, vessel availability and weather constraints.

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

Activity overview

Activity purpose:	All of the proposed seismic surveys are over areas where Woodside has previously acquired seismic data and are termed 'time lapse' or 4D surveys. Data acquired from these surveys will be important to help inform current and future reservoir management decisions.					
Activity:	Six marine seismic surveys in three Operational Areas: o **Area A** - Pluto 4D M2 and Harmony 4D M1 surveys o **Area B** - Scarborough 4D B1 survey o **Area C** - Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys					
	Area A		**Area B**	**Area C**		
	Pluto 4D M2	**Harmony 4D M1**	**Scarborough 4D B1**	**Laverda 4D M1**	**Cimatti 4D M1**	**Vincent 4D M2**
Distance from Acquisition Area to nearest port:	163 km north-west of Dampier	160 km north-west of Dampier	357 km north-west of Dampier	49 km north-west of Exmouth	47 km north-west of Exmouth	51 km north-west of Exmouth
Approximate water depth:	41 – 1,382 m	39 – 1,195 m	961 – 1,242 m	205 – 1,198 m	183 – 1,028 m	153 – 983 m
Earliest commencement date:	Q4 2019	Q1 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020
Estimated duration	28 days	20 to 23 days	45 days	12-13 days	11 days	23 days
Vessels:	Three project vessels, comprising the seismic vessel and up to two support and chase vessels, will be required for the surveys in Areas A and B. An additional source vessel may be required for surveys in Area C.					
Exclusion Zone:	A 500 m 'safe navigation area' will be in place around the primary vessel and streamers during seismic operations.					

Survey locations

Please refer to the Consultation Information Sheet attached.

Your feedback

Your feedback on the proposed activity and our response will be included in an Environment Plan for consideration by the National Offshore Petroleum Safety and Environmental Management Authority, as is required under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please provide your views by **3 May 2019** to allow us sufficient time to inform our planning for the proposed activity. Comments can be made by email, letter or by phone.

Notification will be provided to relevant marine users closer to the time of the proposed activity.

Please note under new public transparency arrangements being implemented by NOPSEMA, the Environment Plan for this activity will be published in full following acceptance by the Authority. Please advise Woodside if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan. The information received will form part of the EP assessment however it will not be released publicly and will remain confidential to NOPSEMA throughout.

Regards

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Email to WAFIC – 4 April 2019

Further to your conversation with [Redacted] last week please find below information on the meeting with yourself and relevant fishery licence holders on the proposed North-west Australia 4D seismic campaign from **10am - 12pm on 15 August** (and thank you for hosting the meeting).

Proposed meeting overview
The meeting is an opportunity for us to present on the activity and possible impact to relevant fisheries and seek feedback to be considered as part of the management and mitigation strategies for input into the EP. Based on your discussion with Dan we will address the points you have raised:

- Activity Overview (Location (map, latitude and longitudes), geophysical parameters, previous seismic surveys, survey details (timing, duration, water depth, area, distance to port/marina))
- Fisheries Maps
- Fisheries Licence Holders
- Fishery Considerations
- Potential Risks and mitigation
- Noise Modelling

I will provide you with a copy of the slide pack around a week in advance of the meeting for your consideration. I will also ensure there are the relevant Woodside representatives that attend the meeting.

Invitees

Based on our assessment of the Fishcube data, mapping and the State of Fisheries report we have identified the WA Mackerel Fishery – Pilbara (Area 2), Pilbara Line and Pearl Oyster Management Fishery as relevant licence holders and would like to invite them to the meeting.

I have email addresses for the Pilbara Line Fishery, and Aaron at Pearl Producers but do not have email addresses or phone numbers for those licence holders who fish in Area 2 of the WA Mackerel Fishery.

I have requested this information from DPIRD but unfortunately they do not have this information either. I understand there are about 16 of 48 licence holders who fish in this area. I have asked DPIRD if they can identify who these 16 licence holders are.

On receipt of this it would be greatly appreciated if you are able to assist in providing their contact details (if you have them), or advise of the most appropriate means of contacting them, excluding postal addresses?

Obviously not wanting to place the burden on you to invite them but any assistance to ensure they are engaged and have an opportunity to consider and comment would be great.

Thanks

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Email to Pilbara Line and Pilbara Trap fishery licence holders – 4 April 2019

Good afternoon Pilbara Line Fishery Licence Holders

Woodside would like to invite you to a meeting to consider and provide your feedback on our proposed NW Australia 4D Seismic Campaign.

Earlier this week I sent you an information sheet (attached) on the activity as well as analysis on specific risks to fisheries and mitigation and management strategies.

In addition to the information sheet we would like to offer a meeting to present further information on the activity and how potential risks to fisheries will be managed, including taking into account your feedback. Your feedback will be included as part of the Environment Plan for this activity.

We have analysed DPIRD's Fishcube data and the State of the Fisheries reports and have identified the Pilbara Line Fishery as actively fishing over Area A and Area C of the proposed campaign. We will also invite WAFIC, WA Mackerel Licence Holders – Pilbara Area 2, and the Pearl Producers Association to the meeting.

Meeting details
Location: WAFIC office: Level 1/56 Marine Terrace in Fremantle.
Date: 15 April 2019
Time: 10am – 12pm

Lunch will be provided following the meeting.

Proposed agenda

We will provide you with the meeting presentation around a week prior to the meeting which will include:

- Activity Overview (Location (map, latitude and longitudes), geophysical parameters, previous seismic surveys, survey details (timing, duration, water depth, area, distance to port/marina))
- Fisheries Maps
- Fisheries Licence Holders
- Fishery Considerations
- Potential Risks and mitigation
- Noise Modelling

RSVP
Please let me know if you would interested in attending the meeting via response email.

If you're unable to attend in person a teleconference number will be provided.

Should you have any questions prior to the meeting, or about the proposed seismic activity please let me know.

Thanks

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Email to DPIRD – 4 April 2019

As discussed on Wednesday we would really like to create a single point of reference for industry to understand habitat and life history information etc for key commercial species and look forward to hearing your thoughts on how best to do this.

However in the interim we have a seismic EP with some fairly urgent timeframes that I was hoping we could inform by simply populating the attached spreadsheet?

We've made a quick start and I was wondering if I could possibly sit down with yourself or maybe [name supplied] next Monday to populate. Alternatively feel free to have a play with it and send something back?

Please give me a call if you want to discuss.

Thanks

[Redacted]
Environment Adviser | HSEQ
Woodside Energy Ltd

Email to Pilbara Line and Pilbara Trap fishery licence holders – 18 April 2019

Dear Licence Holder,

Following our previous email of 1 April 2019, please find attached further information on Woodside's proposed North West Australia Marine Seismic Survey scheduled to commence in Q4 2019.

This information includes a summary of the possible temporal and spatial spawning impacts to key indicator fish species within the Pilbara Line, Pilbara Trap, and Mackerel fisheries. This information is based on spawning depth information sourced from the Department of Primary Industries and Regional Development. We have also updated the fishery risk and mitigation and management measure table to include noise modelling results.

We welcome any feedback you may have by email, letter or phone by 10 May 2019.

Under new public transparency arrangements being implemented by NOPSEMA, the Environment Plan for this activity will be published in full following acceptance by the Authority. Please advise Woodside if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan, which will remain confidential to NOPSEMA.

The consultation information sheet on the proposed activity is available on the Woodside website at https://www.woodside.com.au/sustainability/transparency/consultation-activities

Yours sincerely

[Redacted]
Graduate | Corporate Affairs
Woodside Energy Ltd

Email to WAFIC – 18 April 2019

Further to earlier emails / discussions, please find attached some further information on the proposed North West Australia 4D seismic campaign which we have sent to licence holders today.

This information includes a matrix of the possible temporal and spatial spawning impacts to key indicator fish species within the Pilbara Line, Pilbara Trap, and Mackerel fisheries. This information is based on spawning depth information sourced from the Department of Primary Industries and Regional Development. We have also updated the fishery risk and mitigation and management measure table to include noise modelling results.

We welcome any feedback you may have, including whether you think a meeting with yourself and interested licence holders is required to discuss anything in further detail.

As per the new NOPSEMA transparency measures, please advise us if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan, which will remain confidential to NOPSEMA.

The consultation information sheet on the proposed activity is available on the Woodside website at https://www.woodside.com.au/sustainability/transparency/consultation-activities.

Have a happy and safe Easter break.

[Redacted]

Corporate Affairs Manager | Operations
Woodside Energy Ltd

Email to DNP – 2 May 2019

Woodside is planning to conduct a series of marine seismic surveys in three areas of Commonwealth waters in North West Australia, starting in Q4 2019 pending approvals, vessel availability and weather constraints.

A small portion of the Area A and Area C Operational Areas overlap the Montebello Marine Park Multiple Use Zone and the Gascoyne Marine Park Multiple Use Zone. Acoustic emissions from the seismic survey activities have the potential to impact marine park values. In unlikely event of a hydrocarbon release there is risk of hydrocarbons entering the Montebello or Gascoyne Marine Parks. Potential impacts of acoustic emissions and hydrocarbon releases on the values of the marine park and proposed control measures are outlined in the attached impact assessment sheet. The Operational Area is also adjacent to the Ningaloo Coast World Heritage Property and we have provided information relevant to this area.

We appreciate you may have some queries about the assessment and the outputs of the noise modelling and would be happy to arrange a discussion to provide any further clarity required.

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

Activity Information

Activity purpose:	All of the proposed seismic surveys are over areas where Woodside has previously acquired seismic data and are termed ‘time lapse’ or 4D surveys. Data acquired from these surveys will be important to help inform current and future reservoir management decisions.					
Activity:	Six marine seismic surveys in three Operational Areas: o **Area A** - Pluto 4D M2 and Harmony 4D M1 surveys o **Area B** - Scarborough 4D B1 survey o **Area C** - Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys					
	Area A		**Area B**	**Area C**		
	Pluto 4D M2	**Harmony 4D M1**	**Scarborough 4D B1**	**Laverda 4D M1**	**Cimatti 4D M1**	**Vincent 4D M2**
Distance from Acquisition Area to nearest port:	163 km north-west of Dampier	160 km north-west of Dampier	357 km north-west of Dampier	49 km north-west of Exmouth	47 km north-west of Exmouth	51 km north-west of Exmouth
Approximate water depth:	41 – 1,382 m	39 – 1,195 m	961 – 1,242 m	205 – 1,198 m	183 – 1,028 m	153 – 983 m
Earliest commencement date:	Q4 2019	Q1 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020
Estimated duration	28 days	20 to 23 days	45 days	12-13 days	11 days	23 days

Vessels:	Three project vessels, comprising the seismic vessel and up to two support and chase vessels, will be required for the surveys in Areas A and B. An additional source vessel may be required for surveys in Area C.
Exclusion Zone:	A 500 m 'safe navigation area' will be in place around the primary vessel and streamers during seismic operations.

Your feedback
Your feedback on the proposed activity and our response will be included in an Environment Plan for consideration by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), as is required under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please note under new public transparency arrangements being implemented by NOPSEMA, the Environment Plan for this activity will be published in full following acceptance by the Authority and subject to a 30 day public comment period. Please advise Woodside if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan. The information received will form part of the EP assessment however it will not be released publicly and will remain confidential to NOPSEMA throughout.

Please provide your views by close of business **30 May 2019** to allow us sufficient time to inform our planning for the proposed activity. Comments can be made by email, letter or by phone.

Regards

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Email to DNP – 6 May 2019

Woodside recently sent consultation regarding the North-west 4D Seismic Survey Environment Plan, dated 2nd May 2019. In that consultation we note that the Commonwealth Ningaloo Marine Park was excluded from our impact assessment table.

Please find attached impact assessment for Ningaloo Marine Park. There are no additional control measures proposed therefore will remain the same as consultation information issued on 2 May 2019.

Regards

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Designated Values	Potential Impacts to Australian Marine Park Conservation Values
Continental slope demersa l fish communities K	Minimum water depths in areas of KEF overlapped by the Acquisition Areas are ~280 m. Maximum predicted received sound levels at, or close to, the seafloor at this water depth do not exceed the injury or TTS thresholds for all hearing groups of fishes,

ey Ecological Feature (KEF)	or for fish eggs and larvae. Behavioural responses will only occur within tens of metres of the seismic source. Therefore, any impacts to demersal fish communities at, or close to, the seafloor are highly unlikely to occur.
Canyons linking Cuvier AbyssalPlain and Cape Range Peninsula KEF	Minimum water depths in areas of KEF overlapped bythe Acquisition Areasare ~360 m. Maximum predictedreceived sound levels at, or close to, the seafloor atthis water depth do not exceed the injury or TTS thresholds for all hearing groups of fishes, or for fish eggs and larvae. Behavioural responses will only occur within tens ofmetres of the seismic source. Therefore, impacts to site-attached fish communities or benthic invertebrates on the seafloor will not occur. Area of overlap between the KEF and the Acquisition Areas for the Laverda, Cimatti and Vincent surveys is~218 km^2, which represents ~4.0% of the designated area of the KEF.
Commonwealth waters adjacent toNingaloo Reef KEF	No overlap between the Laverda, Cimatti and Vincent Acquisition Areas and the KEF. Maximum predicted receivedsound levels at the boundary of the KEF are ~136 dB re 1 µPa (SPL), which is below the TTS thresholds forcetaceans and turtles, and well below the behavioural thresholds for cetaceans (160 dB re 1 µPa [SPL]), or turtles (166 dB re 1 µPa [SPL]). Therefore, no impacts are predicted to occur to cetaceans, turtles or whale sharks within the KEF.
Humpback whale migration Biologically Important Area (BIA)	Not relevant due to timing of the activity
Pygmy blue whale migration BIA	Potential overlap between the acquisition of the Cimatti and Vincent surveys and the commencement of thenorthbound migration. PTS threshold for pygmy blue whales may be exceeded out to maximum distance of 2.14 km from nearest seismic line, and TTS threshold out to maximum distance of 55.2 km. These impact ranges are based on the cumulativeSEL_{24h} metric, and therefore PTS and TTS would only occur if individuals remained within these ranges of theoperating seismic source for the full 24 hour duration, which is extremely unlikely to occur. Area of overlap between the Acquisition Areas and the BIA is ~285 km^2, which represents <0.1% of the overall area ofthe BIA. Impacts are likely to be restricted to temporary behavioural changes (avoidance) in individuals movingnorth during the commencement of the northbound migration.
Pygmy blue whale possible foraging BIA	Potential overlap between the acquisition of the Cimatti and Vincent surveys and the commencement of thenorthbound migration and opportunistic foraging within the BIA . Based on a maximum predicted range to PTS effects of ~2 km, and there is no potential for impact occurring to whales present within the BIA during acquisition of the Cimatti and Vincent surveys. Based on the application of thecetacean behavioural threshold there is no potential for behavioural effects occurring to whales present within theBIA during acquisition of the Cimatti and Vincent surveys. Maximum predicted distance to the TTS thresholds for pygmy blue whales is 47.2 km from the nearest survey line inthe Cimatti Acquisition Area, based on application of the SEL_{24h} threshold. The area of overlap between the ≥168dB re 1 $\mu Pa^2 \cdot s$ (SEL_{24h}) isopleths and the northern portion of the possible foraging BIA is approximately 200 km^2,which represents ~2% of the overall area of the BIA. An individual whale would have to remain within a range of47.2 km of the operating seismic source for a full 24 hour period to be exposed to sound levels that could causeTTS. Impacts are likely to be restricted to temporary behavioural changes (avoidance) in individuals movingnorth during the commencement of the northbound migration.
Flatback turtle 'Habitat Critical'	The Cimatti and Vincent surveys are planned to be acquired outside peak periods for turtle nesting and breeding. The Laverda survey may overlap peak periods for breeding or nesting periods for turtles in the region. Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Receivedsound levels at

	the boundary of the Habitat Critical will not exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are likely to occur to flatback turtles within the Habitat Critical during acquisition of the Laverdasurvey.
Green & logge rhead turtle 'H abitat Critical'	The Laverda survey may overlap peak periods for breeding or nesting periods for turtles in the region. The Laverdasurvey may overlap the peak nesting period for green turtles in the region (Jan-Feb). Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Receivedsound levels at the boundary of the Habitat Critical will not exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are likely to occur to green turtles within the Habitat Critical during acquisition of t he Laverdasurvey.
Green turtle int ernesting BIA	The Laverda survey may overlap peak periods for breeding or nesting periods for turtles in the region. The Laverdasurvey may overlap the peak nesting period for green turtles in the region (Jan-Feb). Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Receivedsound levels at the boundary of the internesting BIA will not exceed the 166 dB re 1 µPa SPL behavioural threshold criterion. Therefore, no impacts are likely to occur to green turtles within the BIA during acquisition of the Laverda survey.
Hawksbill & lo ggerhead turtl e internestingB IA	The Laverda survey may overlap peak periods for breeding or nesting periods for turtles in the region. The Laverdasurvey may overlap the peak nesting period for green turtles in the region (Jan-Feb). Injury (PTS) or TTS effects will only occur within very close range of the seismic source (<20 m). Receivedsound levels at the boundary of the internesting BIA will not exceed the 166 dB re 1 µPa SPL behaviouralthreshold criterion. Therefore, no impacts are likely to occur to hawksbill or loggerhead turtles within the BIA during acquisit ion of theLaverda survey.
Whale shark foraging (high density prey)BI A	It is possible that whale sharks may be present in Area C during the acquisition of the Laverda, Cimatti and Vincent surveys. Injury effects will only occur within very close range of the seismic source (<60 m). TTS effects could occurout to ~2.5 km from the source. Given the ranges to behavioural and TTS impacts, there is no likelihood of any effects occurring to whal esharks aggregating at Ningaloo Reef within the BIA at the start of the aggregation season in March.

Email to DBCA, Parks and Wildlife Service – 3 May 2019

Woodside is planning to conduct a series of marine seismic surveys in three areas of Commonwealth waters in North West Australia, starting in Q4 2019 pending approvals, vessel availability and weather constraints.

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website. The Operational Area for Area C is adjacent to the Ningaloo Coast Marine Park and we have attached information relevant to this area.

Activity Information

Activity purpose:	All of the proposed seismic surveys are over areas where Woodside has previously acquired seismic data and are termed 'time lapse' or 4D surveys. Data acquired from these surveys will

	be important to help inform current and future reservoir management decisions.					
Activity:	Six marine seismic surveys in three Operational Areas: o **Area A** - Pluto 4D M2 and Harmony 4D M1 surveys o **Area B** - Scarborough 4D B1 survey o **Area C** - Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys					
	Area A		**Area B**	**Area C**		
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Distance from Acquisition Area to nearest port:	163 km north-west of Dampier	160 km north-west of Dampier	357 km north-west of Dampier	49 km north-west of Exmouth	47 km north-west of Exmouth	51 km north-west of Exmouth
Approximate water depth:	41 – 1,382 m	39 – 1,195 m	961 – 1,242 m	205 – 1,198 m	183 – 1,028 m	153 – 983 m
Earliest commencement date:	Q4 2019	Q1 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020	Q1-Q2 2020
Estimated duration	28 days	20 to 23 days	45 days	12-13 days	11 days	23 days
Vessels:	Three project vessels, comprising the seismic vessel and up to two support and chase vessels, will be required for the surveys in Areas A and B. An additional source vessel may be required for surveys in Area C.					
Exclusion Zone:	A 500 m 'safe navigation area' will be in place around the primary vessel and streamers during seismic operations.					

Your feedback
Your feedback on the proposed activity and our response will be included in an Environment Plan for consideration by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), as is required under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please note under new public transparency arrangements being implemented by NOPSEMA, the Environment Plan for this activity will be published in full following acceptance by the Authority and subject to a 30 day public comment period. Please advise Woodside if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan. The information received will form part of the EP assessment however it will not be released publicly and will remain confidential to NOPSEMA throughout.

Please provide your views by close of business **30 May 2019** to allow us sufficient time to inform our planning for the proposed activity. Comments can be made by email, letter or by phone.

Regards

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

Insert DBCA, Parks and Wildlife Service impact assessment sheet

Email to DAWR – 10 May 2019

Dear Department of Agriculture and Water Resources

Woodside is planning to conduct a series of marine seismic surveys in three areas of Commonwealth waters in North West Australia, starting in Q4 2019 pending approvals, vessel availability and weather constraints.

A Consultation Information Sheet is attached, which provides background on the proposed activity, including a summary of potential key risk and associated management measures. The Information Sheet is also available on our website.

Maps of Commonwealth fisheries relevant to the proposed activities are also attached.

Activity overview

Activity purpose:	All of the proposed seismic surveys are over areas where Woodside has previously acquired seismic data and are termed 'time lapse' or 4D surveys. Data acquired from these surveys will be important to help inform current and future reservoir management decisions.
Activity:	Six marine seismic surveys in three Operational Areas: o **Area A** - Pluto 4D M2 and Harmony 4D M1 surveys o **Area B** - Scarborough 4D B1 survey o **Area C** - Laverda 4D M1, Cimatti 4D M1 and Vincent 4D M2 surveys

	Area A		**Area B**	**Area C**		
	Pluto 4D M2	**Harmony 4D M1**	**Scarborough 4D B1**	**Laverda 4D M1**	**Cimatti 4D M1**	**Vincent 4D M2**
Distance from Acquisition Area to nearest port:	163 km north-west of Dampier	160 km north-west of Dampier	357 km north-west of Dampier	49 km north-west of Exmouth	47 km north-west of Exmouth	51 km north-west of Exmouth
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Estimated duration	28 days	20 to 23 days	45 days	12-13 days	11 days	23 days

Vessels:	Three project vessels, comprising the seismic vessel and up to two support and chase vessels, will be required for the surveys in Areas A and B. An additional source vessel may be required for surveys in Area C.
Exclusion Zone:	A 500 m ‘safe navigation area’ will be in place around the primary vessel and streamers during seismic operations.

Survey locations

Please refer to the Consultation Information Sheet attached.

Your feedback

Your feedback on the proposed activity and our response will be included in an Environment Plan for consideration by the National Offshore Petroleum Safety and Environmental Management Authority, as is required under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth).

Please provide your views by **30 May 2019** to allow us sufficient time to inform our planning for the proposed activity. Comments can be made by email, letter or by phone.

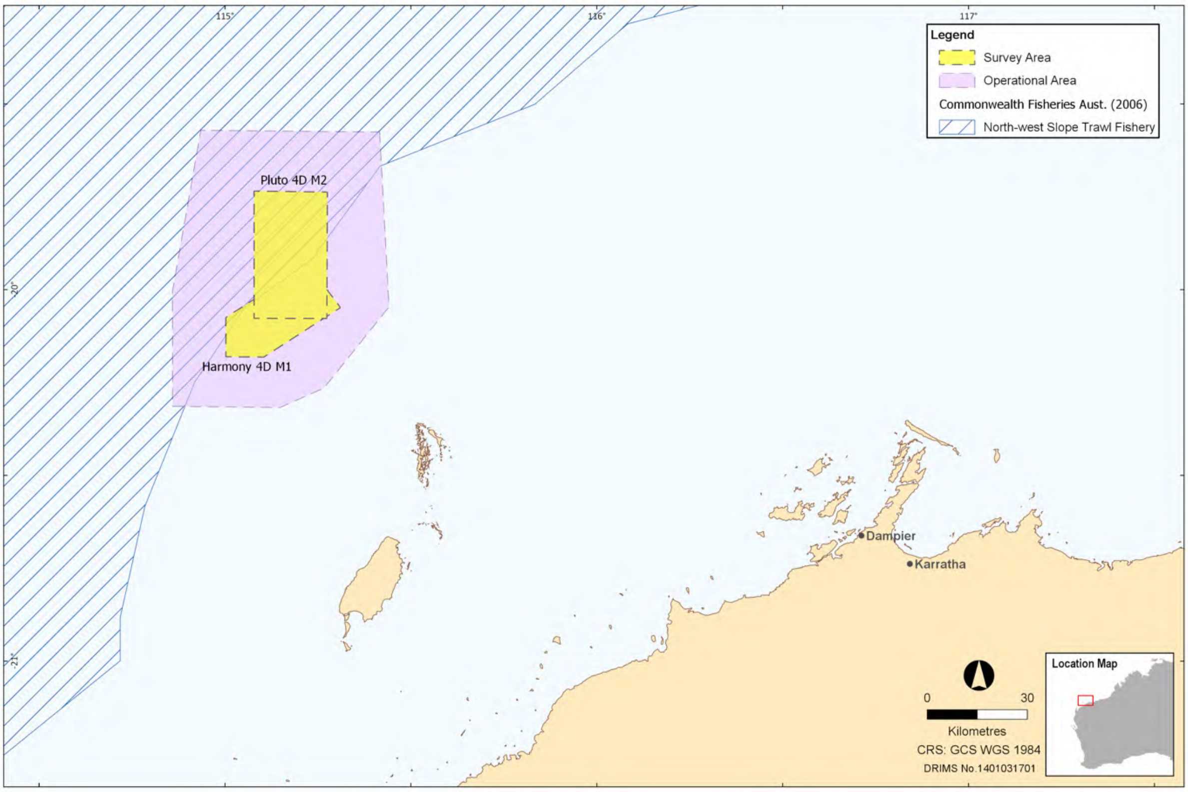
Notification will be provided to relevant marine users closer to the time of the proposed activity.

Please note under new public transparency arrangements being implemented by NOPSEMA, the Environment Plan for this activity will be published in full following acceptance by the Authority. Please advise Woodside if you do not wish any part of your feedback to be published and we will ensure it is included in the sensitive information part of the Environment Plan. The information received will form part of the EP assessment however it will not be released publicly and will remain confidential to NOPSEMA throughout.

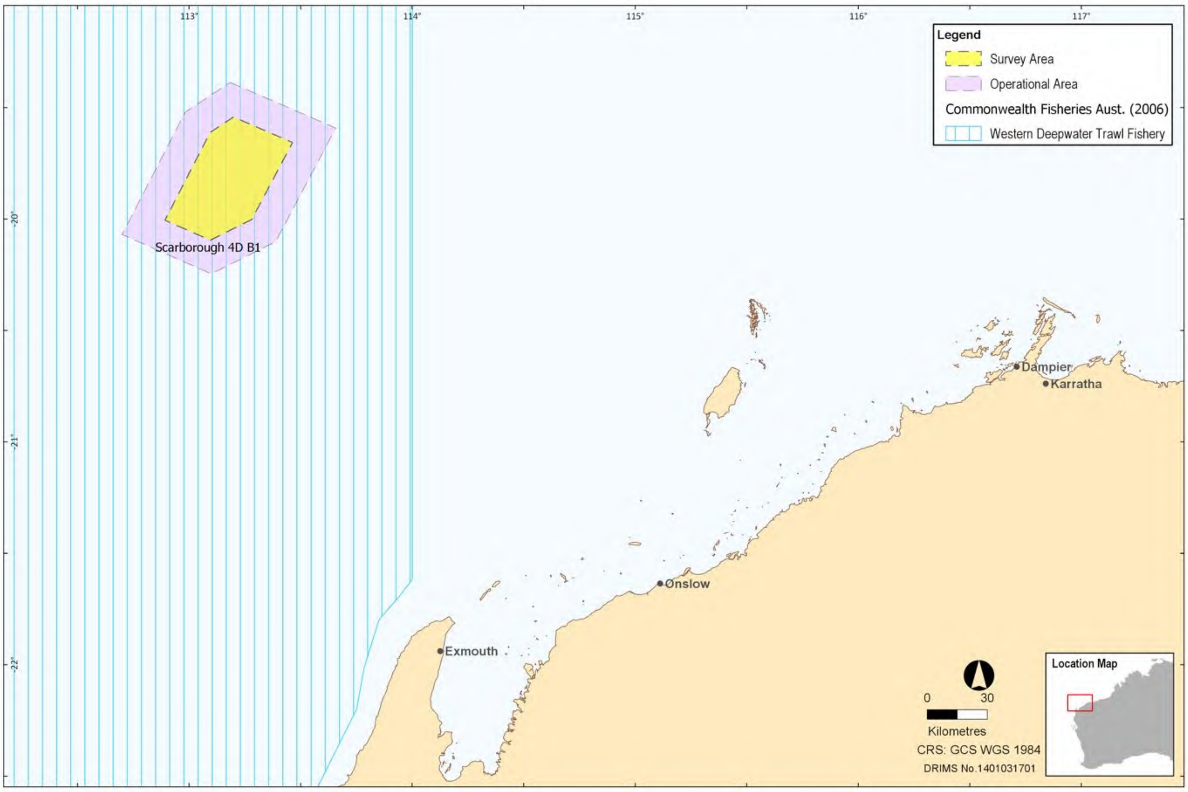
Regards

[Redacted]
Corporate Affairs Adviser | Corporate Affairs
Woodside Energy Ltd

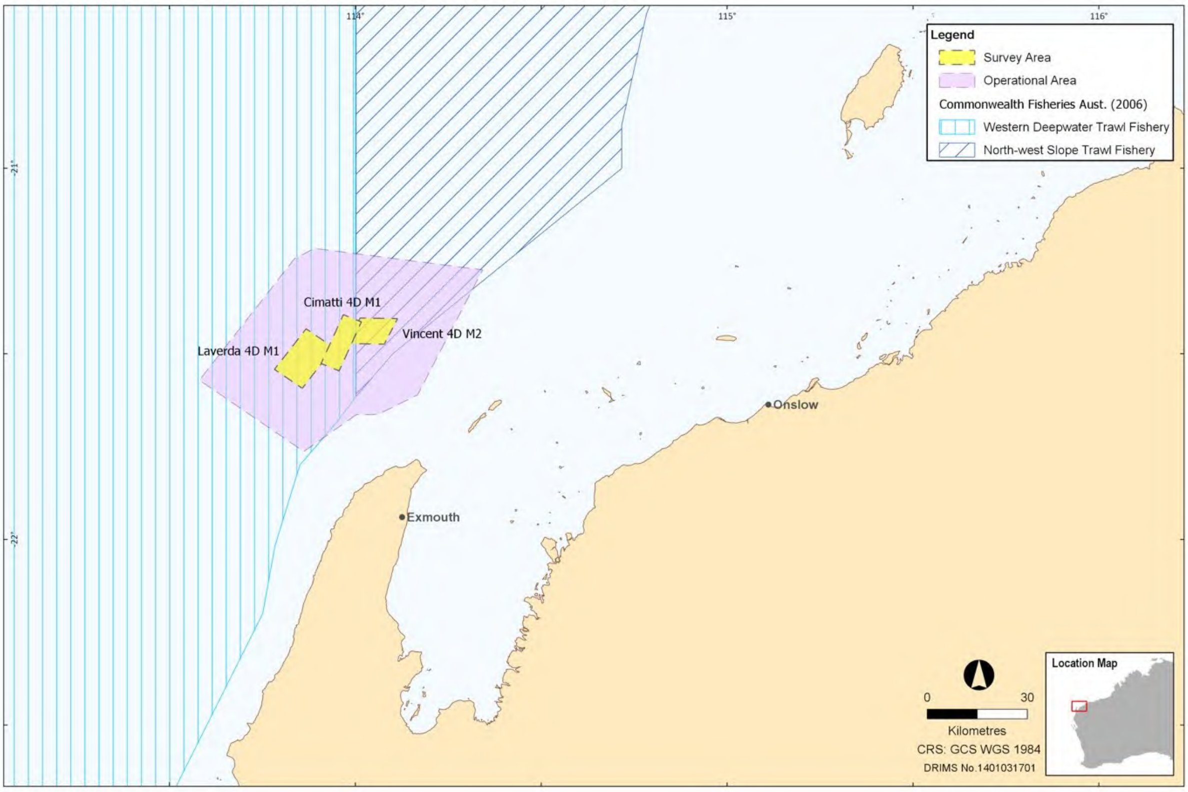
Commonwealth Fishery map for Area A provided to AFMA, DAWR and CFA



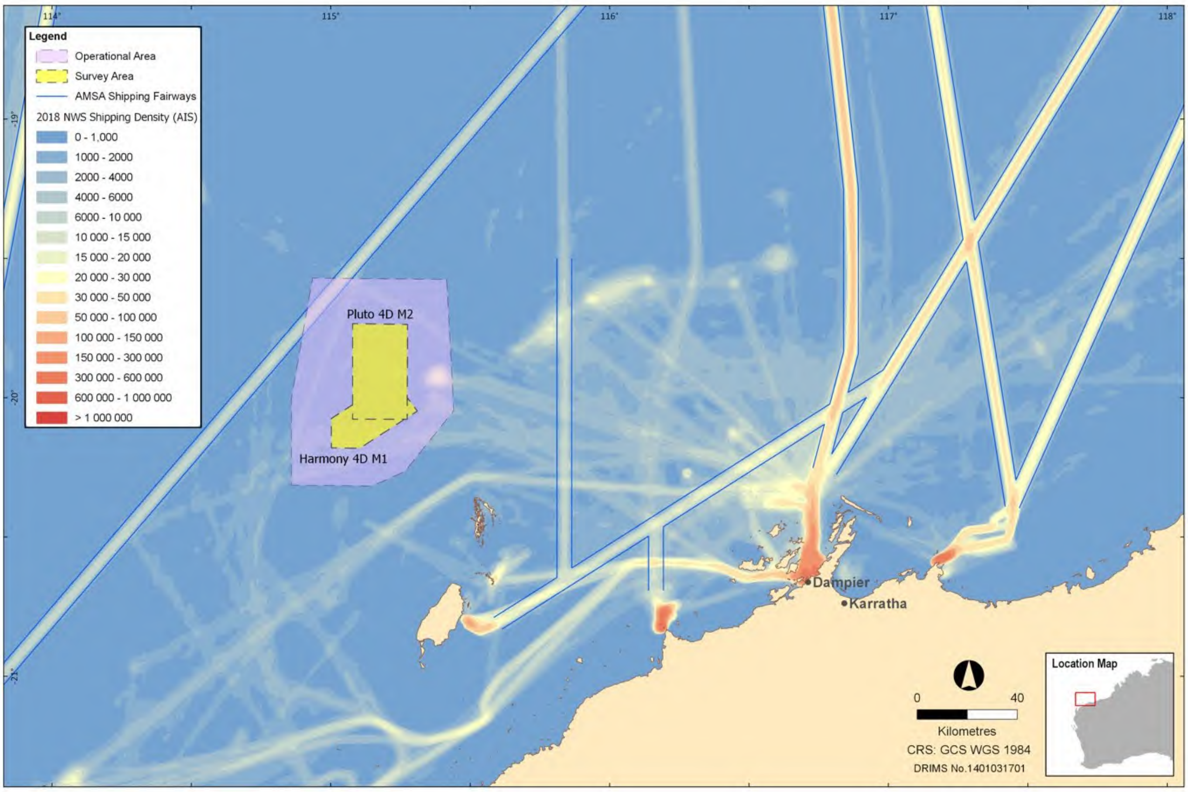
Commonwealth Fishery map for Area B provided to AFMA, DAWR and CFA



Commonwealth Fishery map for Area A provided to AFMA, DAWR and CFA

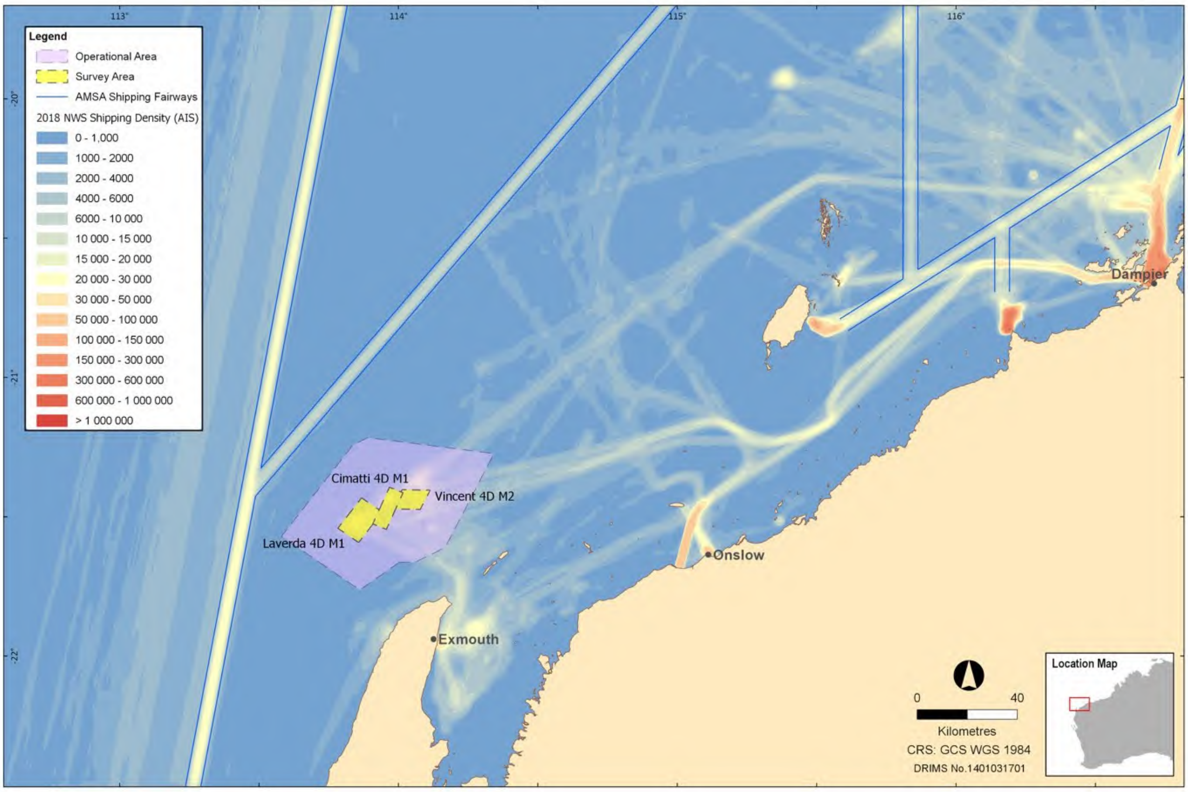


Shipping lane map for Area A provided to AMSA and AHO

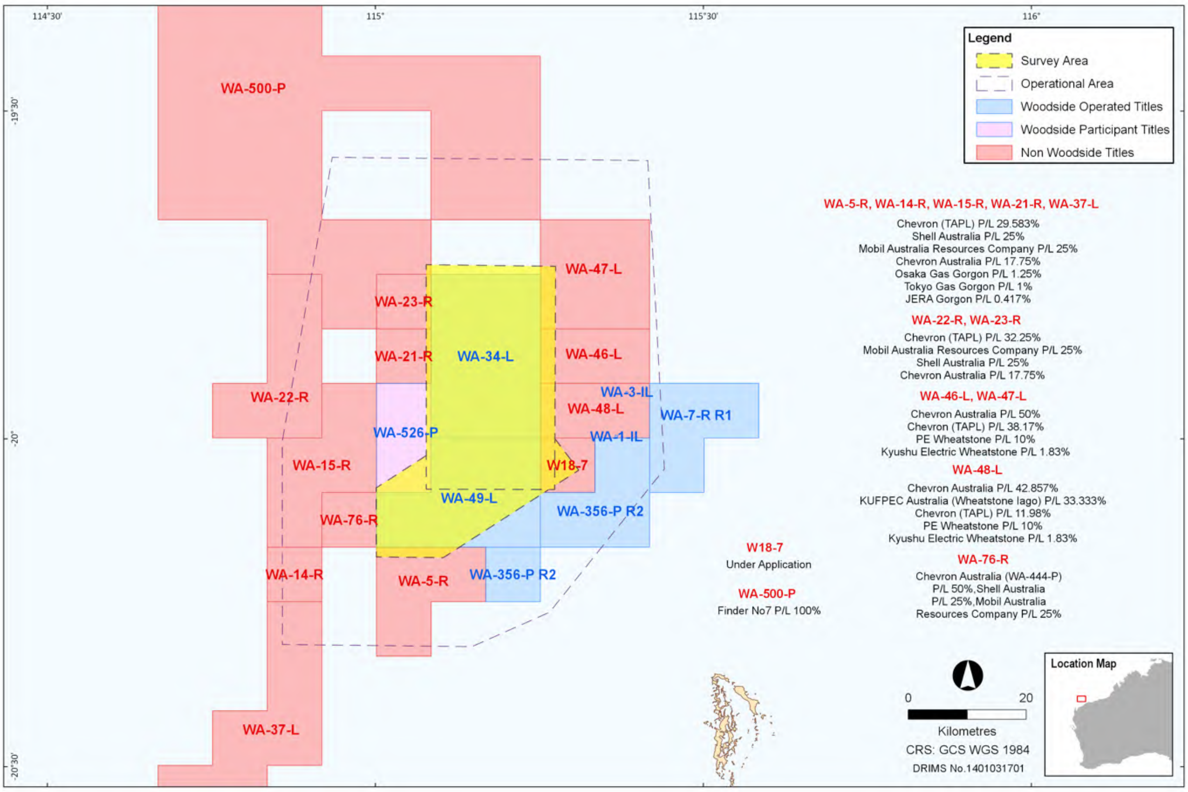


Shipping lane map for Area B provided to AMSA and AHO

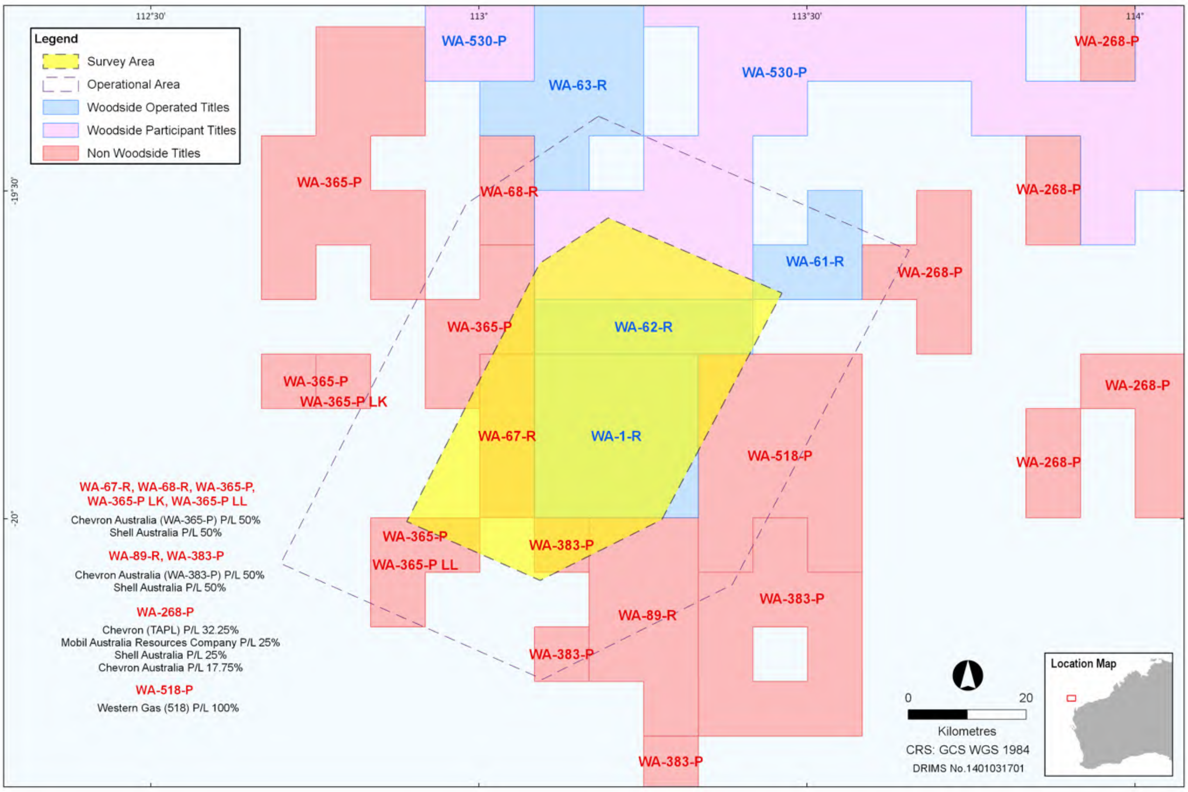
Shipping lane map for Area C provided to AMSA and AHO



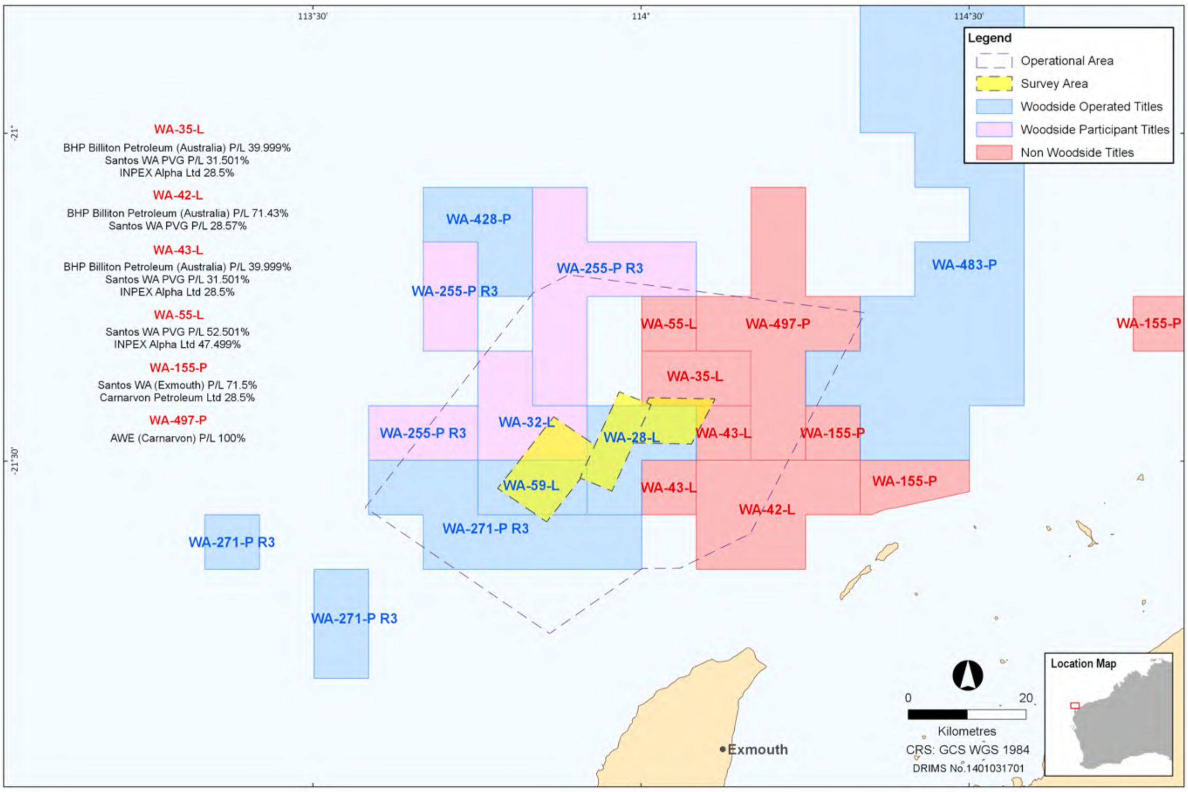
Map of Area A provided to Chevron



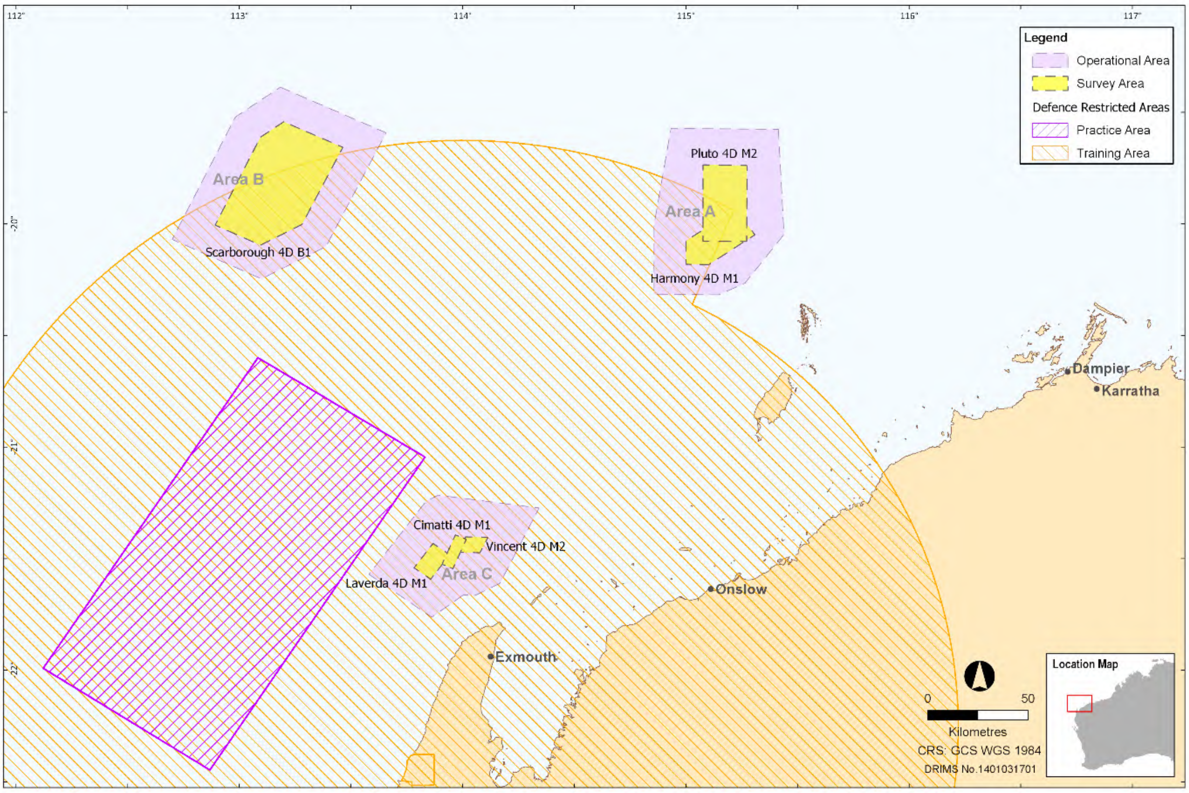
Map of Area B provided to Chevron and Western Gas



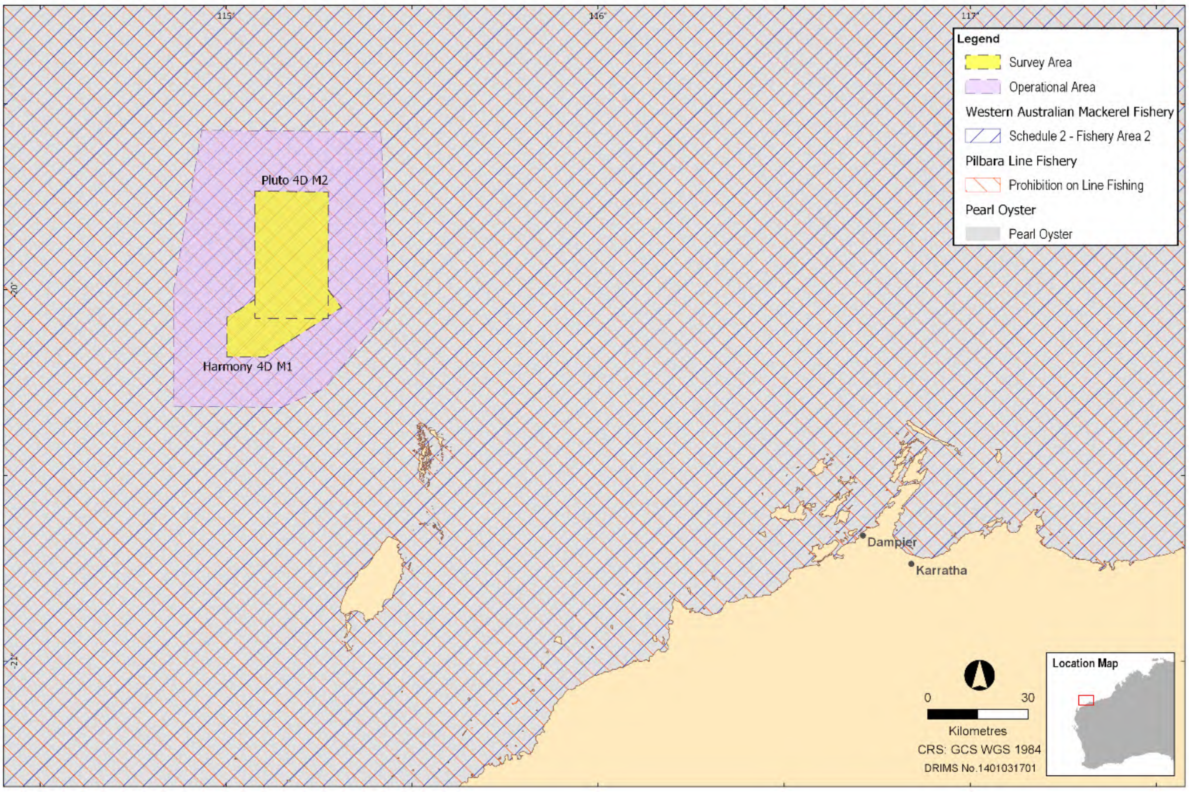
Map of Area C provided to BHP, Chevron and Santos

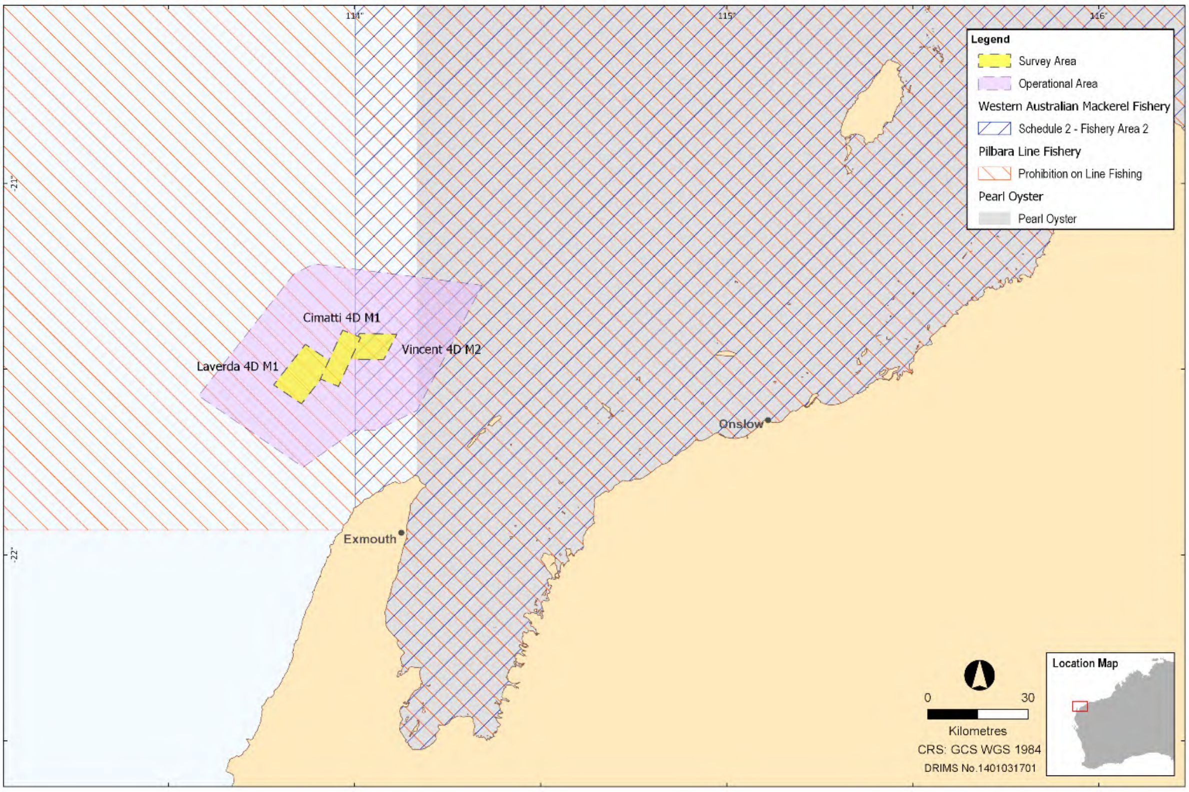


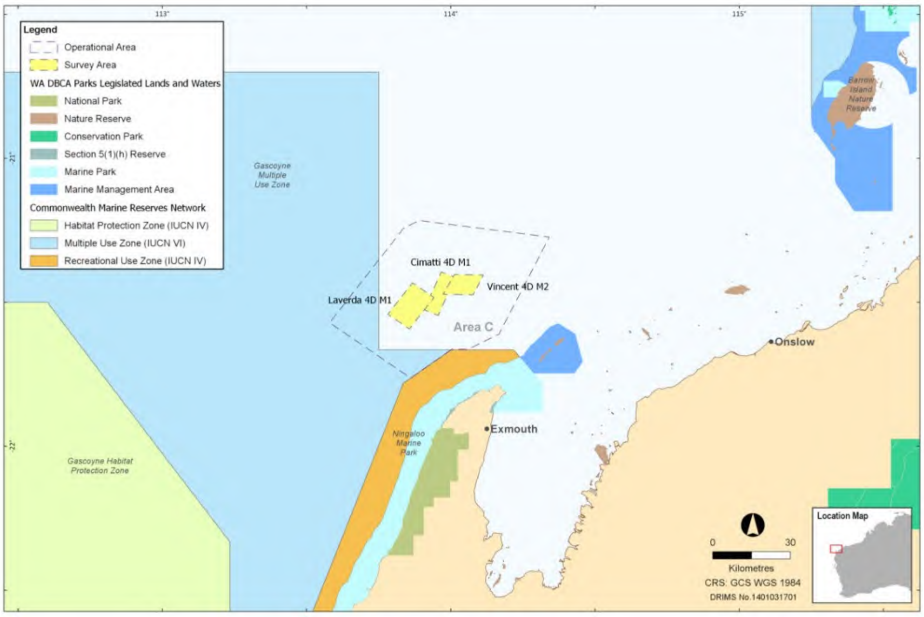
Map of Areas A, B and C provided to DoD



State Fishery maps provided to DPIRD, WAFIC, PPA, Recfishwest and fishing licence holders







Presentation slides provided to WAFIC and relevant State Fishery licence holders – 18 April 2019

Oil Pollution Consultation

Woodside sent the emails below to stakeholders with responsibilities for oil pollution response in Commonwealth and State waters.

Email to DoT – 3 May 2019

Good afternoon

Just following up my voice messages with email.

Please can you call me at your convenience this afternoon, or I'd be happy to arrange a time early next week.

I'd like to briefly discuss the changes to modelling for a proposed NW 4D seismic campaign and DoT consultation period.

Many thanks,

[Redacted]
Hydrocarbon Spill Adviser | Security & Emergency Management
Woodside Energy Ltd

Email to DoT – 8 May 2019

As part of Woodside's ongoing consultation for its current and planned activities, I would like to advise Woodside is preparing an Environment Plan (EP) for the North-West Australia 4D Seismic Campaign.

The proposed petroleum activities program is a series of marine seismic surveys in three areas of Commonwealth waters in north-west Australia starting in Q4 2019 pending approvals, vessel availability and weather constraints.

A Consultation Information Sheet is attached, providing information on the proposed activity. The Information Sheet is available on our website.

Information as requested in the Offshore Petroleum Industry Guidance Note (September 2018) is presented in the table below.

In accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cth), Woodside will submit an EP in May to support these activities.

As part of this approval submission Woodside has drafted an Oil Pollution First Strike Plan. Therefore I would like to offer you the opportunity to review or provide comment on the prepared DRAFT (attached).

Should you require additional information or have a comment to make about the proposed activity, please contact myself by close of business on 29 May to allow us sufficient time to inform our activity planning and EP development. Comments can be made by email, letter or by phone.

Please be aware that your feedback will be communicated to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), as is required under legislation.

We look forward to hearing from you.

Kind Regards
[Redacted]

[redacted]	
Description of activity, including the intended schedule, location (including coordinates), distance to nearest landfall and map.	Woodside proposes to conduct seismic acquisition in three survey areas in Commonwealth waters off north-west Australia from December 2018 to July 2019. The acquisition time across the three survey areas is approximately 45 days. Additional information on the activity, timings, location (including coordinates) and planned and unplanned activities is included in the consultation information sheet.
Worst case spill volumes.	Included in Appendix A of the First Strike Response Plan, that has been assessed as 190m3 Marine Diesel oil.
Known or indicative oil type/properties.	Included in Appendix A of the First Strike Response Plan, this is Diesel Fuel Oil (Southern USA 1) API of 37.2.

Amenability of oil to dispersants and window of opportunity for dispersant efficacy.	Included in Section 5 of the First Strike Response Plan, Dispersant use have been assessed as not feasible for the North-West 4D Marine Seismic Survey.
Description of existing environment and protection priorities.	Included in Section 4 of the First Strike Plan, the Receptors for Priority Protection are: Ningaloo Coast North, 14.2 km south from spill release location; and Ningaloo Coast North (World Heritage Area (WHA), 200m south.
Details of the environmental risk assessment related to marine oil pollution - describe the process and key outcomes around risk identification, risk analysis, risk evaluation and risk treatment. For further information see the Oil Pollution Risk Management Information Paper (NOPSEMA 2017).	The credible spill scenarios have been identified and assessed for the North-West 4D Marine Seismic Survey activity using Woodside's Oil Spill Preparedness and Response Mitigation Assessment (OPSRMA) template to ensure the assessment undertaken for the activities are done in a thorough and consistent manner. This response planning process is aligned with guidance provided by NOPSEMA in Guideline N004750-GL1687 (2016) and the Offshore Petroleum and Greenhouse Gas Storage Act and Regulations, that compel titleholders to reduce risks and impacts to a level that is ALARP and Acceptable. The risk assessment established the type of oil, volume and duration, predicted fate and weathering. This information is then used to inform the environment that may be affected (EMBA), time to impact on identified values and sensitivities, and predicted volumes ashore. Five credible spill scenarios were assessed for oil pollution risks, all related to loss of Marine Diesel via errant vessel collision, bunkering and bulk transfer hose failure. The maximum volume assessed was 190m 2 due to (i) breach of seismic vessel fuel tanks due to collision with support vessel and (ii) breach of fuel tanks due to project vessel-other vessel collision including (commercial shipping/ fisheries).
Outcomes of oil spill trajectory modelling, including predicted times to enter State waters and contact shorelines.	The volatile fractions of the marine diesel oil (approximately 45%) is predicted to evaporate within 24 hours of exposure to the atmosphere. The low volatility fraction of the oil (approximately 54%) will take longer times to evaporate, and may persist for an extended period as residual oil. Only a small proportion of the oil is expected to be floating on the water surface (<1%) after 24 hours , and the residual components will tend to remain entrained beneath the surface (approximately 35%). Minimum time to contact receptors at Ningaloo Coast North and Ningaloo Coast North (World Heritage Area) for shoreline oil >100g/m 2 is 23 hrs. The maximum accumulated volume at Ningaloo Coast North and Ningaloo Coast North (World Heritage Area) for shoreline oil >100g/m 2 is 40m3.

Details on initial response actions and key activation timeframes.	Included in Section 2 and 3 of the First Strike Plan, Table 1-1 describes Immediate Notifications, including to WA DoT Duty Manager as s soon as practicable or if spill is likely to extend into WA State waters, and the mobilization of response strategies.
Potential Incident Control Centre arrangements.	Included in Appendix E and F of the First Strike Plan,
Potential staging areas / Forward Operating Base.	Woodside has access to the Harold E Hold Naval Base and jetty in Exmouth that can be used for immediate and sustained operational response.
Details on response strategies.	Included in Section 2 and 3 of the First strike Plan, the response strategies and pre-identified tactics assessed as being suitable for Marine diesel spill are Monitor and Evaluate (Operational Monitoring), using the following pre-identified tactics: Predictive Modelling of Hydrocarbons to Assess Resources at Risk (OMO1), Pre-emptive Assessment of Sensitive Receptors (OMO4), and Shoreline Assessment (OMO5).
Details and diagrams on proposed IMT structure including integration of DoT arrangements as per this IGN.	Included in Appendix E and F of the First Strike Plan, these arrangements are consistent across Woodside's petroleum activities and approach to incident coordination and management with DoT.
Details on testing of arrangements of OPEP/OSCP.	1 x oil spill response themed level 1 drill to be conducted at Area C (date still to be finalised, likely no later than two weeks of arrival on site). This drill should test elements of the recommended response identified in the North-West Australia 4D Marine Seismic Survey Oil Pollution First Strike Plan in relation to the level of the incident. 1x crisis oil spill response focused exercise annually. Testing of Oil Spill Response Arrangements There are a number of arrangements which in the event of a spill will underpin Woodside's ability to implement a response across its petroleum activities. In order to ensure each of these arrangements is adequately tested, the HSP Capability and Competency Coordinator ensures tests are conducted in alignment with the Hydrocarbon Spill Arrangements Testing Schedule (Woodside Doc No. 10058092). Woodside's Hydrocarbon Spill Preparedness & Response Testing Schedule aligns with international good practice for spill preparedness & response management; the testing is compatible with the IPIECA Good Practice Guide and the Australian Emergency Management Institute Handbook. The Hydrocarbon Spill Arrangements Testing Schedule (Woodside Doc No. 10058092) identifies the type of test which will be conducted annually for each arrangement, and how this type will vary over a five year rolling schedule. Testing methods may

	include (but are not limited to): audits, drills, field exercises, functional workshops, assurance reporting, assurance monitoring and reviews of key external dependencies. Activity specific Oil Spill Pollution First Strike Plans are developed to meet the response needs of that particular activity's Worst Credible Spill Scenario (WCCS). The ability to implement these plans may rely on specific arrangements or those common to other Woodside activities. Regardless of their commonality each arrangement will be tested in at least one of the methods annually. This ensures that personnel are familiar with spill response procedures, reporting requirements, and roles/ responsibilities. At the completion of testing a report is produced to demonstrate the outcomes achieved against the tested objectives. The report will include the lessons learned, any improvement actions and a list of the participants. Alternatively, an assurance report, assurance records, or audit report may be produced. These reports record findings and include any recommendations for improvement. Improvement actions and their close-out are actively recorded and managed. This is over and above the emergency management exercises conducted.

[Redacted]
Hydrocarbon Spill Adviser | Security & Emergency Management
Woodside Energy Ltd

Email to AMSA – 8 May 2019

As part of Woodside's ongoing consultation for its current and planned activities, I would like to advise Woodside is preparing an Environment Plan (EP) for the North-West Australia 4D Seismic Campaign.

The proposed petroleum activities program is a series of marine seismic surveys in three areas of Commonwealth waters in north-west Australia starting in Q4 2019 pending approvals, vessel availability and weather constraints.

A Consultation Information Sheet is attached, providing information on the proposed activity. The Information Sheet is available on our website.

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Please be aware that your feedback will be communicated to the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), as is required under legislation.

We look forward to hearing from you.

Kind Regards
[Redacted]
Hydrocarbon Spill Adviser | Security & Emergency Management
Woodside Energy Ltd

APPENDIX G: DEPARTMENT OF DEFENCE HERITAGE ENQUIRY SYSTEM

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

Search Criteria

2 Registered Aboriginal Sites in Custom search area - Polygon - 115.601657851209°E, 20.2433122148669°S (GDA94) : 115.546726210584°E, 20.8014921358364°S (GDA94) : 115.36270521449°E, 20.9990635736824°S (GDA94) : 114.566196425428°E, 20.7116011450548°S (GDA94) : 114.574436171522°E, 19.8847079980286°S (GDA94) : 115.557712538709°E, 19.918281200541°S (GDA94) : 115.601657851209°E, 20.2433122148669°S (GDA94)

Disclaimer

The *Aboriginal Heritage Act 1972* preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Planning, Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at heritageenquiries@dplh.wa.gov.au and we will make every effort to rectify it as soon as possible.

Copyright

Coordinate Accuracy

Coordinates (Easting/Northing metres) are based on the GDA 94 Datum. Accuracy is shown as a code in brackets following the coordinates.

Terminology (NB that some terminology has varied over the life of the legislation)

Place ID/Site ID: This a unique ID assigned by the Department of Planning, Lands and Heritage to the place.
Status:
- **Registered Site**: The place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972.*
- **Other Heritage Place which includes:**
  - **Stored Data / Not a Site:** The place has been assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972.*
  - **Lodged:** Information has been received in relation to the place, but an assessment has not been completed at this *stage* to determine if it meets Section 5 of the *Aboriginal Heritage Act 1972.*

Access and Restrictions:
- **File Restricted = No:** Availability of information that the Department of Planning, Lands and Heritage holds in relation to the place is not restricted in any way.
- **File Restricted = Yes:** Some of the information that the Department of Planning, Lands and Heritage holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Planning, Lands and Heritage receives written approval from the informants who provided the information. To request access please contact heritageenquiries@dplh.wa.gov.au.
- **Boundary Restricted = No:** Place location is shown as accurately as the information lodged with the Registrar allows.
- **Boundary Restricted = Yes:** To preserve confidentiality the exact location and extent of the place is not displayed on the map. However, the shaded region (generally with an area of at least 4km²) provides a general indication of where the place is located. If you are a landowner and wish to find out more about the exact location of the place, please contact the Department of Planning, Lands and Heritage.
- **Restrictions:**
  - **No Restrictions:** *Anyone* can view the information.
  - **Male Access Only:** Only *males* can view restricted information.
  - **Female Access Only:** *Only* females can view restricted information.

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

Basemap Copyright

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

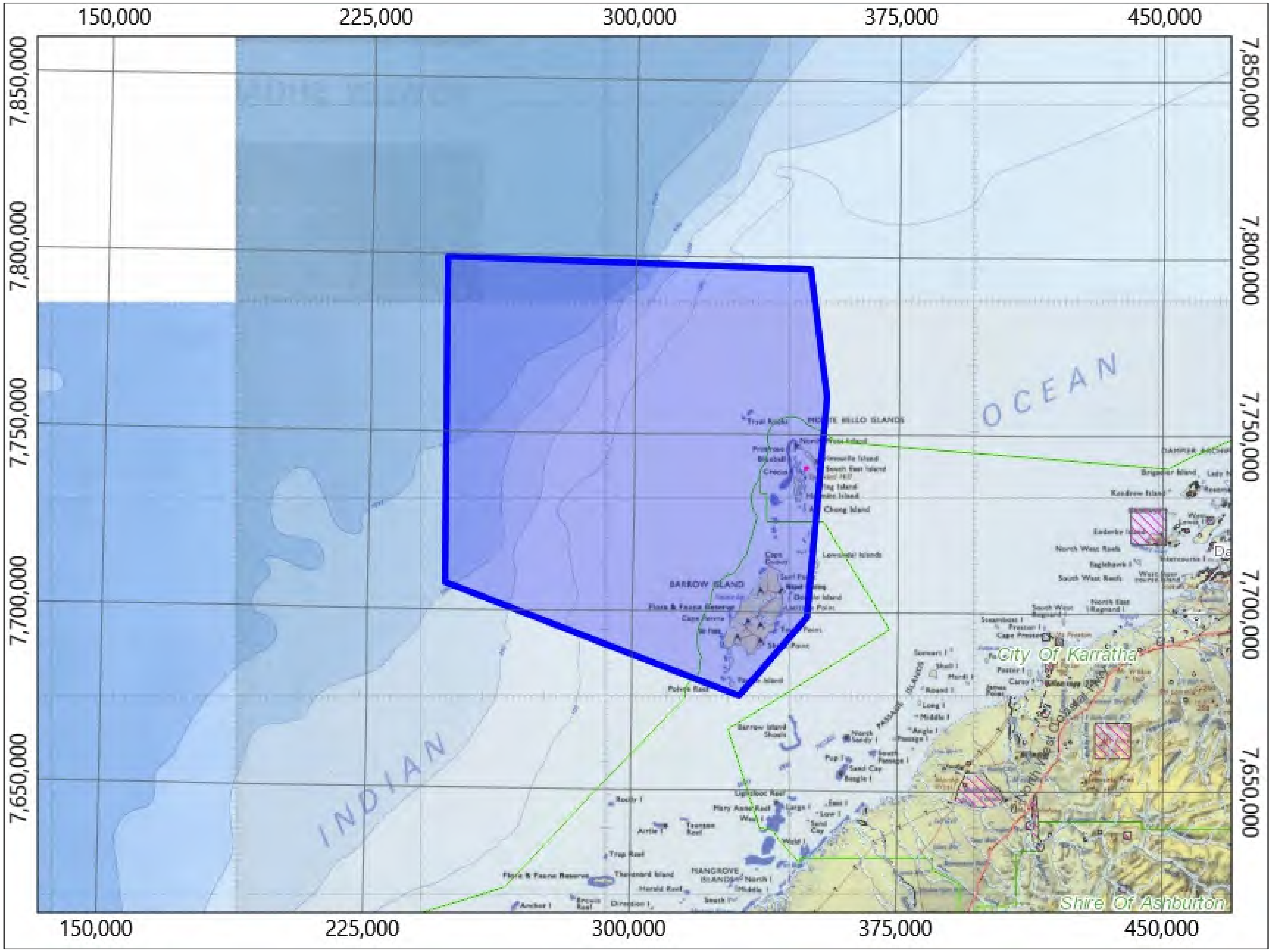
ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
873	MONTEBELLO IS: NOALA CAVE.	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter, Rockshelter, BP Dating: 27,220 +/- 640	*Registered Knowledge Holder names available from DAA	348188mE 7741053mN Zone 50 [Reliable]	P07287
926	MONTEBELLO IS: HAYNES CAVE.	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter, Rockshelter, Arch Deposit	*Registered Knowledge Holder names available from DAA	348289mE 7741005mN Zone 50 [Reliable]	P07286

Department of Planning, Lands and Heritage
GOVERNMENT OF WESTERN AUSTRALIA

Aboriginal Heritage Inquiry System

Map of Registered Aboriginal Sites

For further important information on using this information please see the Department of Planning, Lands and Heritage's Disclaimer statement at https://www.dplh.wa.gov.au/about-this-website



Legend

- Registered Aboriginal Site
- Search Area
- Town
- Road
- River
- Local Government Authority

57.62 kilometres

Map Scale 1 : 1,750,000

MGA Zone 50 (GDA94)

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

Search Criteria

53 Registered Aboriginal Sites in Custom search area - Polygon - 114.396334732271°E, 21.6454732804375°S (GDA94) : 114.269991958834°E, 21.7960159106541°S (GDA94) : 114.091464126802°E, 21.8342643027944°S (GDA94) : 114.017306411959°E, 21.8852462470719°S (GDA94) : 113.989840591646°E, 21.9336622220121°S (GDA94) : 113.893710220552°E, 22.1398820523144°S (GDA94) : 113.833285415865°E, 22.3508809027159°S (GDA94) : 113.781100357271°E, 22.4194504326193°S (GDA94) : 113.723422134615°E, 22.5361946137853°S (GDA94) : 113.66849049399°E, 22.5945297455804°S (GDA94) : 113.182345474459°E, 22.5970654955827°S (GDA94) : 112.698947036959°E, 22.1347938264004°S (GDA94) : 113.877230728365°E, 21.2594725893987°S (GDA94) : 114.322177017427°E, 21.3950725813475°S (GDA94) : 114.396334732271°E, 21.6454732804375°S (GDA94)

Disclaimer

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Copyright

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Status:

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  - No Restrictions: Anyone can view the information.
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  - Female Access Only: Only females can view restricted information.

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

Basemap Copyright

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
563	POINT MURAT 01	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	208716mE 7585665mN Zone 50 [Reliable]	P07501
564	POINT MURAT 02	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	209079mE 7585539mN Zone 50 [Reliable]	P07502
628	CAMP THIRTEEN BURIAL	No	No	No Gender Restrictions	Registered Site	Skeletal Material / Burial	*Registered Knowledge Holder names available from DAA	800392mE 7559449mN Zone 49 [Reliable]	P07434
6017	YARDIE CREEK CARAVAN BURIAL	No	No	No Gender Restrictions	Registered Site	Skeletal Material / Burial	*Registered Knowledge Holder names available from DAA	191538mE 7576555mN Zone 50 [Unreliable]	P07115
6754	OSPREY BAY 6	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	792942mE 7538749mN Zone 49 [Reliable]	P06165
6755	OSPREY BAY INTERDUNAL 1	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	792342mE 7537149mN Zone 49 [Unreliable]	P06166
6756	OSPREY BAY INTERDUNAL 2	No	No	No Gender Restrictions	Registered Site	Midden / Scatter	*Registered Knowledge Holder names available from DAA	792642mE 7537149mN Zone 49 [Reliable]	P06167
6757	BLOODWOOD CREEK MIDDEN 1	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	794942mE 7544549mN Zone 49 [Reliable]	P06168
6758	BLOODWOOD CREEK MIDDEN 2	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	794942mE 7545049mN Zone 49 [Reliable]	P06169
6759	BLOODWOOD CREEK MIDDEN 3	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	795142mE 7544949mN Zone 49 [Reliable]	P06170
6760	BLOODWOOD CREEK SHORELINE	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	794942mE 7545249mN Zone 49 [Reliable]	P06171
6761	LOW POINT MIDDEN	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	802992mE 7566299mN Zone 49 [Reliable]	P06172

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
6762	MILYERING MIDDEN	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	801342mE 7561449mN Zone 49 [Reliable]	P06173
6763	YARDIE ROCKSHELTERS NORTH.	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter, Rockshelter	*Registered Knowledge Holder names available from DAA	791542mE 7530249mN Zone 49 [Unreliable]	P06174
6764	CAMP 17 SOUTH MIDDENS	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	799042mE 7555649mN Zone 49 [Unreliable]	P06175
6765	CAMP 17 NORTH MIDDENS	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	799042mE 7555849mN Zone 49 [Unreliable]	P06176
6782	28 MILE CREEK NORTH 1	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	795242mE 7545949mN Zone 49 [Unreliable]	P06140
6784	MANDU MANDU CREEK SOUTH	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	796642mE 7548649mN Zone 49 [Unreliable]	P06142
6785	MANDU MANDU CREEK NORTH	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	796642mE 7548649mN Zone 49 [Unreliable]	P06143
6787	MANDU MANDU ROCKSHELTERS.	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter, Rockshelter, Arch Deposit, Other: ?	*Registered Knowledge Holder names available from DAA	797242mE 7547449mN Zone 49 [Reliable]	P06145
6790	YARDIE CREEK SOUTH 1	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	788942mE 7527749mN Zone 49 [Reliable]	P06148
6791	YARDIE CREEK SOUTH 2	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	790342mE 7528149mN Zone 49 [Reliable]	P06149
6793	ROAD ALIGNMENT 1	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	794942mE 7541649mN Zone 49 [Unreliable]	P06151
6794	ROAD ALIGNMENT 2	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	794942mE 7541449mN Zone 49 [Unreliable]	P06152

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
6795	ROAD ALIGNMENT 3	No	No	No Gender Restrictions	Registered Site	Midden / Scatter	*Registered Knowledge Holder names available from DAA	794842mE 7541249mN Zone 49 [Reliable]	P06153
6797	YARDIE WELL ROCKSHELTER.	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter, Rockshelter, Arch Deposit, BP Dating: 10, 490+/-180BP, Other: ?	*Registered Knowledge Holder names available from DAA	791542mE 7530449mN Zone 49 [Reliable]	P06155
6798	YARDIE INTERDUNAL SWALE	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	789942mE 7528849mN Zone 49 [Reliable]	P06156
6799	YARDIE BEACH MIDDEN	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	789842mE 7529049mN Zone 49 [Reliable]	P06157
6800	OYSTER STACKS MIDDEN	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	797042mE 7549849mN Zone 49 [Reliable]	P06158
6801	NORTH T-BONE BAY	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	801666mE 7562059mN Zone 49 [Reliable]	P06159
6802	OSPREY BAY 1	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	792742mE 7538149mN Zone 49 [Reliable]	P06160
6803	OSPREY BAY 2	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	792742mE 7538049mN Zone 49 [Reliable]	P06161
6804	OSPREY BAY 3	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	792542mE 7537849mN Zone 49 [Reliable]	P06162
6805	OSPREY BAY 4	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	792342mE 7537049mN Zone 49 [Reliable]	P06163
6806	OSPREY BAY 5	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	792742mE 7538149mN Zone 49 [Reliable]	P06164
7126	MESA CAMP	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	798442mE 7554749mN Zone 49 [Unreliable]	P05792

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
7206	WEALJUGOO MIDDEN.	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter, Camp, Hunting Place	*Registered Knowledge Holder names available from DAA	776584mE 7504740mN Zone 49 [Reliable]	P05710
7254	SANDY BAY NORTH	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	793442mE 7539949mN Zone 49 [Reliable]	P05652
7265	LAKE SIDE VIEW	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	800942mE 7560549mN Zone 49 [Reliable]	P05664
7298	YARDIE CREEK ROCKSHELTERS	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter	*Registered Knowledge Holder names available from DAA	790635mE 7529704mN Zone 49 [Reliable]	P05644
7299	YARDIE CREEK	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	789642mE 7528649mN Zone 49 [Unreliable]	P05645
7300	MANDU MANDU CK ROCKSHELTERS	Yes	Yes	No Gender Restrictions	Registered Site	Artefacts / Scatter	*Registered Knowledge Holder names available from DAA	Not available when location is restricted	P05646
7301	CAMP 17 CREEK EAST	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	800342mE 7555749mN Zone 49 [Reliable]	P05647
7303	TULKI WELL MIDDEN	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	798642mE 7554249mN Zone 49 [Reliable]	P05649
7304	PILGRAMUNNA BAY MIDDEN	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	794642mE 7543349mN Zone 49 [Reliable]	P05650
7305	MANGROVE BAY.	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter, Skeletal Material / Burial, Hunting Place	*Registered Knowledge Holder names available from DAA	804142mE 7568149mN Zone 49 [Reliable]	P05651
10381	VLAMING HEAD	Yes	Yes	No Gender Restrictions	Registered Site	Ceremonial, Mythological	*Registered Knowledge Holder names available from DAA	Not available when location is restricted	P01799
11400	YARDIE CREEK STATION	No	No	No Gender Restrictions	Registered Site	Engraving	*Registered Knowledge Holder names available from DAA	191638mE 7576655mN Zone 50 [Unreliable]	P00750

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
11401	5 Mile Well (Cape Range)	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Engraving, Painting, Quarry, Arch Deposit	*Registered Knowledge Holder names available from DAA	198638mE 7583655mN Zone 50 [Unreliable]	P00751
11458	NINGALOO (near)	No	No	No Gender Restrictions	Registered Site	Painting	*Registered Knowledge Holder names available from DAA	781642mE 7511649mN Zone 49 [Unreliable]	P00701
11885	PADJARI MANU CAVE (Formerly Bunbury Cave)	Yes	Yes	No Gender Restrictions	Registered Site	Artefacts / Scatter, Ceremonial, Engraving, Painting, Arch Deposit, Water Source	*Registered Knowledge Holder names available from DAA	Not available when location is restricted	P00267
15322	POINT MURAT/WHITE OPAL	No	No	No Gender Restrictions	Registered Site	Artefacts / Scatter, Midden / Scatter	*Registered Knowledge Holder names available from DAA	209012mE 7585213mN Zone 50 [Reliable]	P07916
17448	CHUGORI ROCKHOLE	No	No	No Gender Restrictions	Registered Site	Ceremonial, Grinding Patches / Grooves, Man-Made Structure, Mythological, Water Source	*Registered Knowledge Holder names available from DAA	193492mE 7579323mN Zone 50 [Reliable]	

Department of Planning, Lands and Heritage
GOVERNMENT OF WESTERN AUSTRALIA

Aboriginal Heritage Inquiry System

Map of Registered Aboriginal Sites

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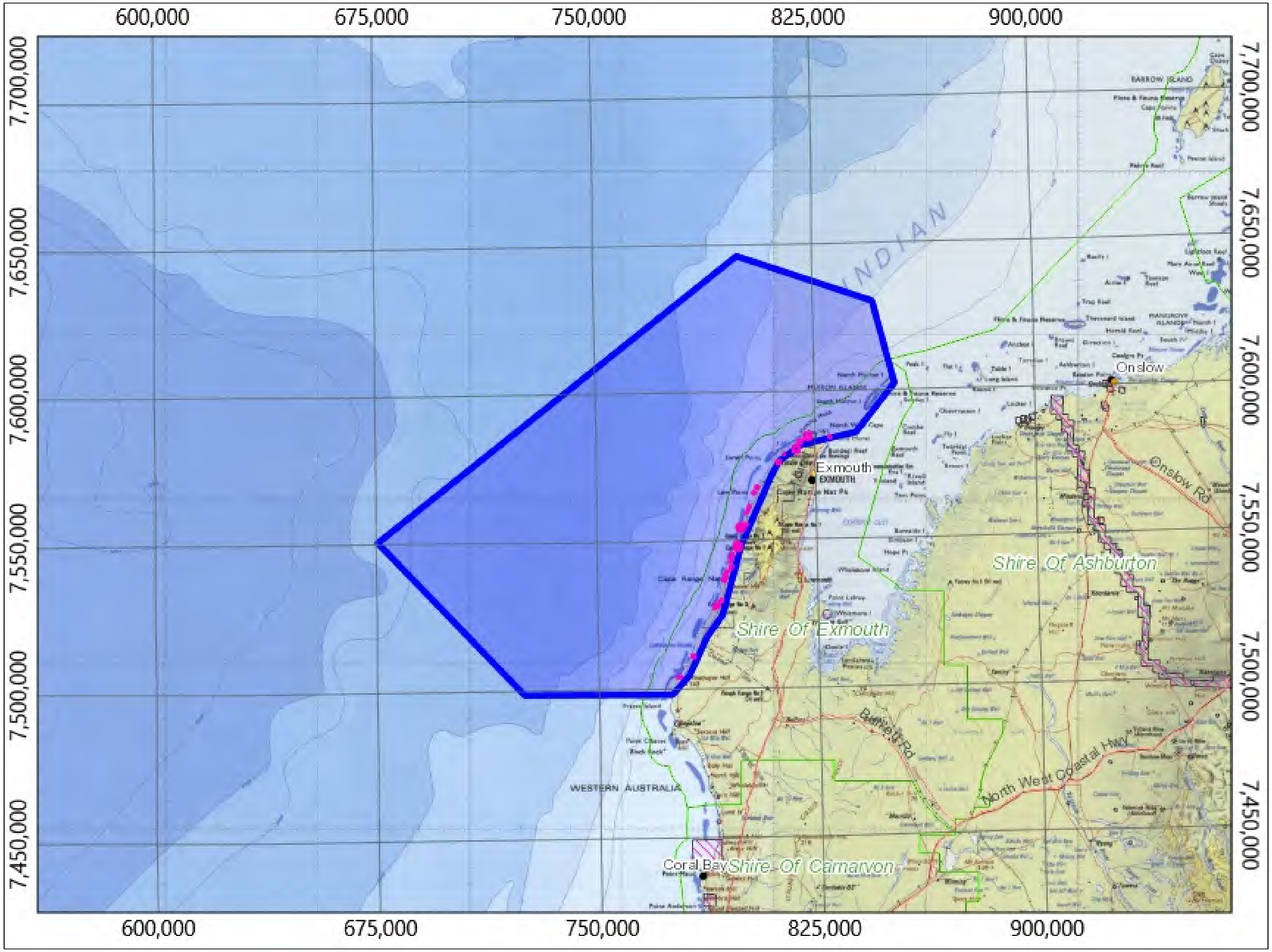

Legend

- Registered Aboriginal Site
- Search Area
- Town
- Road
- River
- Local Government Authority

69.86 kilometres

Map Scale 1 : 2,120,000

MGA Zone 49 (GDA94)

Map created: 07/06/2019 8:17:15 AM by: GIS_NET_USER

Identifier: 398036

APPENDIX H: JASCO NOISE MODELLING REPORTS

Woodside 4-D Marine Seismic Survey

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:

Jeremy Fitzpatrick
Woodside Energy Limited
Contract: 4510565458

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Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

EXECUTIVE SUMMARY 12

1. INTRODUCTION 16

2. MODELLING SCENARIOS 18
- 2.1. Pygmy Blue Whales 26
- 2.2. Turtles 26

3. NOISE EFFECT CRITERIA 28
- 3.1. Marine Mammals 29
  - 3.1.1. Behavioural response 29
  - 3.1.2. Injury and hearing sensitivity changes 29
- 3.2. Fish, Turtles, Fish Eggs, and Fish Larvae 30
  - 3.2.1. Turtles 31
- 3.3. Benthic Invertebrates (Crustaceans and Bivalves) 32
- 3.4. Human health assessment threshold 32

4. METHODS 34
- 4.1. Acoustic Source Model 34
- 4.2. Sound Propagation Models 34
- 4.3. Parameter Overview 34
- 4.4. Accumulated SEL 35
- 4.5. Geometry and Modelled Regions 35

5. RESULTS 37
- 5.1. Acoustic Source Levels and Directivity 37
- 5.2. Per-pulse Sound Fields 38
  - 5.2.1. Area A 39
  - 5.2.2. Area B 64
  - 5.2.3. Area C 70
- 5.3. Multiple Pulse Sound Fields 87
  - 5.3.1. Area A: Pluto 4-D Survey 87
  - 5.3.2. Area A: Harmony 4-D Survey 91
  - 5.3.3. Area B: Scarborough 4-D Survey 94
  - 5.3.4. Area C: Laverda 4-D Survey 98
  - 5.3.5. Area C: Cimatti 4-D Survey 101
  - 5.3.6. Area C: Vincent 4-D Survey 105

6. DISCUSSION 109
- 6.1. Overview and Source Levels 109
- 6.2. Per-Pulse Sound Fields 109
- 6.3. Multiple Pulse Sound Fields 110
  - 6.3.1. Survey Area A 111
  - 6.3.2. Survey Area B 111
  - 6.3.3. Survey Area C 111
- 6.4. Summary 111

LITERATURE CITED 116

APPENDIX A. ACOUSTIC METRICS A-1

APPENDIX B. ACOUSTIC SOURCE MODEL B-1
APPENDIX C. SOUND PROPAGATION MODELS C-1
APPENDIX D. METHODS AND PARAMETERS D-1
APPENDIX E. ADDITIONAL RESULTS E-1

Figures

Figure 1. Overview of the modelling sites, acquisition lines, and features for the Woodside 4-D seismic campaign. 16
Figure 2. *Area A*: Modelling sites and survey fullfold areas. 20
Figure 3. *Area B*: Modelling sites and survey fullfold area. 21
Figure 4. *Area C*: Modelling sites and survey fullfold areas. 21
Figure 5. *Area A, Pluto Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Pluto 4-D Survey. 22
Figure 6. *Area A, Harmony Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Harmony 4-D Survey. 22
Figure 7. *Area B, Scarborough Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Scarborough 4-D Survey. 23
Figure 8. *Area C, Laverda Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Laverda 4-D Survey. 23
Figure 9. *Area C, Cimatti Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Cimatti 4-D Survey. 24
Figure 10. *Area C, Vincent Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Vincent 4-D Survey. 24
Figure 11. *Area A*: Sound field sampling locations and close modelling sites. 25
Figure 12. *Area B*: Sound field sampling location and modelling sites. 25
Figure 13. *Area C*: Sound field sampling locations and close modelling sites. 26
Figure 14. *Site 1, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 43
Figure 15. *Site 2, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 44
Figure 16. *Site 3, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 44
Figure 17. *Site 4, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 45
Figure 18. *Site 5, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 45
Figure 19. *Site 6, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 46
Figure 20. *Site 7, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 46
Figure 21. *Site 8, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 47
Figure 22. *Site 9, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 47
Figure 23. *Site 10, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 48
Figure 24. *Site11, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 48
Figure 25. *Site 12, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 49
Figure 26. *Site 13, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 49
Figure 27. *Site 14, SPL:* Sound level contour map showing unweighted maximum-over-depth results. 50
Figure 28. *Site 1, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 50

Figure 29. *Site 2, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 51
Figure 30. *Site 3, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 51
Figure 31. *Site 4, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 52
Figure 32. *Site 5, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 52
Figure 33. *Site 6, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 53
Figure 34. *Site 7, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 53
Figure 35. *Site 8, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 54
Figure 36. *Site 9, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 54
Figure 37. *Site 10, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results............ 55
Figure 38. *Site11, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results. 55
Figure 39. *Site 12, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results............ 56
Figure 40. *Site 13, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results............ 56
Figure 41. *Site 14, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results............ 57
Figure 42. Site 1: Vertical slice of the predicted SPL for the 3150 in^3 array. 57
Figure 43. *Site 2*: Vertical slice of the predicted SPL for the 3150 in^3 array. 58
Figure 44. *Site 3*: Vertical slice of the predicted SPL for the 3150 in^3 array. 58
Figure 45. *Site 4*: Vertical slice of the predicted SPL for the 3150 in^3 array. 59
Figure 46. *Site 5*: Vertical slice of the predicted SPL for the 3150 in^3 array. 59
Figure 47. *Site 6*: Vertical slice of the predicted SPL for the 3150 in^3 array. 60
Figure 48. *Site 7*: Vertical slice of the predicted SPL for the 3150 in^3 array. 60
Figure 49. *Site 8*: Vertical slice of the predicted SPL for the 3150 in^3 array. 61
Figure 50. *Site 9*: Vertical slice of the predicted SPL for the 3150 in^3 array. 61
Figure 51. *Site 10*: Vertical slice of the predicted SPL for the 3150 in^3 array. 62
Figure 52. *Site 11*: Vertical slice of the predicted SPL for the 3150 in^3 array. 62
Figure 53. *Site 12*: Vertical slice of the predicted SPL for the 3150 in^3 array. 63
Figure 54. *Site 13*: Vertical slice of the predicted SPL for the 3150 in^3 array. 63
Figure 55. *Site 14*: Vertical slice of the predicted SPL for the 3150 in^3 array. 64
Figure 56. *Site 4*: Long-range vertical slice of the predicted SPL for the 3150 in^3 array. 64
Figure 57. *Site 15, SPL:* Sound level contour map showing unweighted maximum-over-depth results............ 67
Figure 58. *Site 15, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results............ 68
Figure 59. *Site 15*: Vertical slice of the predicted SPL for the 3150 in^3 array. 68
Figure 60. *Site 15*: Long range vertical slice of the predicted SPL for the 3150 in^3 array. 69

Figure 61. *Site 16 (2650 in³), SPL:* Sound level contour map showing unweighted maximum-over-depth results. 74
Figure 62. *Site 17 (2650 in³), SPL:* Sound level contour map showing unweighted maximum-over-depth results. 75
Figure 63. *Site 18 (2650 in³), SPL:* Sound level contour map showing unweighted maximum-over-depth results. 75
Figure 64. *Site 19, SPL:* Sound level contour map showing unweighted maximum-over-depth results.... 76
Figure 65. *Site 20, SPL:* Sound level contour map showing unweighted maximum-over-depth results.... 76
Figure 66. *Site 21, SPL:* Sound level contour map showing unweighted maximum-over-depth results.... 77
Figure 67. *Site 22, SPL:* Sound level contour map showing unweighted maximum-over-depth results.... 77
Figure 68. *Site 23, SPL:* Sound level contour map showing unweighted maximum-over-depth results.... 78
Figure 69. *Site 16 (2650 in³), SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.... 78
Figure 70. *Site 17 (2650 in³), SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.... 79
Figure 71. *Site 18 (2650 in³), SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.... 79
Figure 72. *Site 19, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.... 80
Figure 73. *Site 20, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.... 80
Figure 74. *Site 21, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.... 81
Figure 75. *Site 22, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.... 81
Figure 76. *Site 23, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.... 82
Figure 77. *Site 16, SPL*: Vertical slice of the predicted SPL for the 2650 in³ array. 82
Figure 78. *Site 17, SPL*: Vertical slice of the predicted SPL for the 2650 in³ array. 83
Figure 79. *Site 18, SPL*: Vertical slice of the predicted SPL for the 2650 in³ array. 83
Figure 80. *Site 19, SPL*: Vertical slice of the predicted SPL for the 2650 in³ array. 84
Figure 81. *Site 20*: Vertical slice of the predicted SPL for the 3150 in³ array. 84
Figure 82. *Site 21*: Vertical slice of the predicted SPL for the 3150 in³ array. 85
Figure 83. *Site 22*: Vertical slice of the predicted SPL for the 3150 in³ array. 85
Figure 84. *Site 23*: Vertical slice of the predicted SPL for the 3150 in³ array. 86
Figure 85. *Pluto 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results.... 89
Figure 86. *Pluto 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales. 89

Figure 87. *Pluto 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales. ... 90
Figure 88. *Pluto 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales. ... 90
Figure 89. *Harmony 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results... 92
Figure 90. *Harmony 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales. ... 93
Figure 91. *Harmony 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales. ... 93
Figure 92. *Harmony 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales. ... 94
Figure 93. *Scarborough 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results. ... 96
Figure 94. *Scarborough 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales. ... 96
Figure 95. *Scarborough 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales. ... 97
Figure 96. *Scarborough 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales. ... 97
Figure 97. *Laverda 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results... 99
Figure 98. *Laverda 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales. ... 100
Figure 99. *Laverda 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales. ... 100
Figure 100. *Laverda 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales. ... 101
Figure 101. *Cimatti 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results... 103
Figure 102. *Cimatti 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales. ... 103
Figure 103. *Cimatti 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales. ... 104
Figure 104. *Cimatti 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales. ... 104
Figure 105. *Vincent 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results... 106
Figure 106. *Vincent 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales. ... 107
Figure 107. *Vincent 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales. ... 107
Figure 108. *Vincent 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales. ... 108

Figure A-1. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by NMFS (2018). ... A-4
Figure B-1. 3150 in^3 array: Predicted source level details at a 6 m towed depth. ... B-2
Figure B-2. 2650 in^3 array: Predicted source level details at a 5 m towed depth. ... B-2
Figure B-3. 3150 in^3 array: Directionality of the predicted horizontal source levels , 10 Hz to 2 kHz. ... B-3
Figure B-4. 2650 in^3 array: Directionality of the predicted horizontal source levels, 10 Hz to 2 kHz. ... B-4

Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM. C-1
Figure C-2. PK and SPL and per-pulse SEL versus range from a 20 in^3 seismic source. C-2
Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. D-1
Figure D-2. Slices for the 3150 in^3 array at Site 1: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. D-2
Figure D-3. Slices for the 3150 in^3 array at Site 7: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. D-3
Figure D-4. Slices for the 3150 in^3 array at Site 9: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. D-3
Figure D-5. Slices for the 3150 in^3 array at Site 13: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. D-3
Figure D-6. Slices for the 3150 in^3 array at Site 15: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. D-4
Figure D-7. Slices for the 2560 in^3 array at Site 16: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. D-4
Figure D-8. Slices for the 3150 in^3 array at Site 19: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. D-4
Figure D-9. Slices for the 3510 in^3 array at Site 21: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. D-5
Figure D-10. The final sound speed profile (December) used for the modelling of sites in the Pluto and Harmony survey areas. D-6
Figure D-11. The final sound speed profile (May) used for the modelling of sites in the Scarborough survey area. D-6
Figure D-12. The final sound speed profile (May) used for the modelling of sites in the Laverda, Cimatti, and Vincent survey areas. D-7
Figure D-13. Layout of the modelled 3150 in^3 seismic source array. D-10
Figure D-14. Layout of the modelled 2650 in^3 seismic source array. D-10
Figure E-1. *Site 1, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-1
Figure E-2. *Site 2, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-2
Figure E-3. *Site 3, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-2
Figure E-4. *Site 4, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-3
Figure E-5. *Site 5, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-3
Figure E-6. *Site 6, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-4
Figure E-7. *Site 7, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-4
Figure E-8. *Site 8, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-5
Figure E-9. *Site 9, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-5
Figure E-10. *Site 10, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-6
Figure E-11. *Site 11, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-6
Figure E-12. *Site 12, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-7

Figure E-13. *Site 13, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-7
Figure E-14. *Site 14, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-8
Figure E-15. *Site 15, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-8
Figure E-16. *Site 16, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-9
Figure E-17. *Site 17, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-9
Figure E-18. *Site 18, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-10
Figure E-19. *Site 19, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-10
Figure E-20. *Site 20, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-11
Figure E-21. *Site 21, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-11
Figure E-22. *Site 22, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-12
Figure E-23. *Site 23, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth. E-12
Figure E-24. *Site 4*: Long-range vertical slice of the predicted SPL for the 3150 in^3 array. E-13
Figure E-25. *Site 4*: Long-range vertical slice of the predicted SPL for the 3150 in^3 array. E-13

Tables

Table 1. Distances to marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) 13
Table 2. Summary of maximum marine mammal PTS onset distances for 24 h SEL modelled scenarios 13
Table 3. Summary of maximum PTS onset distances for Pygmy blue whale 24-h SEL modelled scenarios 13
Table 4. Distances to turtle behavioural response criteria for maximum over depth range of ≤ 250 m. 14
Table 5. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and 24 h SEL modelled scenarios 14
Table 6. The distance to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017a) relevant to plankton was estimated within each Survey Area through full-waveform modelling using FWRAM 15
Table 7. Surveys within the Woodside 4-D North-West-Shelf seismic campaign 17
Table 8. Location details for the standalone single impulse sites. 19
Table 9. Details for each 24 h SEL Scenario for each survey. 19
Table 10. Sound field sampling locations for single impulse sound fields in each Survey Area relevant to identified receptors. 20
Table 11. Dive depths recorded for leatherback turtles. 27
Table 12. Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine mammals. 29
Table 13. Criteria for seismic noise exposure for fish 31
Table 14. Far-field source level specifications for the 3150 in^3 array, for a 6 m tow depth. 37
Table 15. Far-field source level specifications for the 2650 in^3 array, for a 5 m tow depth. 37
Table 16. *Area A*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the 14 single impulse sites. 39

Table 17. *Area A*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth SPL isopleths from the 14 single impulse sites 40
Table 18. *Area A*; Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled SPL isopleths from the 14 single impulse sites within the specified biologically relevant depths. 41
Table 19. *Area A*: Maximum (R_{max}) horizontal distances (km) from the 3150 in^3 array to modelled maximum-over-depth peak pressure level (PK) thresholds 41
Table 20. *Area A*: Maximum (R_{max}) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth 178 dB re 1µPa PK-PK 42
Table 21. *Area A*: Received maximum-over-depth SPL at sound field sampling receivers (Table 10) from the nearest modelling sites. 42
Table 22. *Area A*: Maximum (R_{max}) horizontal distances (in m) from the 3150 in^3 array to modelled seafloor PK from three single-impulse modelling sites (Table 8). 42
Table 23. *Area A*: Maximum (R_{max}) horizontal distances (in m) from the 3150 in^3 array to modelled seafloor PK-PK from three modelling sites (Table 8). Results included in relation to benthic invertebrates (Section 3.3). 43
Table 24. *Area B*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the single impulse site. 65
Table 25. *Area B*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth SPL isopleths from the single impulse site. 65
Table 26. *Area B*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled SPL isopleths from the single impulse site within the specified biologically relevant depths. 66
Table 27. *Area B*: Maximum (R_{max}) horizontal distances (km) from the 3150 in^3 array to modelled maximum-over-depth peak pressure level (PK) thresholds 66
Table 28. *Area B*: Maximum (R_{max}) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth 178 dB re 1µPa PK-PK 66
Table 29. *Area B*: Received SPL at sound field sampling receivers (Table 10) from the closest modelling site for maximum-over-depth (MOD) and specified biologically relevant depths for pygmy blue whales 67
Table 30. *Area C*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2650 and 3150 in^3 arrays to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the single impulse sites. 70
Table 31. *Area C*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2650 and 3150 in^3 arrays to modelled maximum-over-depth SPL isopleths from the single impulse sites. 71
Table 32. *Area C*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) the 2650 and 3150 in^3 arrays to modelled SPL isopleths from the single impulse sites within the specified biologically relevant depths. 72
Table 33. *Area C:* Maximum (R_{max}) horizontal distances (km) from the 2650 and 3150 in^3 arrays to modelled maximum-over-depth peak pressure level (PK) thresholds 72
Table 34. *Area C*: Maximum (R_{max}) horizontal distances (in km) from the 2650 and 3150 in^3 arrays to modelled maximum-over-depth 178 dB re 1µPa PK-PK 73
Table 35. *Area C*: Received maximum-over-depth SPL at sound field sampling receivers (Table 10) from the nearest modelling sites. 73
Table 36. *Area C*: Maximum (R_{max}) horizontal distances (in m) from the 3150 in^3 array to modelled seafloor PK from one single-impulse modelling site (Table 8). 73
Table 37. *Area C*: Maximum (R_{max}) horizontal distances (in m) from the 3150 in^3 array to modelled seafloor PK-PK from a single modelling site 74
Table 38. *Pluto 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018). 87
Table 39. *Pluto 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. 88

Table 40. *Pluto 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria. 88
Table 41. *Harmony 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018). 91
Table 42. *Harmony 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. 91
Table 43. *Harmony 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria. 92
Table 44. *Scarborough 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018). 94
Table 45. *Scarborough 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. 95
Table 46. *Scarborough 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria. 95
Table 47. *Laverda 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018). 98
Table 48. *Laverda 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. 98
Table 49. *Laverda 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria. 99
Table 50. *Cimatti 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018). 101
Table 51. *Cimatti 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. 102
Table 52. *Cimatti 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria. 102
Table 53. *Vincent 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018). 105
Table 54. *Vincent 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. 105
Table 55. *Vincent 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria. 106
Table 56. Distances to marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL), Tables 17, 18, 25, 26, 31 and 32. 112
Table 57. Summary of maximum marine mammal PTS onset distances for 24-h SEL modelled scenarios (PK values from Tables 19, 27 and 33 and SEL_{24h} values from Tables 38, 41, 44, 47, 50 and 53. 112
Table 58. Summary of maximum PTS onset distances for Pygmy blue whale 24-h SEL modelled scenarios from Tables 39 42 45 48 51 and 54. 113
Table 59. Distances to turtle behavioural response criteria for maximum over depth range of ≤ 250 m, Tables 18, 26, and 32. 113
Table 60. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and 24 h SEL modelled scenarios 114
Table 61. The distance to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017a) relevant to plankton was estimated within each Survey Area through full-waveform modelling using FWRAM 114

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018). A-3
Table D-1. Shallow water sites: Estimated geoacoustic profile. D-8
Table D-2. Mid-depth water sites: Estimated geoacoustic profile. D-8
Table D-3. Deep water sites: Estimated geoacoustic profile. D-9
Table D-4. Layout of the modelled 3150 in^3 seismic source array. D-11
Table D-5. Layout of the modelled 2650 in^3 seismic source array. D-11

Executive Summary

JASCO Applied Sciences performed a numerical estimation study of underwater sound levels associated with six planned 4-D Marine Seismic Surveys (MSS) within three Survey Areas constituting the Woodside 4-D North-West-Shelf seismic campaign. The aim of this study was to assist in understanding the potential acoustic impact on key regional receptors including marine mammals, fish, turtles, benthic invertebrates, and plankton. Two seismic sources were considered: a 3150 in^3 seismic source towed at a 6 m depth used for five surveys and a 2650 in^3 seismic source towed at a 5 m depth used for one survey.

A specialised airgun array source model was used to predict the acoustic signature of the two seismic sources, and complementary underwater acoustic propagation models were used in conjunction with the modelled array signatures to estimate sound levels over a large area around the source. Single-impulse sound fields were predicted at twenty-three defined locations within the three Survey Areas, and accumulated sound exposure fields were predicted for one representative scenario for likely survey operations over 24 hours for each of the six surveys. The modelling methodology considered source directivity and range-dependent environmental properties in each of the areas assessed. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_{p}), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{\mathrm{pk\text{-}pk}}$), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_{E}) as appropriate for different noise effect criteria. A conservative sound speed profile that would be most supportive of sound propagation conditions for the period of the survey in each Survey Area was defined and applied to all modelling.

The analysis considered the distances away from the seismic source at which several effects criteria or relevant sound levels were reached. The results are summarised below for the representative single-impulse sites and accumulated SEL scenarios. Additionally, sound levels were predicted at ten specific fixed receiver locations.

Marine mammal injury and behaviour

- The distances in each Survey Area to where the NMFS (2014) marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded are summarised in Table 1.
- The results for the criteria applied for marine mammal Permanent Threshold Shift (PTS), NMFS (2018), consider both metrics within the criteria (PK and SEL_{24h}). The longest distance associated with either metric is required to be applied. Table 2 summarises the maximum distances for PTS, along with the relevant metric and the location of the results within this report. For mid-frequency cetaceans, because the arrays are not a point source (approximately 14 × 12 m and 16 × 9 m), the actual ranges from the edge of airgun arrays are small.
- The 24-h SEL is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The corresponding SEL_{24h} radii for low-frequency cetaceans were larger than those for peak pressure criteria, but they represent an unlikely worst-case scenario. More realistically, marine mammals (and fish) would not stay in the same location or at the same range for 24 hours. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with injury (either PTS or TTS) if it remained in that range for 24 hours.

Table 1. Distances to marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL)

Fauna and water column section	Distance (km)				
	Survey Area A		Survey Area B	Survey Area C	
	Min	Max	Single Site	Min	Max
All cetaceans, Maximum-over-depth	2.3	8.5	6.8	4	6.5
Pygmy blue whales, depth ≤ 24 m	2.1	7.9	6.8	3.1	6.1
Pygmy blue whales, depth ≤ 129 m	2.3	7.9	6.8	3.1	6.5
Pygmy blue whales, depth ≤ 506 m	2.3	8.5	6.8	3.2	6.5

Table 2. Summary of maximum marine mammal PTS onset distances for 24 h SEL modelled scenarios

Relevant hearing group	Metric associated with longest distance to PTS onset	R_{max} (km)					
		Pluto	*Harmony*	*Scarborough*	*Laverda*	*Cimatii*	*Vincent*
Low-frequency cetaceans†	SEL_{24h}	0.86	1.1	5.96	0.7	2.14	2.07
Mid-frequency cetaceans	PK	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
High-frequency cetaceans	PK	0.22	0.22	0.19	0.19	0.19	0.19

† The model does not account for shutdowns.

Table 3. Summary of maximum PTS onset distances for Pygmy blue whale 24-h SEL modelled scenarios

Species	Depth limit (m)	R_{max} (km)					
		Pluto	*Harmony*	*Scarborough*	*Laverda*	*Cimatii*	*Vincent*
Pygmy blue whales, Low-frequency cetacean weighted†	506	0.86	1.1	5.95	0.44	1.35	2.03
	129	0.40	0.50	5.93	0.35	0.58	2.0
	24	0.22	0.24	4.50	0.2	0.25	1.38

† The model does not account for shutdowns.

Turtles

- The PK turtle injury criteria of 232 dB re 1 µPa for PTS and 226 dB re 1 µPa for TTS from Finneran et al. (2017) was not exceeded at a distance greater than 20 m from the centre of the array. Because the arrays are not a point source (approximately 14 × 12 m and 16 × 9 m), the actual ranges from the edge of airgun arrays are small.
- The distances in each Survey Area to where the NMFS criterion (NSF 2011a) for behavioural effects in turtles of 166 dB re 1 µPa (SPL) and the Moein et al. (1995) criterion could be exceeded are summarised in Table 4.

Table 4. Distances to turtle behavioural response criteria for maximum over depth range of ≤ 250 m.

SPL (L_p; dB re 1 µPa)	Distance (km)				
	Survey Area A		Survey Area B	Survey Area C	
	Min	Max	Single Site	Min	Max
175[#]	0.72	1	0.74	0.6	0.8
166[†]	1.4	2.9	1.5	1.3	3.3

† Threshold for turtle behavioural response to impulsive noise (NSF 2011b).
# Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).

Fish, fish eggs, and fish larvae

- The modelling study assessed the ranges for quantitative criteria based on Popper et al. (2014) and considered both PK and SEL_{24h} metrics associated with mortality and potential mortal injury and impairment in the following groups:
  - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
  - Fish with a swim bladder that do not use it for hearing
  - Fish that use their swim bladders for hearing
  - Fish eggs and fish larvae
- Table 5 summarises the distances to injury criteria for fish, fish eggs, and fish larvae along with the relevant metric.

Table 5. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and 24 h SEL modelled scenarios

Relevant hearing group	Injury criteria	Water column				Seafloor		
		Metric associated with longest distance to injury criteria	R_{max} (km)			Metric associated with longest distance to injury criteria	R_{max} (km)	
			Area A	Area B	Area C		Area A	Area C
Fish: No swim bladder	Injury	PK	0.06	0.05	0.06	PK	0.06	-
	TTS	SEL_{24h}	2.54	14.0	5.16	SEL_{24h}	2.38	2.78
Fish: Swim bladder not involved in hearing Swim bladder involved in hearing	Injury	PK	0.11	0.11	0.11	PK	0.13	0.05
	TTS	SEL_{24h}	2.54	14.0	5.16	SEL_{24h}	2.38	2.78
Fish eggs, and larvae	Injury	PK	0.11	0.11	0.11	PK	0.13	0.05

Crustaceans and Bivalves, Sponges and Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following have been determined:

- Crustaceans: The sound level of 202 dB re 1 µPa PK-PK from Payne et al. (2008) was considered; it was reached at ranges between 375 and 415 m depending on the modelled site within Area A and at 424 m within Area C.
- Sponges and coral: The PK sound level at the seafloor directly underneath the seismic source was estimated at all modelling sites considered for seafloor fish receptors, and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was found that the level was not reached at any of the five considered sites.

- To assist with the assessment of potential effects on plankton, the distances to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017b) were estimated as summarised in Table 6.

Table 6. The distance to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017a) relevant to plankton was estimated within each Survey Area through full-waveform modelling using FWRAM

PK-PK ($L_{pk\text{-}pk}$; dB re 1 µPa)	Distance (km)				
	Survey Area A		Survey Area B	Survey Area C	
	Min	Max	Single Site	Min	Max
178	2.26	9.91	9.57	6.25	9.04

Divers

To assess the potential human health effects of underwater sound levels the following have been considered in this modelling study:

- As part of a precautionary approach for seismic impulses, a broadband level of 145 dB re 1 µPa (SPL) suggested by Fothergill et al. (2001) and Parvin (2005) has been adopted as a human health assessment threshold for recreational divers and swimmers.
- The R_{max} ranges reported herein are highly dependent on the directionality of the seismic source and acoustic propagation effects. The R_{max} range to the threshold of 145 dB re 1 µPa (SPL) is consistently orientated in the offshore direction for the considered modelling sites and scenarios.
- For shallow water source locations, the threshold ranges in the inshore direction are less than the reported R_{max} ranges, additional ranges other than the R_{max} may be estimated from the provided SPL maps.

Marine Protected Areas

Received levels (SPL) at the nearest boundary of marine protected areas have been predicted to vary from 101 to 161 dB re 1 µPa (SPL). The closest marine protected areas to the three survey acquisition areas have been determined to be:

- Montebello Islands Marine Park (Western Australia),
- Gascoyne Marine Park (Commonwealth of Australia),
- Ningaloo Marine Park (Western Australia),
- Murion Islands Marine Management Areas (Western Australia).

The maximum received level at the boundary of any considered marine protected area has been predicated to occur at the boundary of the Gascoyne Marine Park, produced by activities in acquisition Area C, however, this level is predicted to occurs deep waters (>900 m). Levels received at the boundary of marine protected areas in shallow water (<200 m) have been predicted to range from 101 to 122 dB re 1 µPa (SPL) for the considered receiver locations.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with six planned 4-D Marine Seismic Surveys (MSS) within three Survey Areas constituting the Woodside 4-D North-West-Shelf seismic campaign (Figure 1 and Table 7).

The aim of this study was to assist in understanding the potential acoustic impact on key regional receptors including marine mammals, fish, turtles, benthic invertebrates, and plankton. Two seismic sources were considered: a 3150 in^3 seismic source towed at a 6 m depth used for five surveys and a 2650 in^3 seismic source towed at a 5 m depth used for one survey.

JASCO's specialised Airgun Array Source Model (AASM) was used to predict the acoustic signature of both arrays. AASM (Appendix B) accounts for individual airgun volumes and array geometry. Complementary underwater acoustic propagation models were used in conjunction with the selected modelled array signatures to estimate sound levels over a large area around the sources. Single-impulse sound fields were predicted at defined locations within each Survey Area (Section 5.2), and accumulated sound exposure fields were predicted for a representative scenario encompassing likely survey operations over 24 h for each survey (Section 5.3). One conservative sound speed profiles was defined for each Survey Area that would be the most supportive conditions for sound propagation during the possible period of each survey (Section 4.3), and the relevant profile was applied at each modelling site.

The modelling methodology considered source directivity and range-dependent environmental properties. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), zero-to-peak pressure levels (PK, L_{pk}), peak-to-peak pressure levels (PK-PK; $L_{pk\text{-}pk}$), and either single-impulse (i.e., per-pulse) or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria.

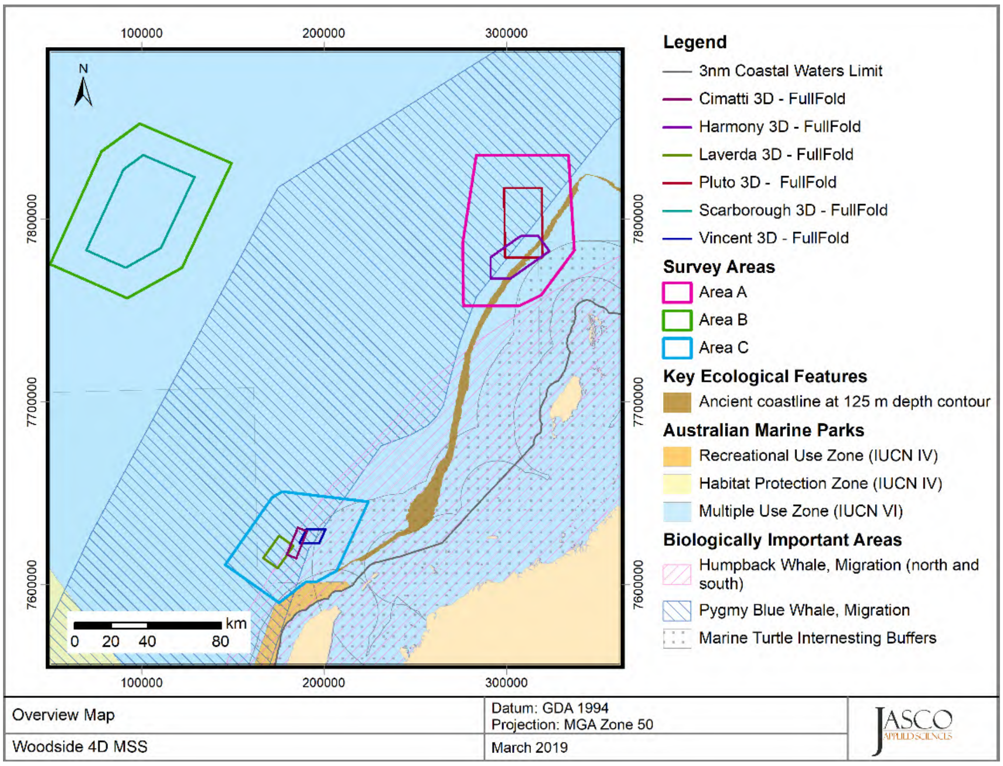

Figure 1. Overview of the modelling sites, acquisition lines, and features for the Woodside 4-D seismic campaign.

Table 7. Surveys within the Woodside 4-D North-West-Shelf seismic campaign

<table>
<tr><th>Survey area</th><th>Survey name</th><th>Array size (in^3)</th><th>Tow depth (m)</th><th>Impulse interval (m)</th><th>Source configuration</th><th>Survey period for sound speed profile</th></tr>
<tr><td rowspan="2">A</td><td>Pluto 4-D</td><td rowspan="3">3150</td><td rowspan="3">6</td><td rowspan="2">18.75</td><td rowspan="2">Dual</td><td rowspan="2">November to February (spring/summer)</td></tr>
<tr><td>Harmony 4-D</td></tr>
<tr><td>B</td><td>Scarborough 4-D</td><td rowspan="4">12.5</td><td>Triple</td><td rowspan="4">January to May (summer/autumn)</td></tr>
<tr><td rowspan="3">C</td><td>Laverda 4-D</td><td>2650</td><td>5</td><td rowspan="3">Dual</td></tr>
<tr><td>Cimatti 4-D</td><td rowspan="2">3150</td><td rowspan="2">6</td></tr>
<tr><td>Vincent 4-D</td></tr>
</table>

2. Modelling Scenarios

For the six planned 4-D Marine Seismic Surveys (MSS) within three Survey Areas constituting the Woodside 4-D North-West-Shelf seismic campaign, twenty-three standalone single impulse sites and one likely scenario for survey operations over 24 hours to assess accumulated SEL were defined for each planned survey. The scenarios were designed considering acquisition lines for previous 3D or 4-D surveys for all except Scarborough, which was designed with a new acquisition line plan. Table 8 provides the locations of all modelling sites, with all sites shown in maps for each Survey Area, A (Figure 2), B (Figure 3), and C (Figure 4). The single impulse locations considered the entire line along with the seismic source would be operational at full-power, including run-outs sections of lines. The lengths of the line run-outs are approximately equal to half the streamer length. Therefore, some single impulse modelling sites and sections of the considered acquisition lines for each 24 h SEL scenario are outside the fullfold areas.

The considered acquisition lines for each 24 h SEL scenario for each survey are shown in Figures 5–10 along with the survey boundaries. Because the Pluto and Harmony 4-D MSS operational areas overlap, Sites 1 and 3 were assessed for both surveys, accounting for the different tow directions for each survey (Table 8, Figures 5 and 6). The modelling assumed that the seismic vessel will sail along the survey lines at ~4.5 knots, with an impulse interval of either 12.5 or 18.75 m depending on the survey (Table 7). The considered survey lines will take between ~2.19–7.89 h to traverse, with ~3.26–3.32 h of turn time required between the lines, the scenarios account for between 4621–11316 impulses. The details for each 24 h SEL scenario are detailed in Table 9.

Single impulse sound fields relevant to identified receptors were also sampled at fixed receiver locations in each Survey Area (Table 10, Figures 11–13). Fixed receiver locations were typically only defined when no part of the identified receptor was within the survey area. Typically, the single impulse sound fields sampled represented the closest potential impulse to the receptor; however, the Area B (Scarborough 4-D Survey) modelling site is 17.1 km from the closest boundary of the fullfold area to the Pygmy Blue Whale Biologically Important Area (BIA) for migration (Figure 12), and results must be considered in this context.

Table 8. Location details for the standalone single impulse sites.

Survey area	Survey/SEL24h scenario	Site	Location		MGA (GDA94), Zone 50		Water depth (m)	Tow direction (°)
			Latitude (S)	Longitude (E)	*X* (m)	*Y* (m)		
A	Pluto	1	20° 03' 28.803"	115° 14' 48.366"	316648.0	7781138	100	0
		2	20° 01' 12.835"	115° 14' 49.858"	316647.5	7785319	125	0
		3	19° 58' 23.066"	115° 14' 51.754"	316648.0	7790540	154	0
		4	19° 53' 28.478"	115° 14' 54.970"	316647.1	7799600	226	0
		5	19° 48' 46.866"	115° 14' 58.066"	316647.3	7808260	328	0
		6	19° 45' 52.523"	115° 14' 59.981"	316647.6	7813622	593	0
		7	19° 44' 14.457"	115° 11' 55.600"	311248.0	7816581	959	180
		8	19° 48' 27.754"	115° 11' 52.732"	311247.4	7808791	573	180
		9	19° 53' 13.914"	115° 11' 49.489"	311247.1	7799991	326	180
		10	19° 59' 17.906"	115° 11' 45.360"	311247.2	7788797	177	180
		11	20° 05' 26.472"	115° 11' 41.173"	311247.9	7777462	121	180
		12	20° 04' 26.392"	115° 16' 12.381"	319107.6	7779393	76	0
	Harmony	1	20° 03' 28.803"	115° 14' 48.366"	316648.0	7781138	100	56
		3	19° 58' 23.066"	115° 14' 51.754"	316648.0	7790540	154	235
		13	20° 06' 26.920"	115° 02' 01.393"	294425.8	7775412	257	56
		14	20° 12' 03.476"	115° 01' 12.961"	293142.1	7765045	159	235
B	Scarborough	15	19° 50' 01.396"	113° 11' 09.236"	100379.1	7802401	910	26 and 206
C	Laverda	16	21° 30' 43.518"	113° 52' 04.642"	175494.6	7617922	788	36 and 215
		17	21° 33' 27.010"	113° 46' 14.540"	165515.2	7612684	903	36
		18	21° 36' 28.030"	113° 50' 40.310"	173280.6	7607269	769	36
	Cimatti	19	21° 28' 06.488"	113° 57' 23.154"	184573.7	7622936	615	23 and 203
		20	21° 33' 37.780"	113° 56' 46.620"	183720.7	7612720	505	23
	Vincent	21	21° 27' 44.083"	114° 05' 47.480"	199088.9	7623902	283	91 and 271
		22	21° 27' 37.263"	113° 59' 05.174"	187495.3	7623892	535	91 and 271
		23	21° 28' 27.670"	114° 05' 18.630"	198282.8	7622545	275	91

Table 9. Details for each 24 h SEL Scenario for each survey.

Survey area	Survey name	Array size (in³)	Impulse interval (m)	Number of survey lines	Average time per line (h)	Number of impulses
A	Pluto 4-D	3150	18.75	3	5.0	9834
	Harmony 4-D			4	3.9	10089
B	Scarborough 4-D		12.5	3	7.2	11316
C	Laverda 4-D	2650		5	2.1	6776
	Cimatti 4-D	3150		5	2.2	7117
	Vincent 4-D			6	1.4	5553

Table 10. Sound field sampling locations for single impulse sound fields in each Survey Area relevant to identified receptors.

Area	Receiver name	Relevant modelling site	Distance (km)	Location		Water depth (m)
				Latitude (S)	Longitude (E)	
A	Flatback Turtle Internesting BIA	12	0.78	20° 04' 47.59"	115° 16' 27.41"	73
	Montebello Islands Marine Park (WA)		32.8	20° 18' 48.03"	115° 27' 18.00"	33
	Humpback Whale BIA, Migration (north and south)		19.8	20° 14' 00.91"	115° 21' 16.81"	18
B	Pygmy Blue Whale BIA, Migration	15	58.5	20° 03' 49.48"	113° 41' 21.42"	1111
C	Gascoyne Marine Park (Commonwealth)	17	2.1	21° 33' 25.75"	113° 45' 00.00"	929
	Ningaloo Marine Park (WA)	18	26.9	21° 46' 57.12"	114° 01' 29.08"	51
	Ningaloo Marine Park (WA)	20	28.2	21° 42' 37.97"	114° 10' 00.82"	36
	Gascoyne Marine Park (Commonwealth)		12.6	21° 39' 55.36"	113° 53' 56.17"	416
	Commonwealth waters adjacent to Ningaloo Reef KEF	23	21.2	21° 39' 55.36"	114° 05' 08.24"	134
	Muiron Islands Marine Management Area (WA)		29	21° 35' 20.75"	114° 20' 25.66"	80

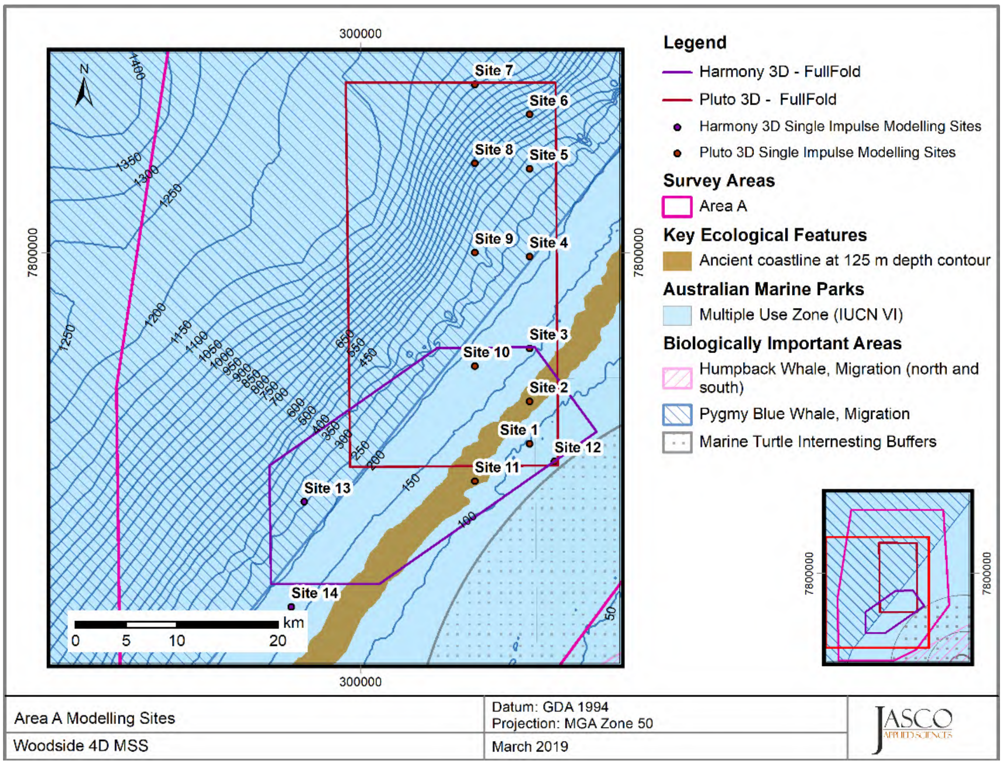

Figure 2. *Area A*: Modelling sites and survey fullfold areas.

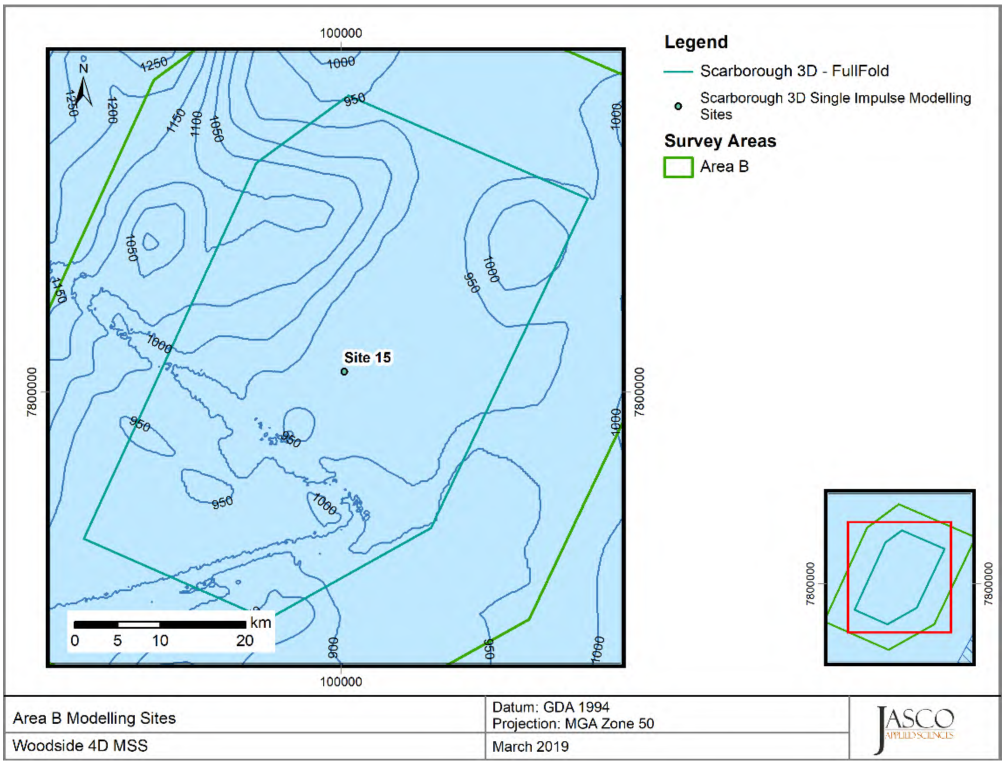

Figure 3. *Area B*: Modelling sites and survey fullfold area.

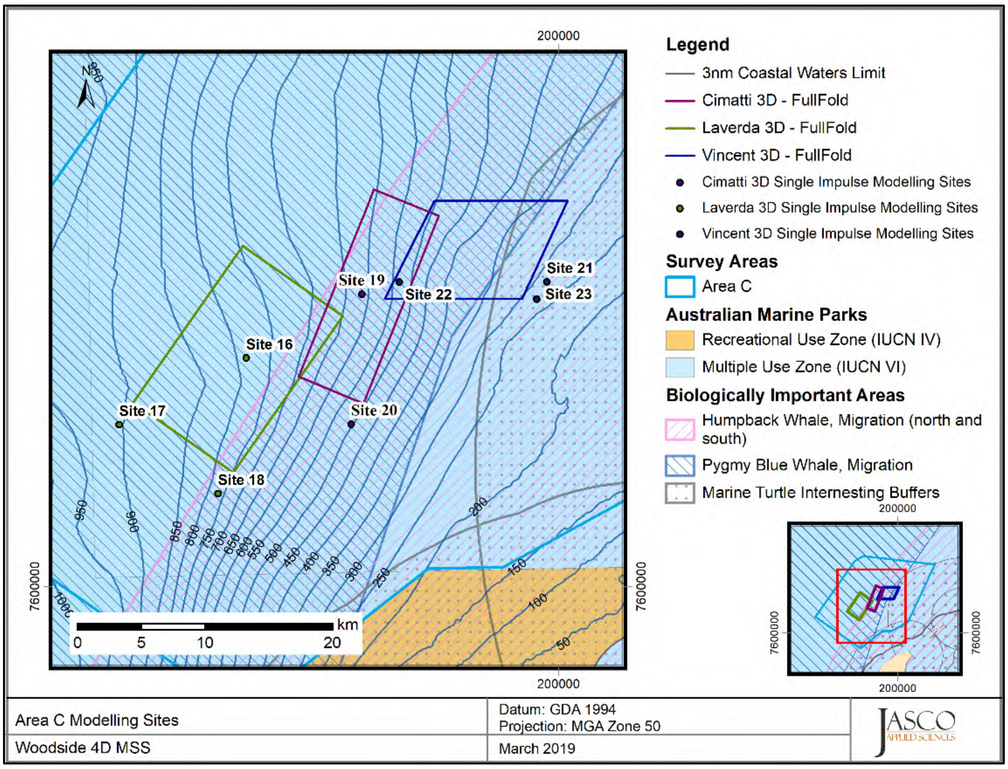

Figure 4. *Area C*: Modelling sites and survey fullfold areas.

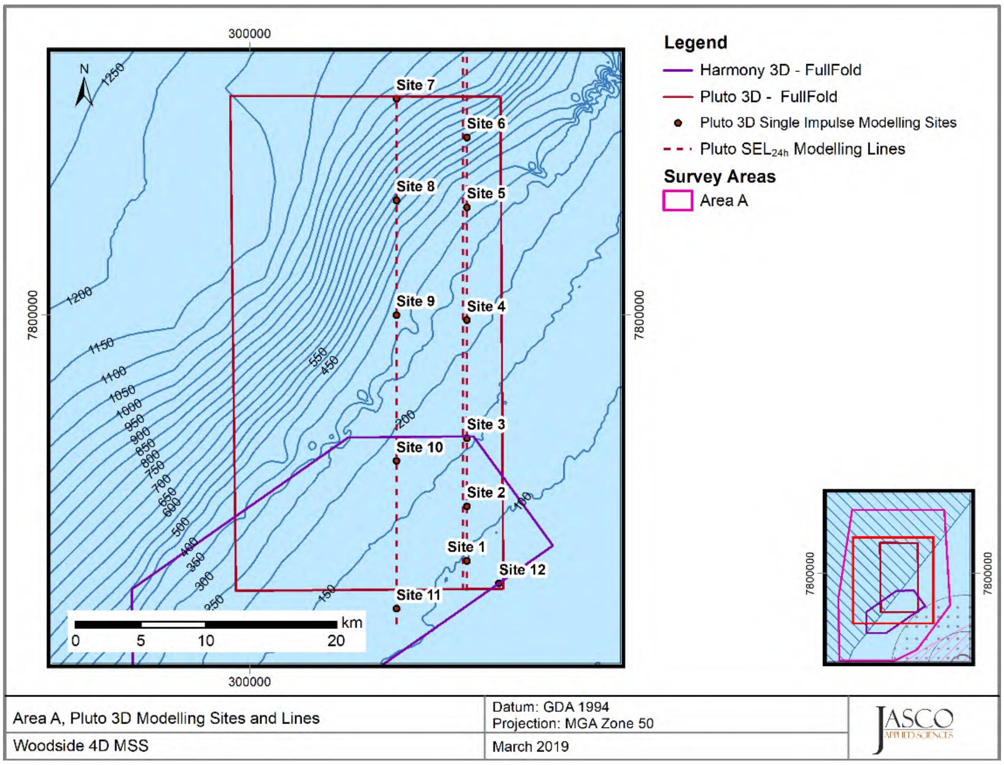

Figure 5. *Area A, Pluto Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Pluto 4-D Survey.

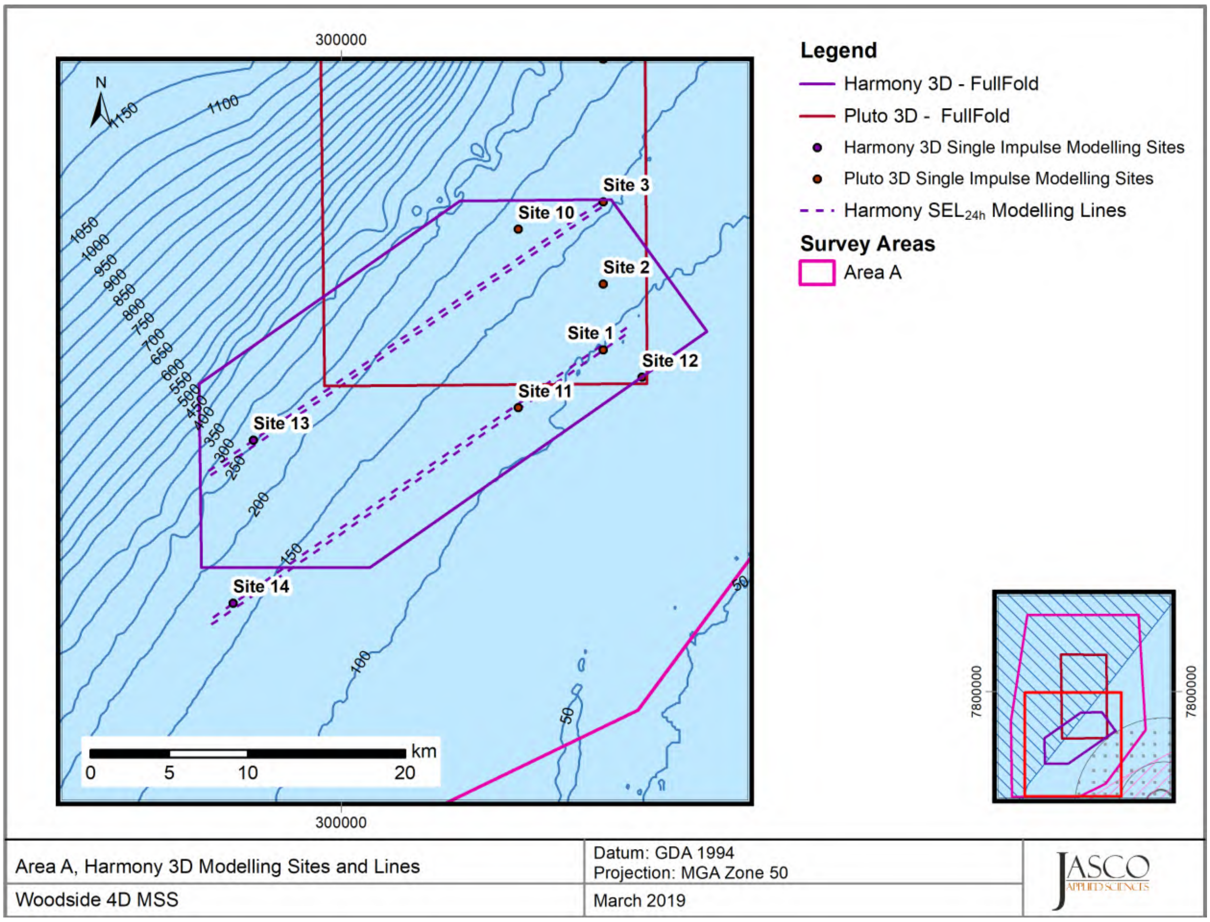

Figure 6. *Area A, Harmony Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Harmony 4-D Survey.

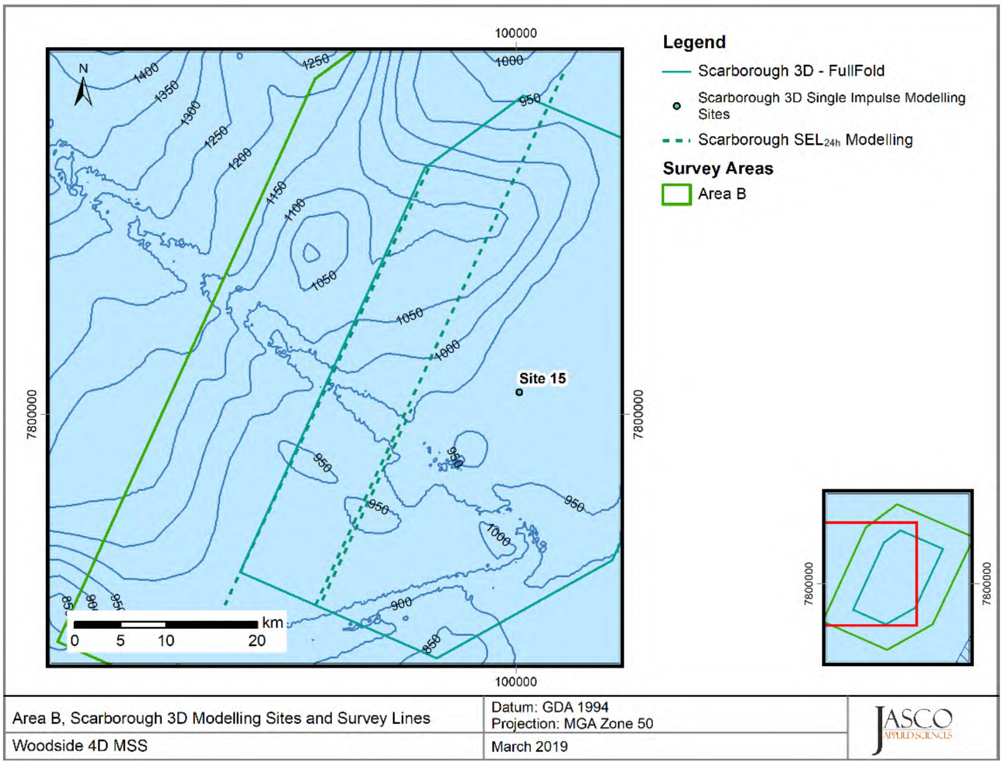

Figure 7. *Area B, Scarborough Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Scarborough 4-D Survey.

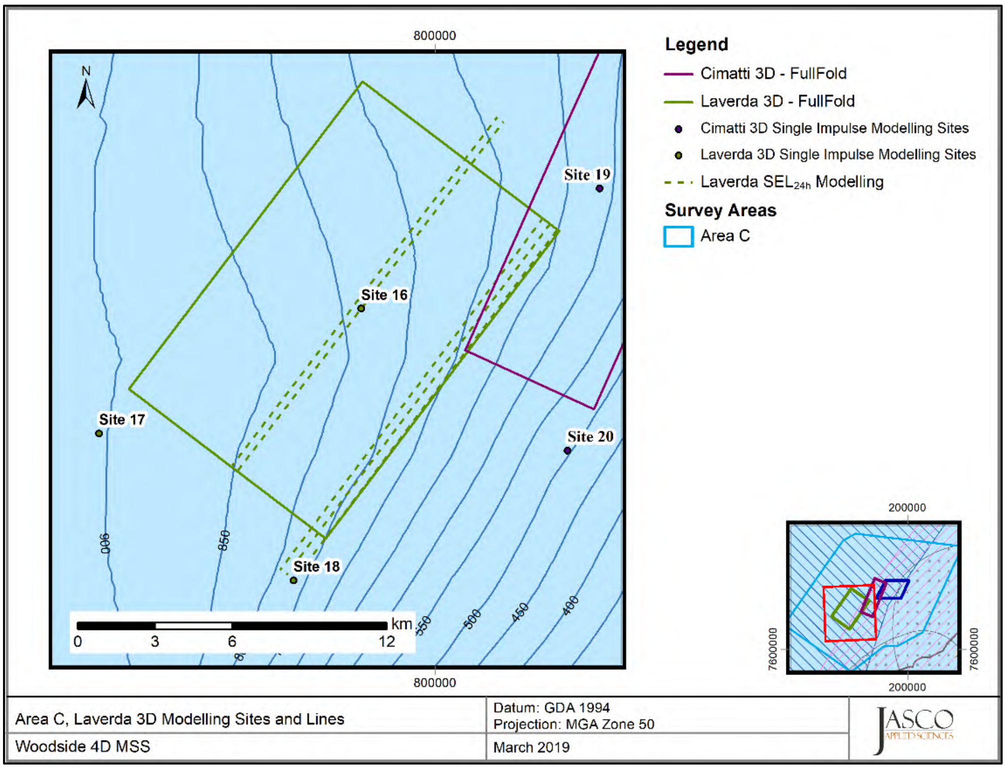

Figure 8. *Area C, Laverda Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Laverda 4-D Survey.

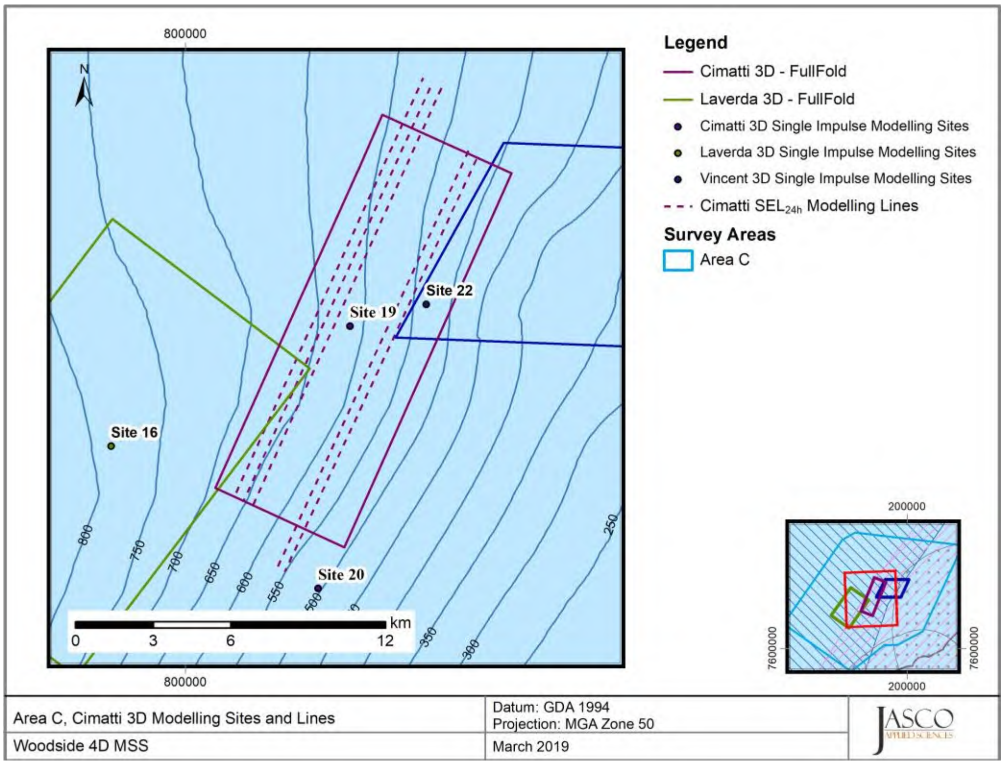

Figure 9. *Area C, Cimatti Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Cimatti 4-D Survey.

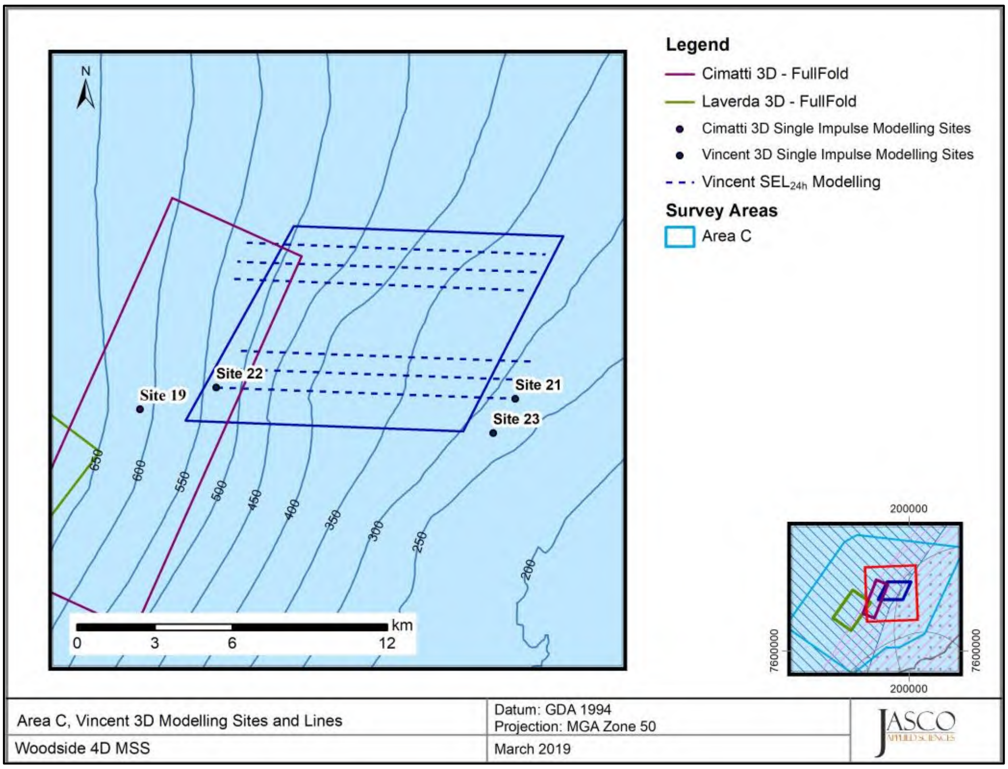

Figure 10. *Area C, Vincent Scenario*: Representative acquisition lines considered for SEL_{24h} calculations for Vincent 4-D Survey.

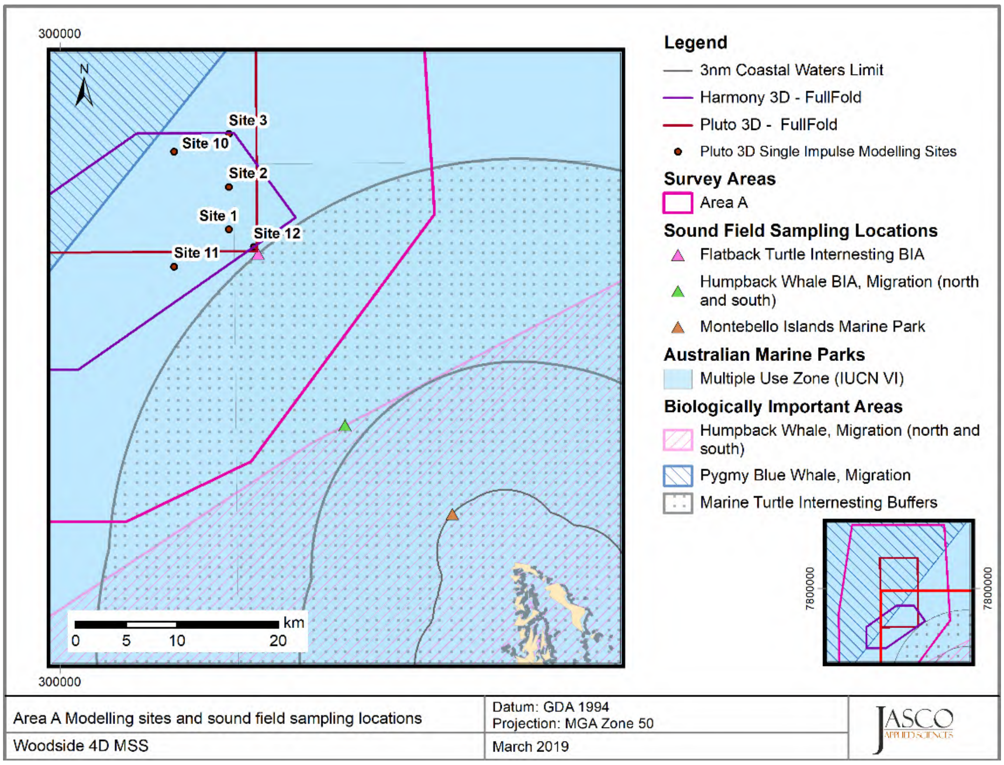

Figure 11. *Area A*: Sound field sampling locations and close modelling sites.

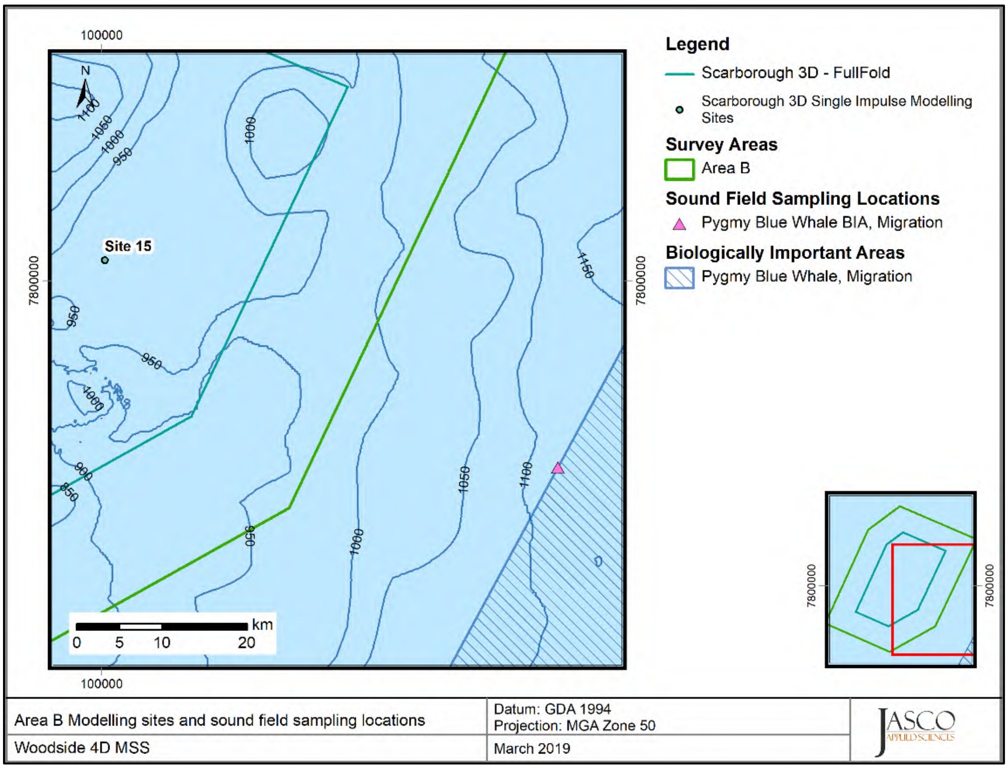

Figure 12. *Area B*: Sound field sampling location and modelling sites.

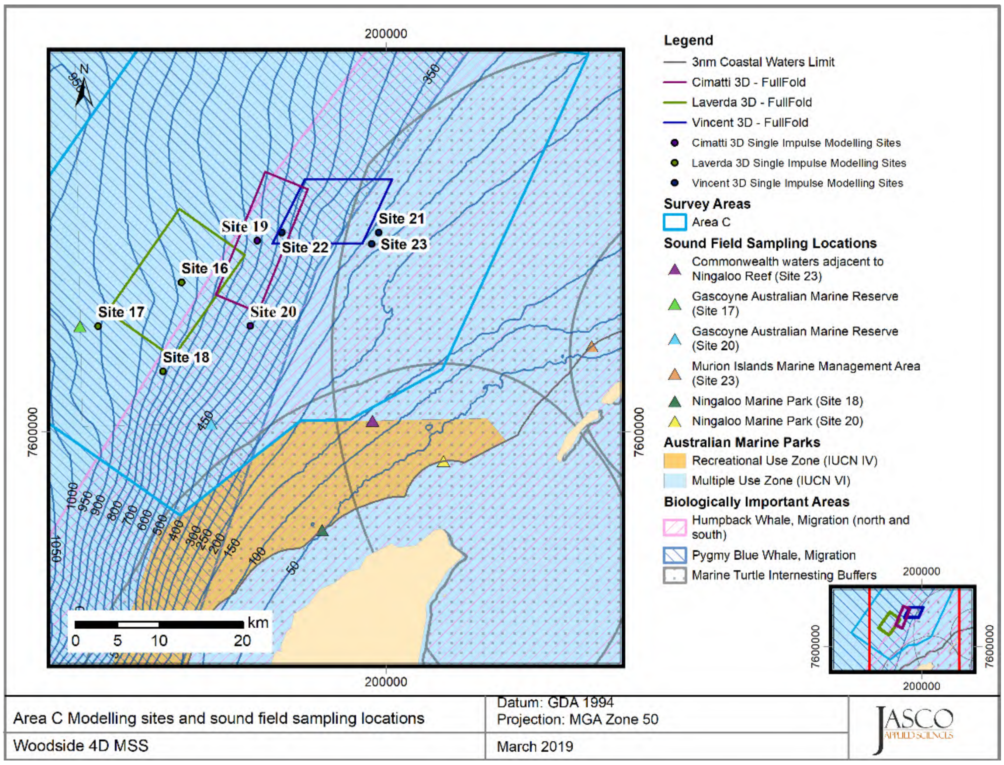

Figure 13. *Area C*: Sound field sampling locations and close modelling sites.

2.1. Pygmy Blue Whales

Blue whales are known to primarily migrate and feed in the first few hundred metres of the water column (Croll et al. 2001, Goldbogen et al. 2011, Owen et al. 2016). A single pygmy blue whale tagged with a multi-sensor tag in Australian waters was tagged 35 km north of the Perth Canyon. The tag remained on the animal for 7.6 days, falling off when the whale was off the coast of Geraldton. This whale spent 94% of its time and completed 99% of its migratory dives at depths less than 24 m, while the mean maximum depth of feeding dives was 129 m and the maximum dive depth was 506 m (Owen et al. 2016). Therefore, this modelling study has considered the sections of the water column ≤24, 129, and 506 m in relation to potential behavioural disturbance, PTS and TTS for pygmy blue whales.

2.2. Turtles

Several turtle species occur in the region of planned survey operations. The turtle with the deepest dive depths as reported in literature is the leatherback turtle (*Dermochelys coriacea*). A summary of the published information on their dive depths is listed Table 11, with the deepest average dive depth of <250 m being applied in the modelling in relation to estimating the potential exposure to sound levels which may cause behavioural disturbance.

Table 11. Dive depths recorded for leatherback turtles.

Reference	Maximum dive depth (m)	Average dive depth (m)	Description
Doyle et al. (2008)	1280 (single sample) and 615 otherwise	–	Animal T1: Deepest dive ever recorded for a reptile; animal diving around a mesoscale oceanographic feature (eddie)
		<200	Animal T1: 1783 of 1815 dives (98%) in the range of 10 to 200 m
		<150	Maximum dive depth generally shallower than 150 m (94%)
Hays et al. (2004)	1230	<250	99% of dives shallower than 250 m

3. Noise Effect Criteria

The perceived loudness of sound, especially impulsive noise such as from seismic airguns, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the pulse rise-time and duration, and the frequency content. Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (Appendix A). The period of accumulation associated with SEL is defined, with this report referencing either a "per pulse" assessment or over 24 h. Appropriate subscripts indicate any applied frequency weighting; unweighted SEL is defined as required. The acoustic metrics in this report reflect the updated ISO standard for acoustic terminology, ISO/DIS 18405.2:2017 (2017).

Whether acoustic exposure levels might injure or disturb marine mammals is an active research topic. Since 2007, several expert groups have investigated an SEL-based assessment approach for injury, with a handful of key papers published on the topic. The number of studies that investigated the level of disturbance to marine animals by underwater noise has also increased substantially.

We chose the following noise criteria and sound levels for this study because they include standard thresholds, thresholds suggested by the best available science, and sound levels presented in literature for species with no suggested thresholds (Sections 3.1–3.3 and Appendix A):

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{\text{E,24h}}$) from the U.S. National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for the onset of Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) in marine mammals.
2. Marine mammal behavioural threshold based on the current interim U.S. National Marine Fisheries Service (NMFS) (2014) of 160 dB re 1 µPa SPL (L_{p}) for impulsive sound sources.
3. Sound exposure guidelines for fish, fish eggs, and larvae (Popper et al. 2014).
4. A threshold for turtle PTS of 232 dB re 1 µPa (PK) (Finneran et al. 2017), and a behavioural response of 166 dB re 1 µPa SPL (L_{p}) (NSF 2011b), as applied by the U.S. NMFS, along with a sound level associated with an increased level of response 175 dB re 1 µPa (SPL) (Moein et al. 1995, McCauley et al. 2000b, McCauley et al. 2000a, NSF 2011b).
5. A sound level 178 dB re 1 µPa peak-peak pressure levels (PK-PK; $L_{\text{pk-pk}}$) in the water column, reported for comparing to McCauley et al. (2017a) for plankton.
6. PK-PK at the seafloor to help assess effects of noise on crustaceans and bivalves, through comparing to results in Payne et al. (2008), and Day et al. (2016).
7. A sound level of 226 dB re 1 µPa PK (L_{pk}) reported for comparing to Heyward et al. (2018) for sponges and corals.

Additionally, to assess the size of the low-power zone required under the Australian Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1, Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008), the distance to an unweighted per-pulse SEL of 160 dB re 1 $\mu Pa^2 \cdot s$ is reported.

To make these results more biologically relevant, specific thresholds were assessed with respect to the dive depths of species of interest in addition to considering the entire water column. As outlined in Section 2.1, the sections of the water column ≤24, 129, and 506 m were assessed for pygmy blue whales in relation to the marine mammal behavioural threshold of 160 dB re 1 µPa SPL (NMFS 2014), and for potential PTS and TTS. Water depths ≤250 m (Section 2.2) were assessed for behavioural disturbance to turtles.

The following sections expand on the thresholds and sound levels for marine mammals, fish, turtles, fish eggs, and fish larvae, benthic invertebrates and humans.

3.1. Marine Mammals

The criteria applied in this study to assess possible effects of airgun noise on marine mammals are summarised in Table 12 and detailed in Sections 3.1.1 and 3.1.2, with frequency weighting explained in Appendix A.3.

Table 12. Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine mammals.

Hearing group	**NMFS (2014)**	**NMFS (2018)**			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213
Mid-frequency cetaceans		185	230	170	224
High-frequency cetaceans		155	202	140	196

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_p denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa²s.
Subscripts indicate the designated marine mammal auditory weighting.

3.1.1. Behavioural response

Southall et al. (2007) extensively reviewed marine mammal behavioural responses to sounds. Their review found that most marine mammals exhibited varying responses between 140 and 180 dB re 1 µPa SPL, but inconsistent results between studies makes choosing a single behavioural threshold difficult. Studies varied in their lack of control groups, imprecise measurements, inconsistent metrics, and that animal responses depended on study context, which included the animal's activity state. To create meaningful quantitative data from the collected information, Southall et al. (2007) proposed a severity scale that increased with increasing sound levels.

NMFS has historically used a relatively simple sound level criterion for potentially disturbing a marine mammal. For impulsive sounds, this threshold is 160 dB re 1 µPa SPL for cetaceans (NMFS 2014). This threshold has been applied for this report.

3.1.2. Injury and hearing sensitivity changes

There are two categories of auditory threshold shifts or hearing loss: permanent threshold shift (PTS), a physical injury to an animal's hearing organs; and Temporary Threshold Shift (TTS), a temporary reduction in an animal's hearing sensitivity as the result of receptor hair cells in the cochlea becoming fatigued.

To assist in assessing the potential for injuries to marine mammals this report applies the criteria recommended by NMFS (2018), considering both PTS and TTS, to help assess the potential for injuries to marine mammals. Appendix A.2 provides more information about the NMFS (2018) criteria.

3.2. Fish, Turtles, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure criteria for fish and turtles, work begun by a panel convened by NOAA two years earlier. The resulting guidelines included specific thresholds for different levels of effects and for different groups of species (Popper et al. 2014). These guidelines defined quantitative thresholds for three types of immediate effects:

- Mortality, including injury leading to death.
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma.
- TTS.

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. These effects are not assessed in this report. Because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to injury from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Turtles, fish eggs, and fish larvae are considered separately.

Table 13 lists relevant effects thresholds from Popper et al. (2014). In general, any adverse effects of seismic sound on fish behaviour depends on the species, the state of the individuals exposed, and other factors. We note that, despite mortality being a possibility for fish exposed to airgun sounds, Popper et al. (2014) do not reference an actual occurrence of this effect. Since the publication of that work, newer studies have further examined the question of possible mortality. Popper et al. (2016) adds further information to the possible levels of impulsive seismic airgun sound to which adult fish can be exposed without immediate mortality. They found that the two fish species in their study, with body masses in the range 200–400 g, exposed to a single-impulse of a maximum received level of either 231 dB re 1 µPa (PK) or 205 dB re 1 µPa^2·s (SEL), remained alive for 7 days after exposure and that the probability of mortal injury did not differ between exposed and control fish.

The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time. Popper et al. (2014) recommend a standard period should be applied, where this is either defined as a justified fixed period or the duration of the activity, however also include caveats about how long the fish will be exposed because they can move (or remain in location) and so can the source. Popper et al. (2014) summarises that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18–24 hours. Due to this, a period of accumulation of 24 hours has been applied in this study for SEL, which is similar to that applied for marine mammals in NMFS (2016, 2018).

In the discussion of the criteria, Popper et al. (2014) discuss the complications in determining a relevant period of mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source, and that in reality a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiver's accumulated level (Gedamke et al. 2011). Additionally, several important factors determine the likelihood and duration a receiver is expected to be in close proximity to a sound source (i.e., overlap in space and time between the source and receiver). For example, accumulation time for fast moving (relative to the receiver) mobile sources is driven primarily by the characteristics of source (i.e., speed, duty cycle; NMFS 2016, NMFS 2018).

Table 13. Criteria for seismic noise exposure for fish , adapted from Popper et al. (2014).

Type of animal	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	>219 dB SEL_{24h} or >213 dB PK	>216 dB SEL_{24h} or >213 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	>>186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or >207 dB PK	203 dB SEL_{24h} or >207 dB PK	186 dB SEL_{24h}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Fish eggs and fish larvae	>210 dB SEL_{24h} or >207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes: Peak sound level (PK) dB re 1 µPa; SEL_{24h} dB re 1µPa^2·s. All criteria are presented as sound pressure, even for fish without swim bladders, since no data for particle motion exist. Relative risk (high, moderate, or low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

3.2.1. Turtles

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. For turtle injury, a PTS of 232 dB re 1 µPa (PK), and TTS of 226 dB re 1 µPa (PK) from Finneran et al. (2017) has been applied as it represents updated information compared to the information in Popper et al. (2014), which suggested injury to turtles could occur for sound exposures above 207 dB re 1 µPa (PK) or above 210 dB re 1 µPa^2·s (SEL_{24h}).

McCauley et al. (2000b) observed the behavioural response of caged turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the turtles increased their swimming activity and above 175 dB re 1 µPa they began to behave erratically, which was interpreted as an agitated state. The 166 dB re 1 µPa level has been used as the threshold level for a behavioural disturbance response by NMFS and applied in the Arctic Programmatic Environment Impact Statement (PEIS) (NSF 2011b). At that time, and in the absence of any data from which to determine the sound levels that could injure an animal, TTS or PTS onset were considered possible at an SPL of 180 dB re 1 µPa (NSF 2011b). Some additional data suggest that behavioural responses occur closer to an SPL of 175 dB re 1 µPa, and TTS or PTS at even higher levels (Moein et al. 1995), but the received levels were unknown and the NSF (2011b) PEIS maintained the earlier NMFS criteria levels of 166 and 180 dB re 1 µPa (SPL) for behavioural response and injury, respectively. Sound levels defined by Popper et al. (2014) show that animals are very likely to exhibit a behavioural response when they are near an airgun (tens of metres), a moderate response if they encounter the source at intermediate ranges (hundreds of metres), and a low response if they are far (thousands of meters) from the airgun. The NMFS criterion for behavioural disturbance (SPL of 166 dB re 1 µPa), the Moein et al. (1995) or McCauley et al. (2000b) criterion for behavioural disturbance (SPL of 175 dB re 1 µPa) were included in this analysis. The analysis did not, however, consider the ranges where an animal could suffer impairment, as defined by Popper et al. (2014).

3.3. Benthic Invertebrates (Crustaceans and Bivalves)

Research is ongoing into the relationship between sound and its effects on crustaceans, including the relevant metrics for both effect and impact. Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and bivalve hearing. Water depth and seismic source size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on crustaceans and bivalves.

At the seafloor interface, crustaceans and bivalves are subject to particle motion stimuli from several acoustic or acoustically-induced waves. These include the particle motion associated with an impinging sound pressure wave in the water column (the incident, reflected, and transmitted portions), substrate acoustic waves, and interface waves of the Scholte type. However, it is unclear which aspect(s) of these waves is/are most relevant to the animals, either when they normally sense the environment or their physiological responses to loud sounds so there is not enough information to establish similar criteria and thresholds as done for marine mammals and fish. Including recent research, such as Day et al. (2016), current literature does not clearly define an appropriate metric or identify relevant levels (pressure or particle motion) for an assessment. This includes the consideration of what particle motion levels lead to a behavioural response, or mortality. Therefore, at this stage, we cannot propose authoritative thresholds to inform the impact assessment. However, levels can be determined for pressure metrics presented in literature to assist the assessment.

In relation to particle motion, Day et al. (2016) suggests that interface waves, such as Scholte waves, could contribute to the physiological and behavioural responses for scallops, and we argue that this could be the case for lobsters as well. Scholte waves are capable of traveling moderate distances with relatively little attenuation, making their area of potential impact quite large. However, the ability to excite Scholte waves decreases exponentially with source height above the seabed and hence, for airgun arrays, with water depth. As the shallowest depth considered in this study is 76 m, Scholte wave excitement is less likely to occur here than in shallower water. Therefore, for crustaceans, a PK-PK sound level of 202 dB re 1 µPa (Payne et al. 2008) is considered to be associated with no impact, and therefore applied in the assessment. Additionally for context, the PK-PK sound levels determined for crustaceans in Day et al. (2016), 209–212 dB re 1 µPa, are also included.

3.4. Human health assessment threshold

Under water, the human ear is about 20 dB less sensitive than it is in air at low frequencies (20 Hz), increasing to 40 dB at mid-frequencies (less than 1 kHz), and increasing to 70–80 dB less sensitive at higher frequencies (Parvin 1998). Divers who wear neoprene hoods have even higher hearing thresholds (lower sensitivity) above 500 Hz because the hood material absorbs high-frequency sounds (Sims et al. 1999). Exposure studies related to divers have typically focused on military sonar exposure, with little information on piling or dredging operations, and as such care is required when considering thresholds for recreational divers and swimmers, particularly for impulsive sounds such as pile driving (Ainslie 2008).

The auditory threshold of hearing under water was lowest at 1 kHz (70 dB re 1 µPa SPL) and increased for lower and higher frequencies to around 120 dB re 1 µPa at 20 Hz and at 20 kHz (Parvin 1998). Fothergill et al. (2000) and Fothergill et al. (2001) conducted controlled acoustic exposure experiments on military divers under fully controlled conditions at a US Ocean Simulation Facility and an US Open water test facility; in all tests, the diver were covered with soft or hard shell dive suits and their position and distance relative to sound source, signal characteristics and received levels were controlled and documented (Pestorius et al. 2009). A total of 89 male Navy divers were exposed to pure tone signals and sweeps between 160-320 Hz at SPLs up to 160 dB re 1 µPa. The divers were exposed to these sounds over 100 seconds at depths from 10 to 40 metres. The divers rated the sounds on a severity scale. For frequencies between 100 and 500 Hz, at a received SPL of 130 dB re 1 µPa, divers and swimmers detected body vibration. None of the divers tested rated levels of 140 dB re 1 µPa as “very severe”; however, at 157 dB re 1 µPa, sound was rated as “very severe” 19 per cent of the time. No physiological damage was observed at the highest levels tested: 160 dB re 1 µPa (Fothergill et al. 2001). In a subsequent study, recreational divers were exposed to tonal signals or 30 Hz-sweeps at frequencies between 100 and 500 Hz at received levels of 130-157 dB re 1 µPa (Pestorius et al. 2009). Each exposure lasted for seven seconds. Nine female and 17 male scuba divers were tested, all wearing full body neoprene wetsuits. Diver aversion and perception of body vibration were used as test parameters. The results showed no sex-specific differences. The results differed as a function of frequency – while test results showed a strong overall variation between subjects, signals at 100 Hz elicited the strongest aversion in all tests and even at 148 dB a few diver ratings indicated extreme aversion. Due to this and the strong variation between test subjects, the following exposure limit for both military and recreational divers was suggested as a conservative measure: For frequencies between 100 and 500 Hz, the maximum SPL should be 145 dB re 1 µPa over a maximum continuous exposure of 100 seconds or with a maximum duty cycle of 20 per cent and a maximum daily cumulative total of three hours. The trading relation between the maximum SPL and duration was 4 dB per doubling of duration (eg 141 dB SPL for a 200 second exposure) (Pestorius et al. 2009).

Considering only frequencies between 100 and 500 Hz, Parvin (2005) suggested 145 dB re 1 µPa as a safety criterion for recreational divers and swimmers. Seismic impulses are broadband sources, and therefore, to be precautionary, the 145 dB re 1 µPa SPL suggested by Fothergill et al. (2001) and Parvin (2005) has been applied in this study as a broadband SPL and as a human health assessment threshold for recreational divers and swimmers. This does not imply that this level is associated with the onset of injury.

4. Methods

4.1. Acoustic Source Model

The pressure signatures of the individual airguns and the composite 1/3-octave-band point-source equivalent directional levels (i.e., source levels) of two seismic sources (3150 and 2650 in^3) were modelled with JASCO's Airgun Array Source Model (AASM). Although AASM accounts for notional pressure signatures of each seismic source with respect to the effects of surface-reflected signals on bubble oscillations and inter-bubble interactions, the surface-reflected signal (known as surface ghost) is not included in the far-field source signatures. The acoustic propagation models account for those surface reflections, which are a property of the propagating medium rather than the source.

AASM considers:

- Array layout.
- Volume, tow depth, and firing pressure of each airgun.
- Interactions between different airguns in the array.

The array was modelled over AASM's full frequency range, up to 25 kHz. Appendix B details this model.

4.2. Sound Propagation Models

Three sound propagation models were used to predict the acoustic field around the seismic source:

- Combined range-dependent parabolic equation and gaussian beam acoustic ray-trace model (MONM-BELLHOP, 10 Hz to 25 kHz).
- Full Waveform Range-dependent Acoustic Model (FWRAM, 5 Hz to 1 kHz).
- Wavenumber integration model (VSTACK, 5 Hz to 1 kHz).

4.3. Parameter Overview

The specifications of the seismic sources and the environmental parameters used in the propagation models are described in detail in Appendix D. The following seismic sources were considered:

- A 3150 in^3 seismic source array consisting of two strings towed at a 6 m depth, (see Figure D-13 and Table D-4) with a nominal firing pressure of 2000 psi (Pluto, Harmony, Scarborough, Cimatti, and Vincent surveys).
- A 2650 in^3 seismic source array consisting of two strings towed at a 5 m depth, (see Figure D-14 and Table D-5) with a nominal firing pressure of 2000 psi (Laverda survey).

Three sound speed profiles were considered in the modelling with the surveys grouped by geographical location, Survey Area A, B, and C. The profiles were extracted based on the seasonal period that would provide the greatest propagation during the proposed timeframe of the survey (Table 7, Appendix D.3.2).

The following geological profiles were identified and are expanded on in Appendix D.3.3:

- Fine sand layer overlying calcarenite, sites with water depths <200 m (Table D-1).
- Clayey, sandy silt, with surficial silty sand layer overlying calcarenite, sites with water depths within an approximate range of 200–600 m (Table D-2).
- Calcareous ooze overlaying calcarenite, sites with water depths >600 m (Table D-3).

4.4. Accumulated SEL

During a seismic survey, new sound energy is introduced into the environment with each pulse from the seismic source. While some impact criteria are based on the per-pulse energy released, others, such as the marine mammal and fish SEL criteria used in this report (Sections 3.1 and 3.2) account for the total acoustic energy marine fauna is subjected to over a specified period of time, defined in this report as 24 hours. An accurate assessment of the accumulated sound energy depends not only on the parameters of each seismic pulse impulse, but also on the number of impulses delivered in a period and the relative positions of the impulses.

When there are many seismic pulses, it becomes computationally prohibitive to perform sound propagation modelling for every single event. The distance between the consecutive seismic impulses is small enough, however, that the environmental parameters that influence sound propagation are virtually the same for many impulse points. The acoustic fields can, therefore, be modelled for a subset of seismic pulses and estimated at several adjacent ones. After sound fields from representative impulse locations are calculated, they are adjusted to account for the source position for nearby impulses.

Although estimating the cumulative sound field with the described approach is not as precise as modelling sound propagation at every impulse location, small-scale, site-specific sound propagation features tend to blur and become less relevant when sound fields from adjacent impulses are summed. Larger scale sound propagation features, primarily dependent on water depth, dominate the cumulative field. The accuracy of the present method acceptably reflects those large-scale features, thus providing a meaningful estimate of a wide area SEL field in a computationally feasible framework.

To produce the map of accumulated received sound level distributions and calculate distances to specified sound level thresholds, the maximum-over-depth level was calculated at each sampling point within the modelled region. The radial grids of maximum-over-depth and seafloor sound levels for each impulse were then resampled (by linear triangulation) to produce a regular Cartesian grid. The sound field grids from all impulses were summed (Equation A-5) to produce the cumulative sound field grid with cell sizes of 40 m. The contours and threshold ranges were calculated from these flat Cartesian projections of the modelled acoustic fields. The single-impulse SEL fields were computed over model grids 180 × 180 km in range, which encompasses the full area of the cumulative grid (the entire survey area).

The unweighted (fish) and frequency-weighted SEL_{24h} results were rendered as contour maps, including contours that focus on the relevant criteria-based thresholds. Only contours at ranges larger than the nearfield of the seismic source were rendered.

4.5. Geometry and Modelled Regions

To assess sound levels with MONM-BELLHOP, the sound field modelling calculated propagation losses up to distances at least 100 km from the source, with a horizontal separation of 40 m between receiver points along the modelled radials. The sound fields were modelled with a horizontal angular resolution of $\Delta\theta$ = 2.5° for a total of N = 144 radial planes. Receiver depths were chosen to span the entire water column and the seafloor for all the modelling areas. Receiver depths varied depending on the maximum water depth in each calculation area. The receiver depths ranged from 2 to 1500 m (Site 1) and from 2 to 3500 m (Site 17), with step sizes that increased with depth. To supplement the MONM results, high-frequency results for propagation loss were modelled using Bellhop for frequencies from 1 to 25 kHz. The MONM and Bellhop results were combined to produce results for the full frequency range of interest.

FWRAM was run to 100 km, but along only four radials (fore and aft endfire, and port and starboard broadside) for computational efficiency, from 5 to 1000 Hz in 1 Hz steps. This was done to compute SEL-to-SPL conversion curves (Appendix D.2) but also quantify water column PK and PK-PK. The horizontal range step varied depending on frequency, at lower frequencies up to 80 Hz the range step was set at a maximum of 50 m. For frequencies above 800 Hz a minimum range step of 10 m was used.

The maximum modelled range for VSTACK was 1000 m and used a step size of 10 m. Received levels were computed for receivers at seafloor.

5. Results

5.1. Acoustic Source Levels and Directivity

AASM (Section 4.1) was used to predict the horizontal and vertical overpressure signatures and corresponding power spectrum levels for the two seismic sources, the 3150 and 2650 in^3 arrays, with time series and spectral results, as well as horizontal directivity plots presented in Appendix B.2.

Tables 14 and 15 show the PK and per-pulse SEL source levels for each seismic source in the horizontal-plane broadside (perpendicular to the tow direction), endfire (along the tow direction), and vertical directions. The vertical source level that accounts for the "surface ghost" (the out of phase reflected pulse from the water surface) is also presented for easier comparison to the output of other seismic source models.

Figures B-1 and B-2 show the broadside, endfire, and vertical overpressure signature and corresponding power spectrum levels for each array. The signatures consist of a strong primary peak, related to the initial release of high-pressure air, followed by a series of pulses associated with bubble oscillations. Most energy is produced at frequencies below 600 Hz, although this is different for each array, with noticeable differences between the broadside and endfire signatures. Frequency-dependent peaks and nulls in the spectrum result from interference among airguns in the array and correspond with the volumes and relative locations of the airguns to each other.

Table 14. Far-field source level specifications for the 3150 in^3 array, for a 6 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa^{2}m^2)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa^{2}m^{2}s)	
		10–2000 Hz	2000–25000 Hz
Broadside	248.4	224.5	186.3
Endfire	246.5	223.5	187.1
Vertical	254.5	227.4	193.8
Vertical (surface affected source level)	254.5	230.3	196.8

Table 15. Far-field source level specifications for the 2650 in^3 array, for a 5 m tow depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$) (dB re 1 µPa^{2}m^2)	Per-pulse source SEL ($L_{S,E}$) (dB 1 µPa^{2}m^{2}s)	
		10–2000 Hz	2000–25000 Hz
Broadside	248.2	223.7	179.4
Endfire	246.1	222.9	182.2
Vertical	254.5	226.6	189.0
Vertical (surface affected source level)	254.5	228.9	192.2

5.2. Per-pulse Sound Fields

For each Survey Area and the single impulse modelling sites within them, tabulated per-pulse results are presented for SPL, SEL, PK, and PK-PK, including the estimated ranges to the various applicable maximum-over-depth per-pulse effects criteria and isopleths of interest. Additionally, distances to SPL behavioural effects criteria for pygmy blue whales and turtles considering only biologically relevant depths (Sections 2.1 and 2.2) are presented. These are referred to as depth limited SPL results. Sound levels at sound field sampling receivers (Table 10) are also included. The estimated ranges for seafloor per-pulse effects criteria and isopleths of interest are presented for modelling sites shallower than 200 m in Survey Area A and the shallowest modelling site in Area C.

Maps of the estimated sound fields for the SPL sound fields and are included in this section along with maps showing marine mammal and turtle behavioural disturbance related SPL isopleths, while maps of the per-pulse SEL sound field are presented in Appendix E.1. Vertical slices of the modelled SPL sound field are shown in the endfire and broadside directions to provide context for the sound levels received at biologically relevant depths.

The tables in this section are as follows:

- Survey Area A:
  - Per-pulse SEL and SPL: Tables 16 and 17.
  - Depth limited SPL results: Table 18.
  - Distances to PK thresholds for marine mammals, fish and turtles: Table 19.
  - Distances to PK-PK sound level of 178 dB re 1µPa: Table 20.
  - Sound levels at sound field sampling receivers: Table 21.
  - Distances to modelled seafloor PK: Table 22.
  - Distances modelled seafloor PK-PK: Table 23.
- Survey Area B:
  - Per-pulse SEL and SPL: Tables 24 and 25.
  - Depth limited SPL results: Table 26.
  - Distances to PK thresholds for marine mammals, fish and turtles: Table 27.
  - Distances to PK-PK sound level of 178 dB re 1µPa: Table 28.
  - Sound levels at sound field sampling receivers: Table 29.
- Survey Area C:
  - Per-pulse SEL and SPL: Tables 30 and 31.
  - Depth limited SPL results: Table 32.
  - Distances to PK thresholds for marine mammals, fish and turtles: Table 33.
  - Distances to PK-PK sound level of 178 dB re 1µPa: Table 34.
  - Sound levels at sound field sampling receivers: Table 35.
  - Distances to modelled seafloor PK: Table 36.
  - Distances modelled seafloor PK-PK: Table 37.

The figures in this section are as follows:

- Area A:
  - Maps of maximum-over-depth SPL sound fields: Figures 14–27.
  - Maps of marine mammal and turtle behavioural disturbance related SPL isopleths: Figures 28–41.
  - Vertical slice plots of SPL sound fields: Figures 42–56.
  - Maps of maximum-over-depth SEL sound fields: Figure E-1 to Figure E-13.
- Area B:
  - Map of maximum-over-depth SPL sound fields: Figure 57.
  - Map of marine mammal and turtle behavioural disturbance related SPL isopleths: Figure 58.

- Vertical slice plots of SPL sound fields: Figure 59.
- Maps of maximum-over-depth SEL sound fields: Figure E-15.

- Area C:
  - Maps of maximum-over-depth SPL sound fields: Figures 61–68.
  - Maps of marine mammal and turtle behavioural disturbance related SPL isopleths: Figures 69–76.
  - Vertical slice plots of SPL sound fields: Figures 77–84.
  - Maps of maximum-over-depth SEL sound fields: Figures E-16 to E-23.

5.2.1. Area A

Area A includes the Pluto and Harmony 4-D fullfold areas (Figure 2), and the seismic source planned for use within Area A is a 3150 in³ array towed at 6 m (Table 7).

5.2.1.1. Tabulated results for the water column

Table 16. *Area A*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the 14 single impulse sites.The water depth at each site is presented in brackets below the site name.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	Site 1 (100 m)		Site 2 (125 m)		Site 3 (154 m)		Site 4 (226 m)		Site 5 (328 m)		Site 6 (593 m)		Site 7 (959 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
180	0.16	0.13	0.16	0.13	0.16	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.13	0.13
170	0.56	0.48	0.60	0.52	0.60	0.52	0.76	0.64	0.60	0.48	0.48	0.42	0.48	0.42
160†	**1.2**	**1.0**	**1.4**	**1.1**	**1.4**	**1.2**	**2.4**	**1.8**	**2.3**	**1.6**	**2.6**	**2.2**	**2.1**	**1.7**
150	2.9	2.7	3.2	2.8	3.3	3.0	8.4	5.5	7.0	5.7	8.9	7.8	8.8	7.3
140	6.3	5.6	6.9	6.1	7.3	6.5	22.1	16.2	31.6	28.0	41.8	35.7	42.6	32.6
130	12.3	11.2	13.4	11.8	14.9	12.7	101.3	86.1	*	*	*	*	*	*
120	24.2	20.3	30.9	25.6	46.9	38.5	*	*	*	*	*	*	*	*
Per-pulse SEL (L_E; dB re 1 µPa²·s)	**Site 8 (573 m)**		**Site 9 (326 m)**		**Site 10 (177 m)**		**Site 11 (121 m)**		**Site 12 (76 m)**		**Site 13 (257 m)**		**Site 14 (159 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	<0.04	<0.04	<0.04	<0.04
180	0.13	0.12	0.13	0.13	0.16	0.13	0.16	0.13	0.17	0.16	0.14	0.14	0.14	0.14
170	0.48	0.42	0.60	0.48	0.61	0.53	0.57	0.50	0.52	0.46	0.76	0.61	0.61	0.52
160†	**2.4**	**1.9**	**2.2**	**1.6**	**1.4**	**1.2**	**1.3**	**1.1**	**1.2**	**1.1**	**2.2**	**1.8**	**1.4**	**1.2**
150	10.2	7.6	8.2	5.9	3.4	3.1	3.2	2.9	3.0	2.8	8.1	6.8	3.3	3.0
140	33.9	27.3	33.2	27.1	8.8	7.4	6.5	5.9	6.0	5.5	33.3	27.4	7.8	6.9
130	*	*	*	*	20.5	17.1	12.4	11.3	11.6	10.5	*	*	19.6	15.9
120	*	*	*	*	89.2	75.2	25.7	22.2	19.5	17.6	*	*	74.2	64.3

† Low power zone assessment criteria DEWHA (2008).
* R_{max} radii extend beyond the 100 km modelling boundary.

Table 17. *Area A*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth SPL isopleths from the 14 single impulse sites . The water depth at each site is presented in brackets below the site name.

SPL (L_p; dB re 1 µPa)	Site 1 (100 m)		Site 2 (125 m)		Site 3 (154 m)		Site 4 (226 m)		Site 5 (328 m)		Site 6 (593 m)		Site 7 (959 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
190	0.13	0.13	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
180	0.52	0.44	0.56	0.48	0.53	0.48	0.64	0.52	0.44	0.37	0.44	0.40	0.44	0.37
170	1.1	0.9	1.2	1.0	1.2	1.1	1.9	1.6	2.1	1.4	2.4	2.1	1.8	1.5
160‡	**2.3**	**2.1**	**2.5**	**2.2**	**2.6**	**2.3**	**6.2**	**4.8**	**6.1**	**5.1**	**8.5**	**6.7**	**7.9**	**6.5**
150	4.6	4.2	4.8	4.4	5.1	4.7	17.6	13.2	30.5	21.1	34.1	29.8	27.4	23.2
145♦	**6.4**	**5.9**	**7.1**	**6.3**	**7.7**	**6.8**	**45.9**	**32.9**	**49.9**	**42.9**	**70.1**	**48.5**	**59.5**	**42.1**
140	9.7	8.1	10.0	8.8	11.2	9.4	91.5	68.9	*	*	*	*	*	*
130	17.5	14.8	19.3	16.8	26.4	19.1	*	*	*	*	*	*	*	*
SPL (L_p; dB re 1 µPa)	**Site 8 (573 m)**		**Site 9 (326 m)**		**Site 10 (177 m)**		**Site 11 (121 m)**		**Site 12 (76 m)**		**Site 13 (257 m)**		**Site 14 (159 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}
200	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	<0.04	<0.04	<0.04	<0.04
190	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.16	0.13	0.11	0.11	0.11	0.11
180	0.44	0.37	0.48	0.37	0.56	0.48	0.52	0.46	0.48	0.42	0.58	0.47	0.54	0.48
170	2.2	1.8	1.6	1.4	1.3	1.1	1.1	1.0	1.0	0.93	2.0	1.6	1.3	1.1
160‡	**7.8**	**5.6**	**5.7**	**4.4**	**2.5**	**2.3**	**2.4**	**2.2**	**2.3**	**2.2**	**6.3**	**5.2**	**2.5**	**2.3**
150	26.7	20.1	29.4	24.2	5.8	5.0	4.7	4.3	4.5	4.2	26.9	21.2	5.5	4.8
145♦	**49.0**	**41.8**	**68.3**	**51.1**	**8.6**	**7.5**	**6.6**	**6.0**	**6.1**	**5.7**	**63.1**	**52.7**	**7.9**	**7.2**
140	*	*	*	*	13.3	11.5	9.0	8.0	8.4	7.8	*	*	12.4	10.6
130	*	*	*	*	37.6	32.7	17.8	15.7	14.6	13.4	*	*	34.0	31.2

* R_{max} radii extend beyond the 100 km modelling boundary.
‡ Marine mammal behavioural threshold for impulsive sound sources (NMFS 2014).
♦ Threshold for divers from Parvin (2005).

Table 18. *Area A*; Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled SPL isopleths from the 14 single impulse sites within the specified biologically relevant depths. The chosen depths are related to mean dive depths for pygmy blue whales and turtles (Section 2.1 and 2.2).

SPL (L_p; dB re 1 µPa)	Depth limit (m)	Site 1 (100 m)		Site 2 (125 m)		Site 3 (154 m)		Site 4 (226 m)		Site 5 (328 m)		Site 6 (593 m)		Site 7 (959 m)	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
160‡	24	2.1	1.9	2.4	2.0	2.4	2.1	5.6	4.5	6.0	4.7	6.6	5.5	7.9	7.0
	129	2.3	2.1	2.4	2.2	2.4	2.2	6.2	4.9	6.1	5.2	7.1	5.9	7.9	6.9
	506	2.3	2.1	2.5	2.2	2.6	2.3	6.2	4.8	6.1	5.1	8.5	6.7	7.9	6.8
166†	250	1.4	1.3	1.5	1.4	1.6	1.4	2.9	2.4	2.8	2.4	2.3	2.0	1.4	1.2
175#		0.76	0.65	0.84	0.71	0.84	0.72	1.0	0.89	0.76	0.65	0.72	0.62	0.72	0.62
SPL (L_p; dB re 1 µPa)	Depth limit (m)	Site 8 (573 m)		Site 9 (326 m)		Site 10 (177 m)		Site 11 (121 m)		Site 12 (76 m)		Site 13 (257 m)		Site 14 (159 m)	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
160‡	24	6.2	5.5	4.5	4.0	2.4	2.1	2.3	2.0	2.1	1.8	5.4	4.5	2.4	2.1
	129	6.6	5.6	4.9	4.2	2.5	2.2	2.4	2.2	2.3	2.2	6.1	5.2	2.4	2.2
	506	7.8	5.6	5.7	4.4	2.5	2.3	2.4	2.2	2.3	2.2	6.3	5.2	2.5	2.3
166†	250	1.5	1.2	2.9	2.5	1.6	1.4	1.5	1.4	1.4	1.3	2.9	2.4	1.6	1.4
175#		0.72	0.64	0.76	0.65	0.85	0.76	0.80	0.69	0.72	0.62	1.0	0.83	0.84	0.74

‡ Marine mammal behavioural threshold for impulsive sound sources (NMFS 2014).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011b).
# Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).

Table 19. *Area A*: Maximum (R_{max}) horizontal distances (km) from the 3150 in^3 array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for marine mammals, and Popper et al. (2014) for fish and Finneran et al. (2017) for turtles. The water depth at each site is presented in brackets below the site name.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)			
		Site 1 (100 m)	Site 7 (959 m)	Site 9 (326 m)	Site 13 (257 m)
Low-frequency cetaceans (PTS)	219	0.03	0.03	0.03	0.03
Low-frequency cetaceans (TTS)	213	0.05	0.06	0.06	0.05
Mid-frequency cetaceans (PTS)	230	<0.02	<0.02	<0.02	<0.02
Mid-frequency cetaceans (TTS)	224	<0.02	<0.02	<0.02	<0.02
High-frequency cetaceans (PTS)	202	0.22	0.19	0.19	0.19
High-frequency cetaceans (TTS)	196	0.36	0.39	0.39	0.39
Fish: No swim bladder (also applied to sharks)	213	0.05	0.06	0.06	0.05
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.11	0.11	0.11	0.11
Turtles (PTS)	232	<0.02	<0.02	<0.02	<0.02
Turtles (TTS)	226	<0.02	<0.02	<0.02	<0.02

Table 20. *Area A*: Maximum (R_{max}) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth 178 dB re 1µPa PK-PK , assessed along the four FWRAM modelling transects (maximum presented) at four modelling sites (Table 8). The water depth at each site is presented in brackets below the site name.

PK-PK ($L_{pk\text{-}pk}$; dB re 1 µPa)	Distance R_{max} (km)			
	Site 1 (100 m)	Site 7 (959 m)	Site 9 (326 m)	Site 13 (257 m)
178	2.26	9.91	10.0	9.46

Table 21. *Area A*: Received maximum-over-depth SPL at sound field sampling receivers (Table 10) from the nearest modelling sites.

Receiver name	Relevant modelling site	Distance (km)	Location		Water depth (m)	Received SPL (L_p; dB re 1 µPa)
			Latitude (S)	Longitude (E)		
Flatback Turtle Internesting BIA	12	0.78	20° 04' 47.59"	115° 16' 27.41"	73	171.5
Montebello Islands Marine Park		32.8	20° 18' 48.03"	115° 27' 18.00"	33	101.2
Humpback Whale BIA, Migration (north and south)		19.8	20° 14' 00.91"	115° 21' 16.81"	18	118.7

5.2.1.2. Tabulated results for the seafloor

Table 22. *Area A*: Maximum (R_{max}) horizontal distances (in m) from the 3150 in^3 array to modelled seafloor PK from three single-impulse modelling sites (Table 8). The water depth at each site is presented in brackets below the site name.

Hearing group/animal type	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (m)			
		Site 1 (100 m)	Site 2 (125 m)	Site 12 (76 m)	Site 14 (159 m)
Sound levels for sponges and corals†	226	–	–	–	–
Fish: No swim bladder (also applied to sharks)	213	48	39	56	–
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	119	121	132	107

† Heyward et al. (2018)
A dash indicates the level was not reached.

Table 23. *Area A*: Maximum (R_{max}) horizontal distances (in m) from the 3150 in^3 array to modelled seafloor PK-PK from three modelling sites (Table 8). Results included in relation to benthic invertebrates (Section 3.3). The water depth at each site is presented in brackets below the site name.

PK-PK (L_{pk-pk}; dB re 1 µPa)	Distance R_{max} (m)			
	Site 1 (100 m)	Site 2 (125 m)	Site 12 (76 m)	Site 14 (159 m)
213	104	107	111	99
212	120	122	129	116
211	141	132	147	133
210	161	150	165	153
209	185	175	185	167
202	393	402	375	413

5.2.1.3. *Sound level contour maps*

Maps of the estimated sound fields and isopleths of interest for the SPL sound fields have been presented at modelling sites from the Area A in Figures 14–27. Maps showing marine mammal and turtle behavioural disturbance related SPL isopleths are shown in Figures 28–41. Maps of the per-pulse SEL sound field are presented in Appendix E.1.

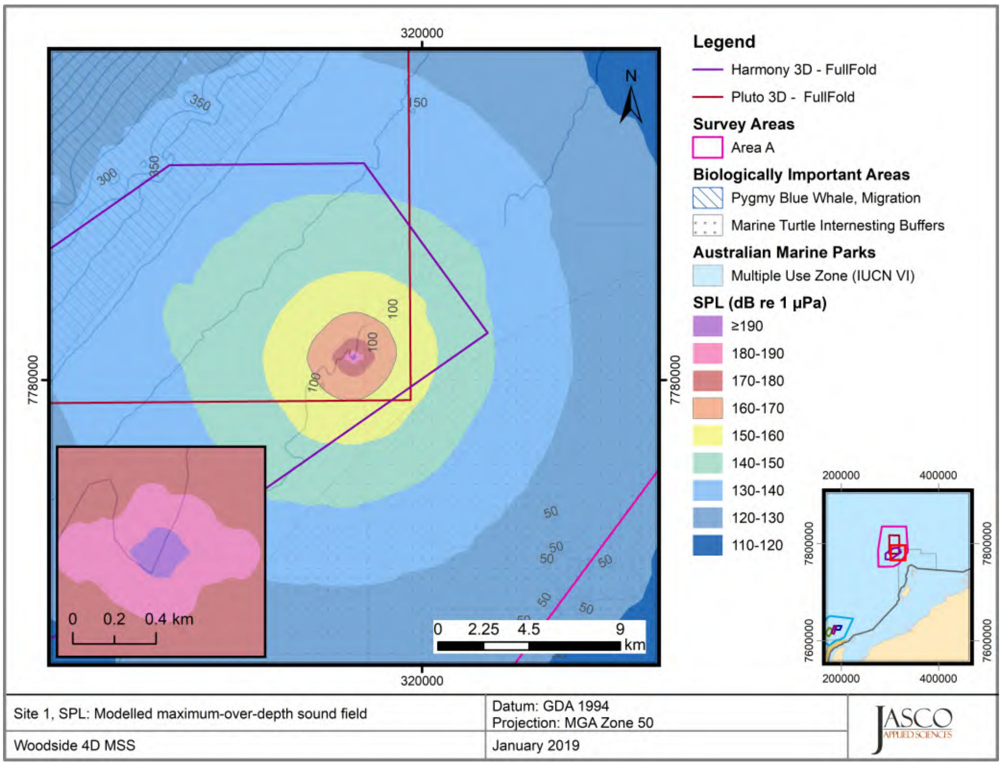

Figure 14. *Site 1, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

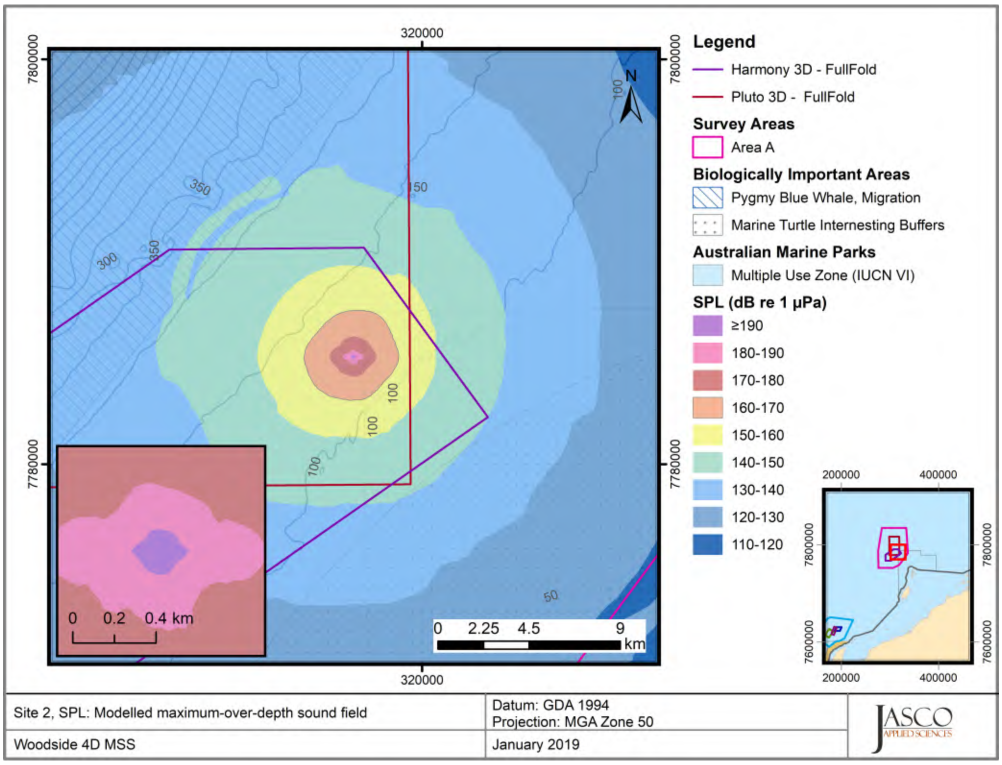

Figure 15. *Site 2, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

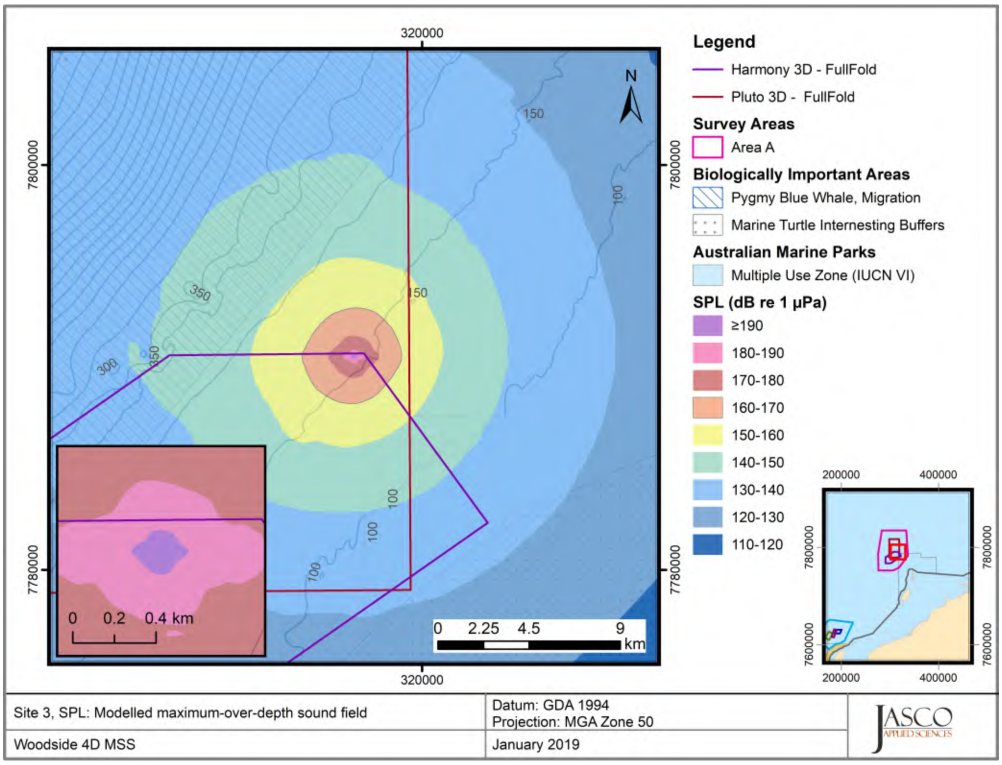

Figure 16. *Site 3, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

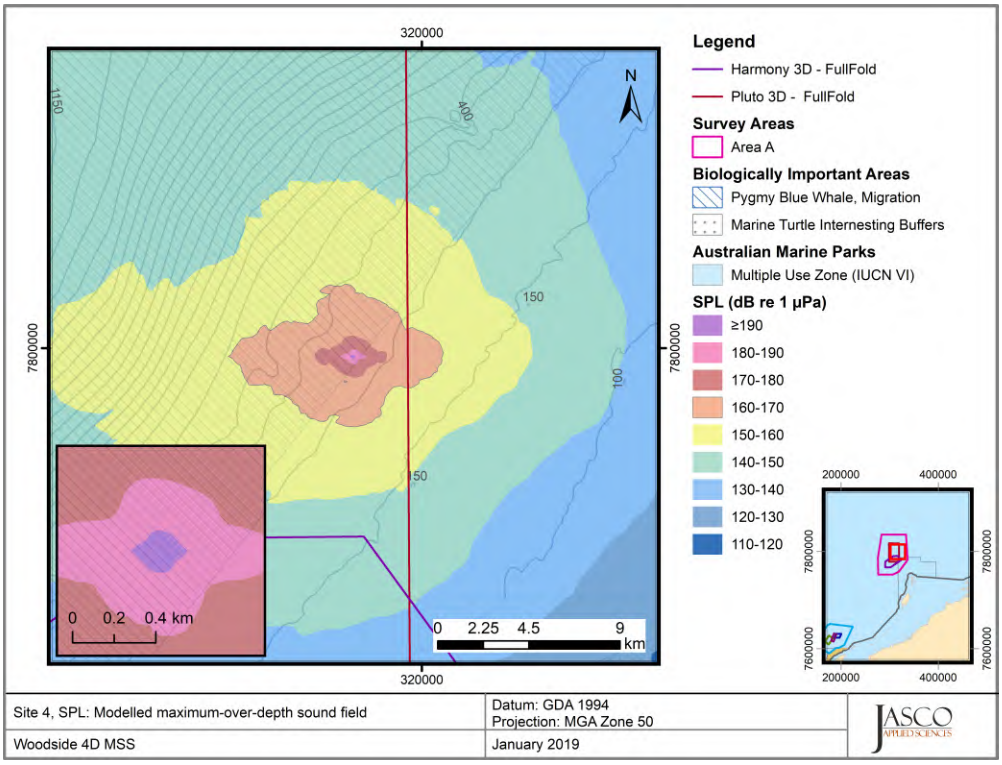

Figure 17. *Site 4, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

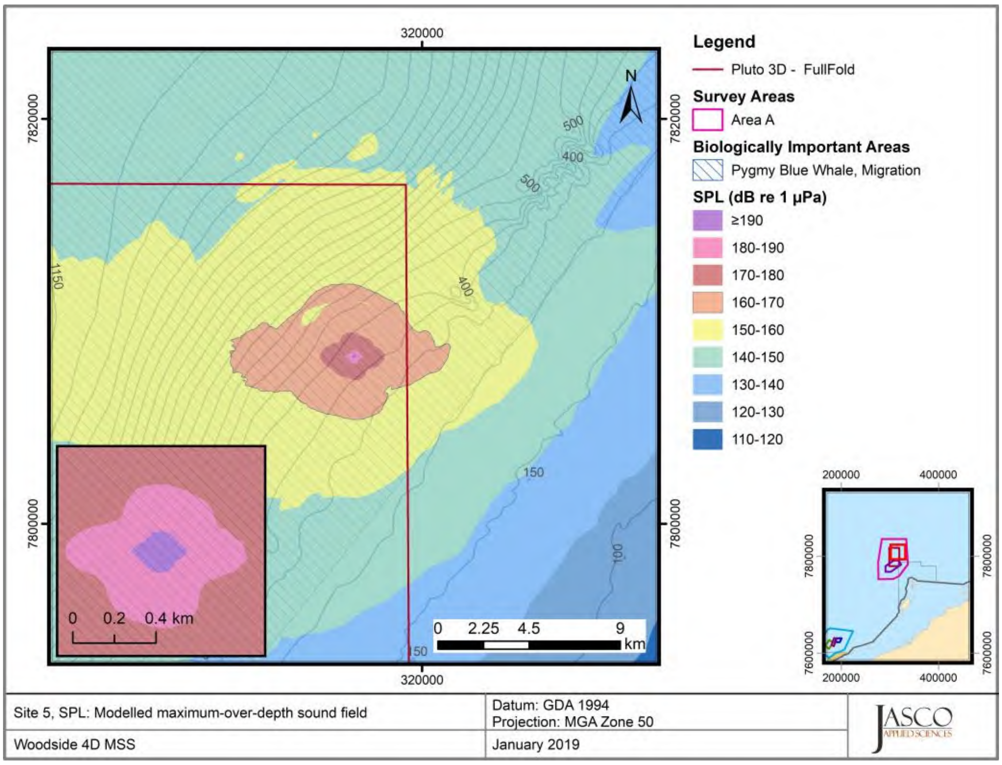

Figure 18. *Site 5, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

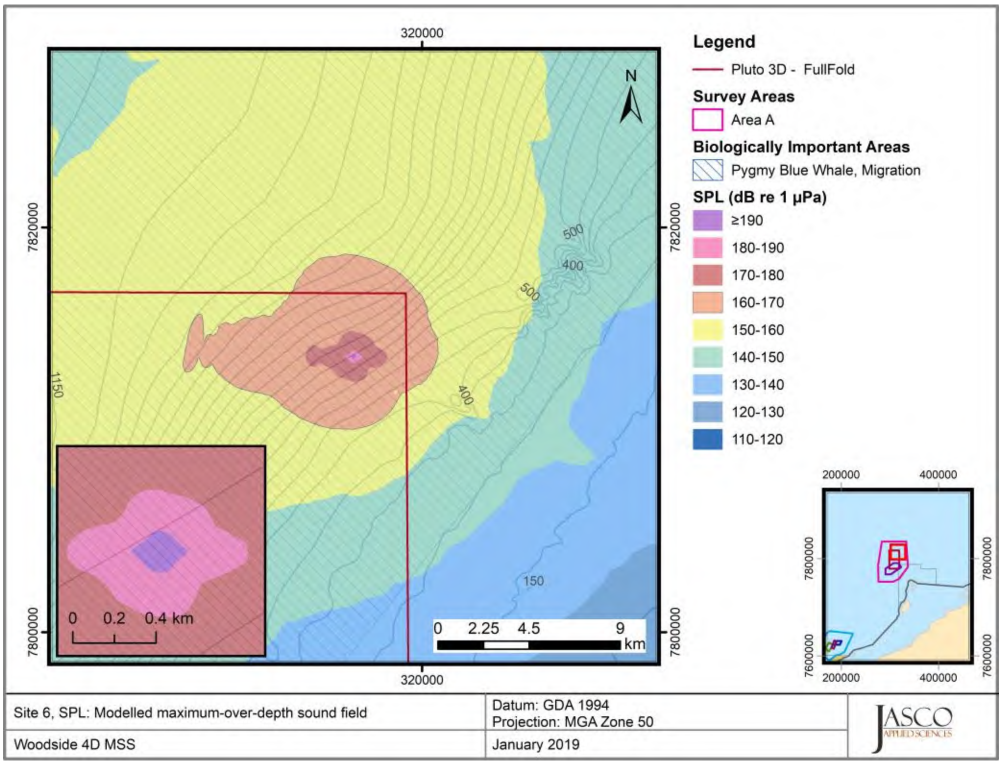

Figure 19. *Site 6, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

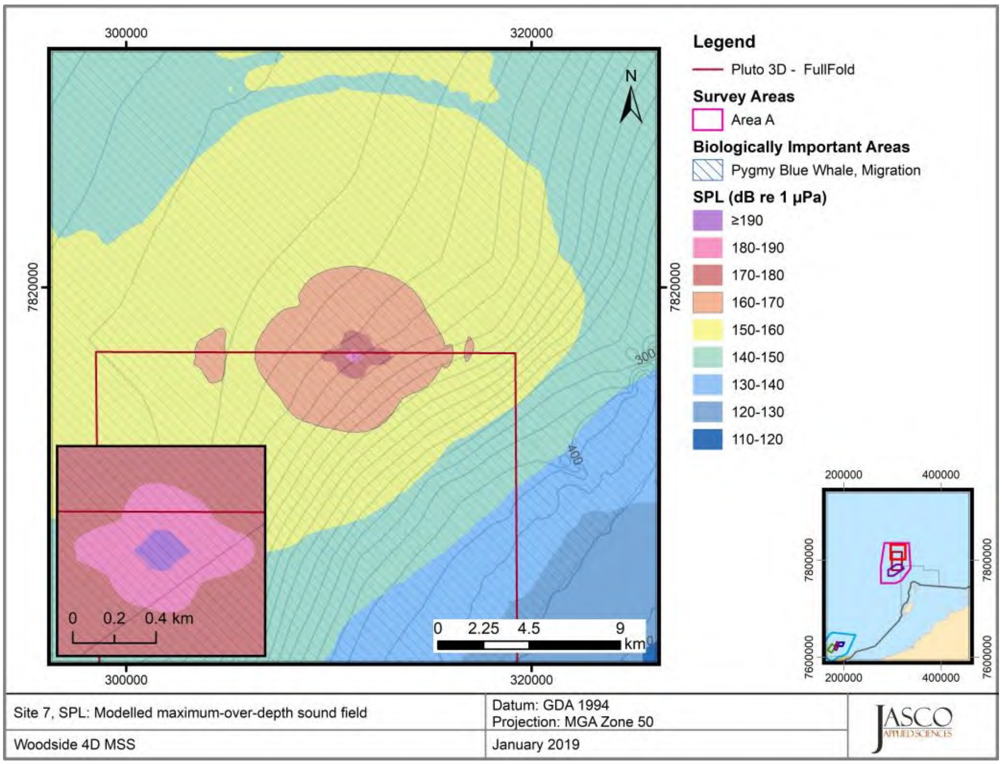

Figure 20. *Site 7, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

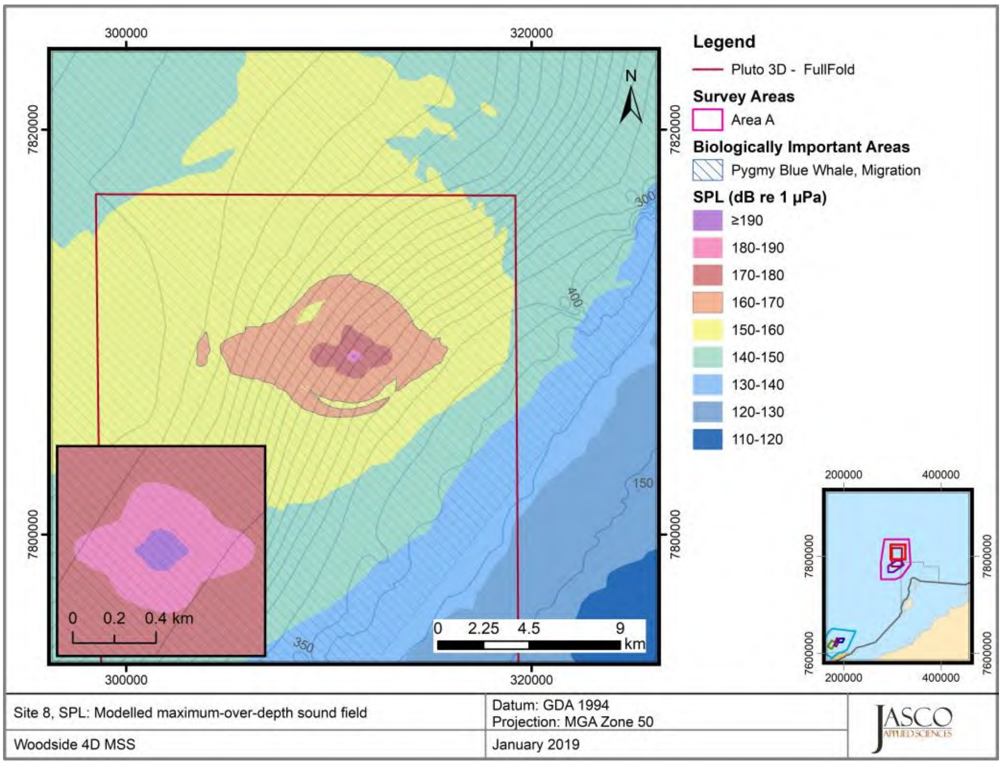

Figure 21. *Site 8, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

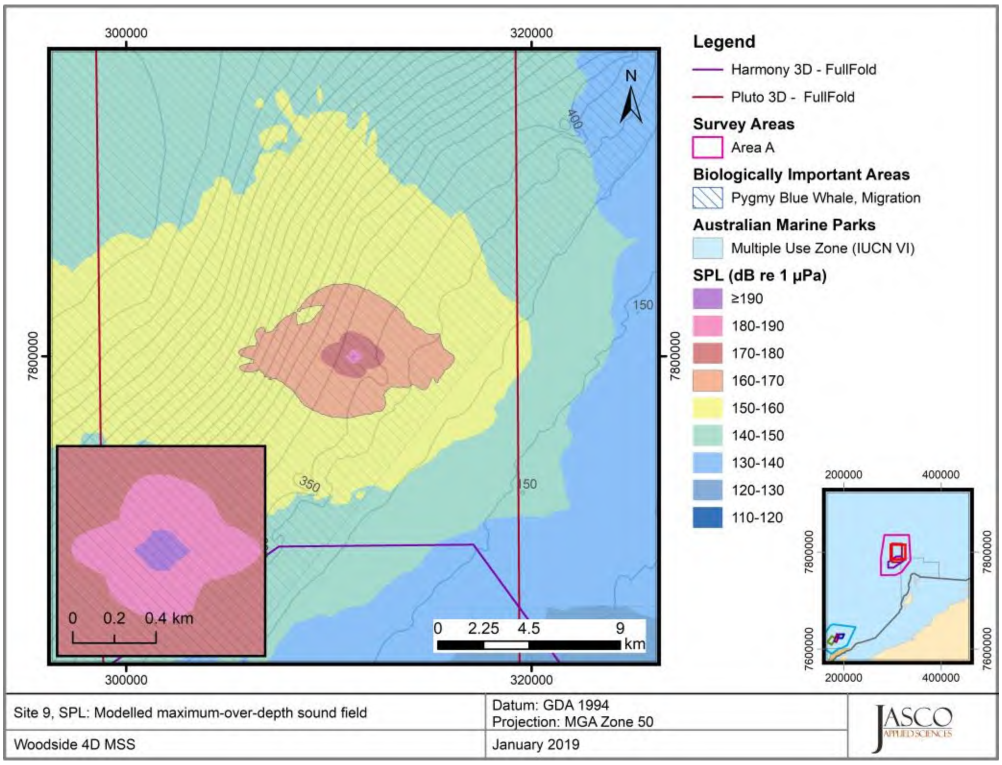

Figure 22. *Site 9, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

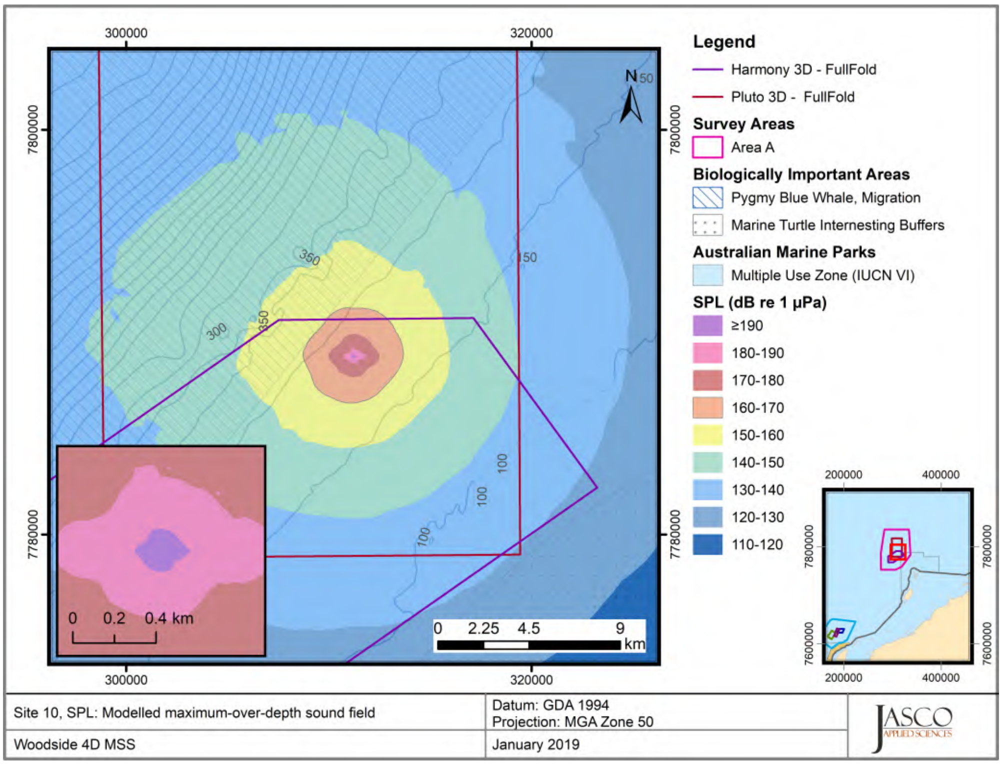

Figure 23. *Site 10, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

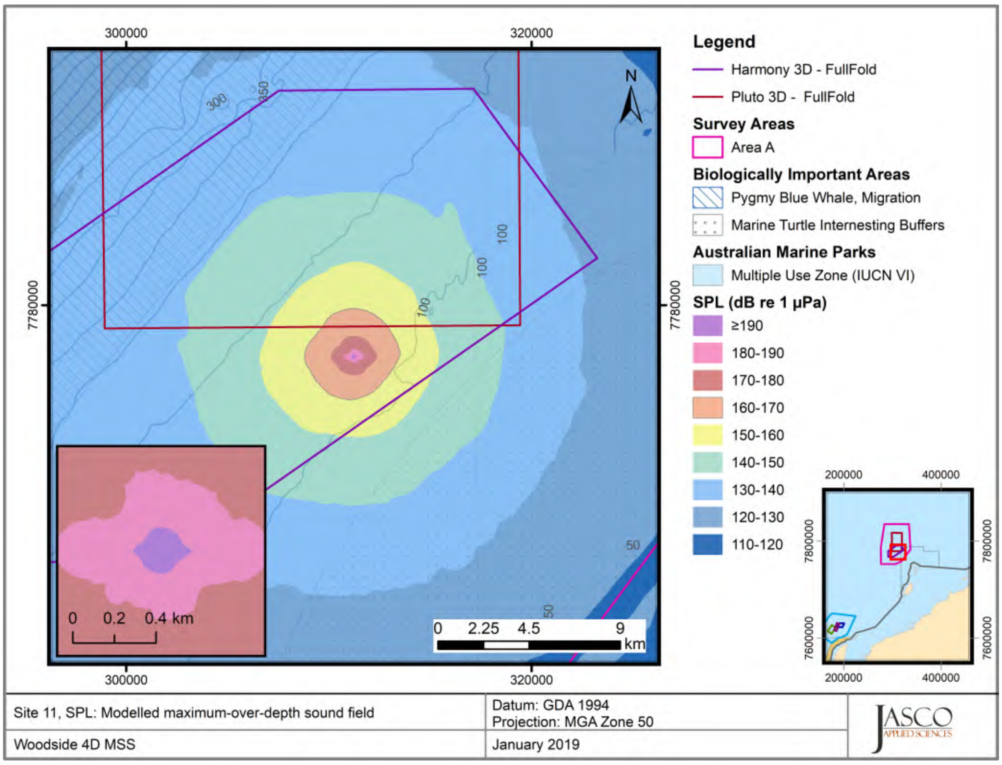

Figure 24. *Site11, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

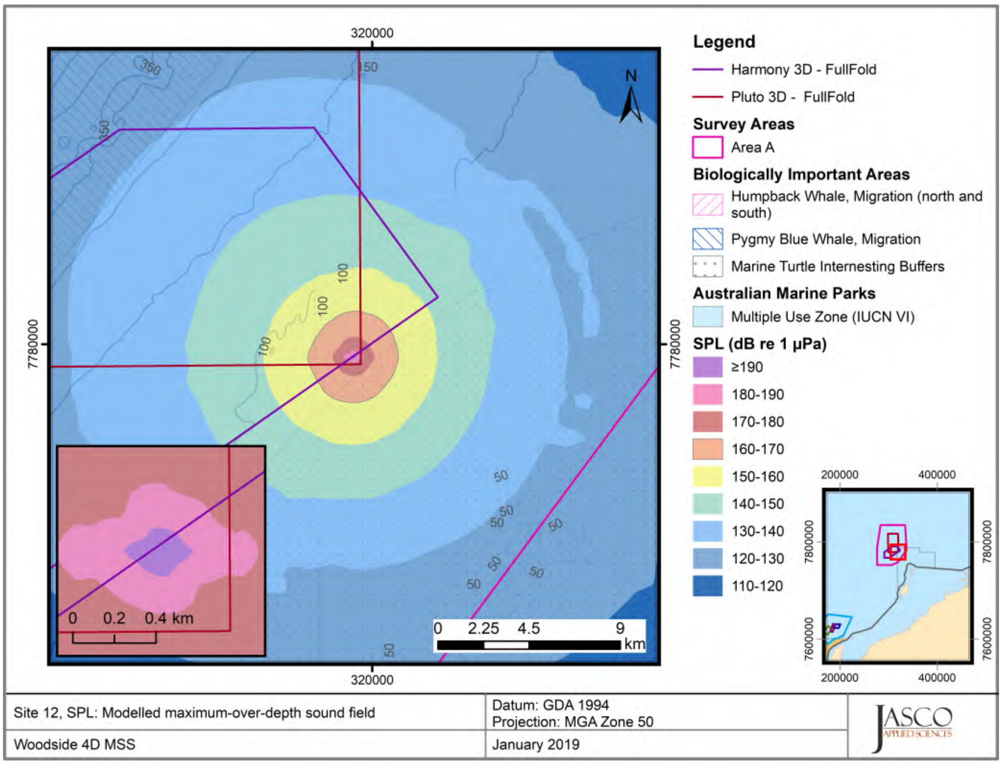

Figure 25. *Site 12, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

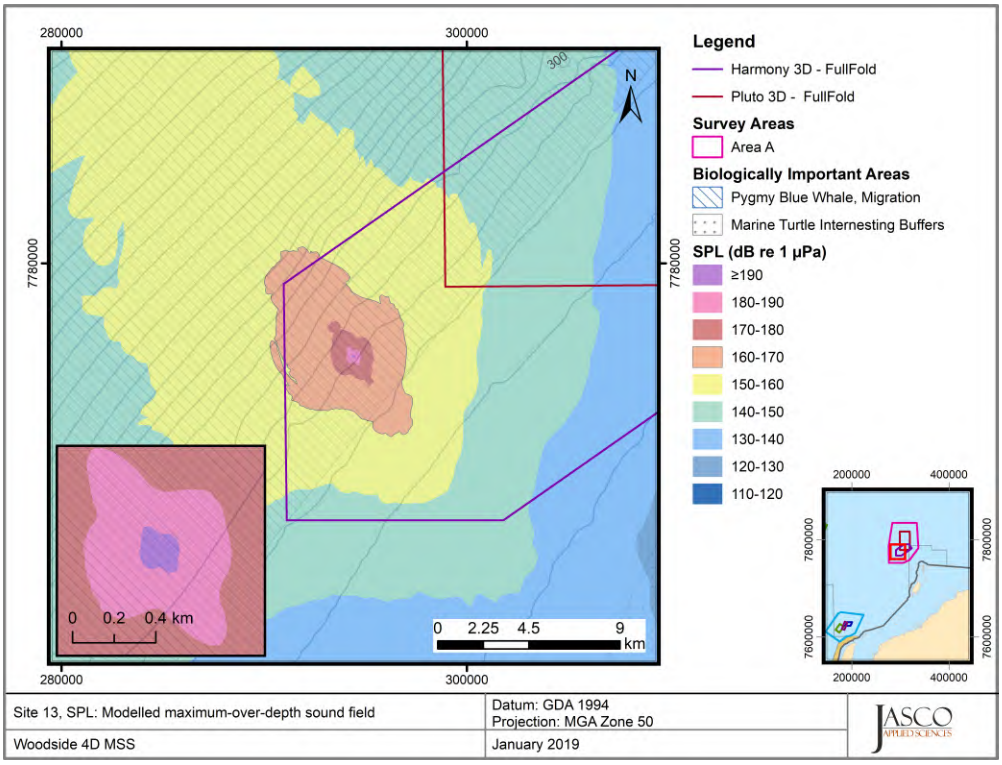

Figure 26. *Site 13, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

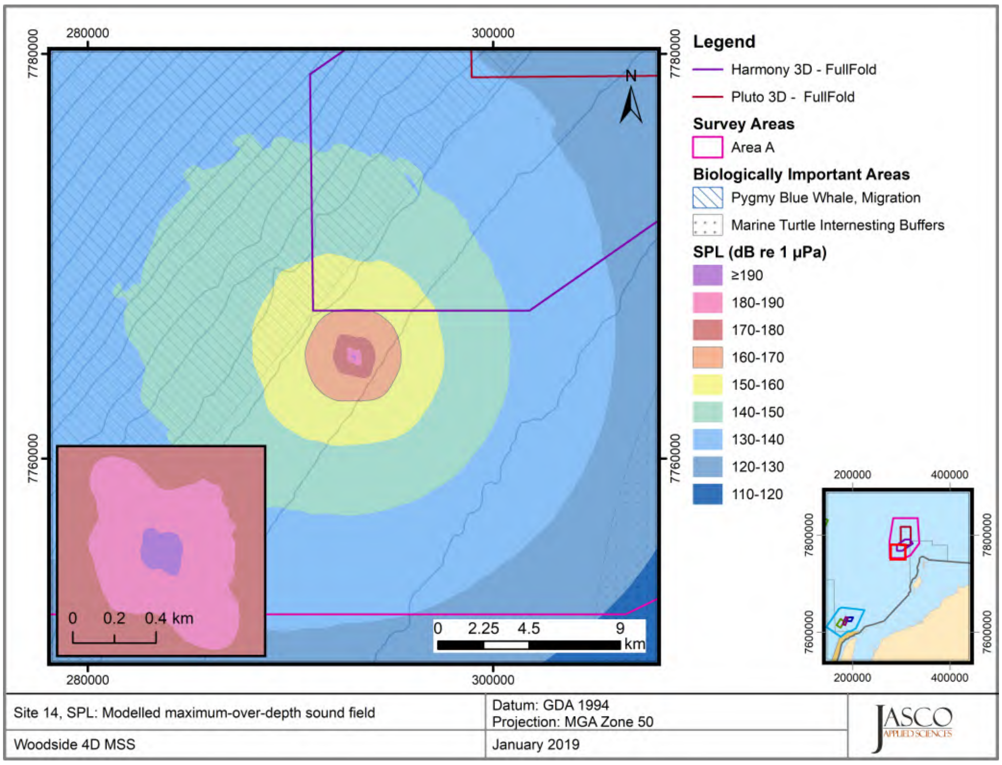

Figure 27. *Site 14, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

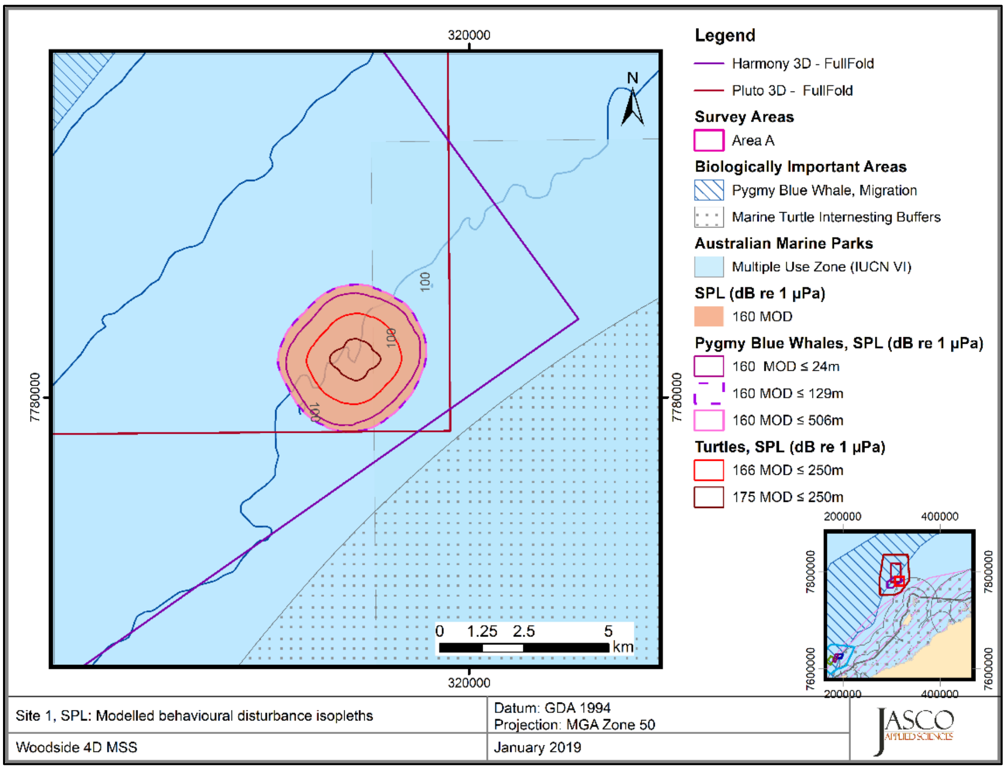

Figure 28. *Site 1, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

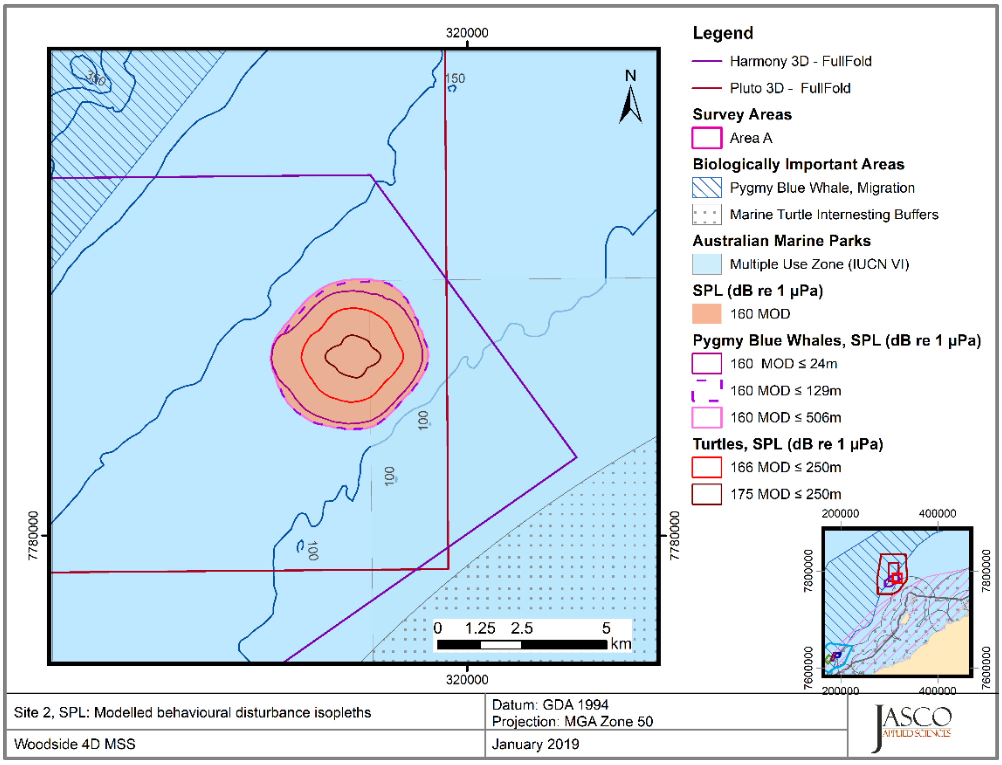

Figure 29. *Site 2, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

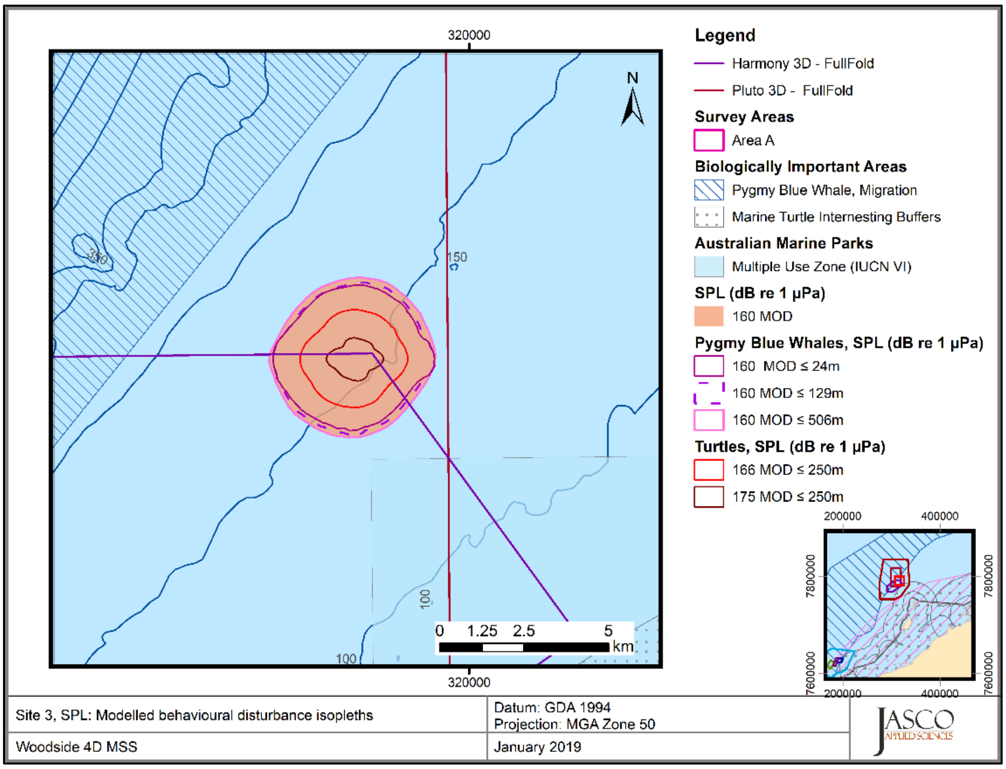

Figure 30. *Site 3, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

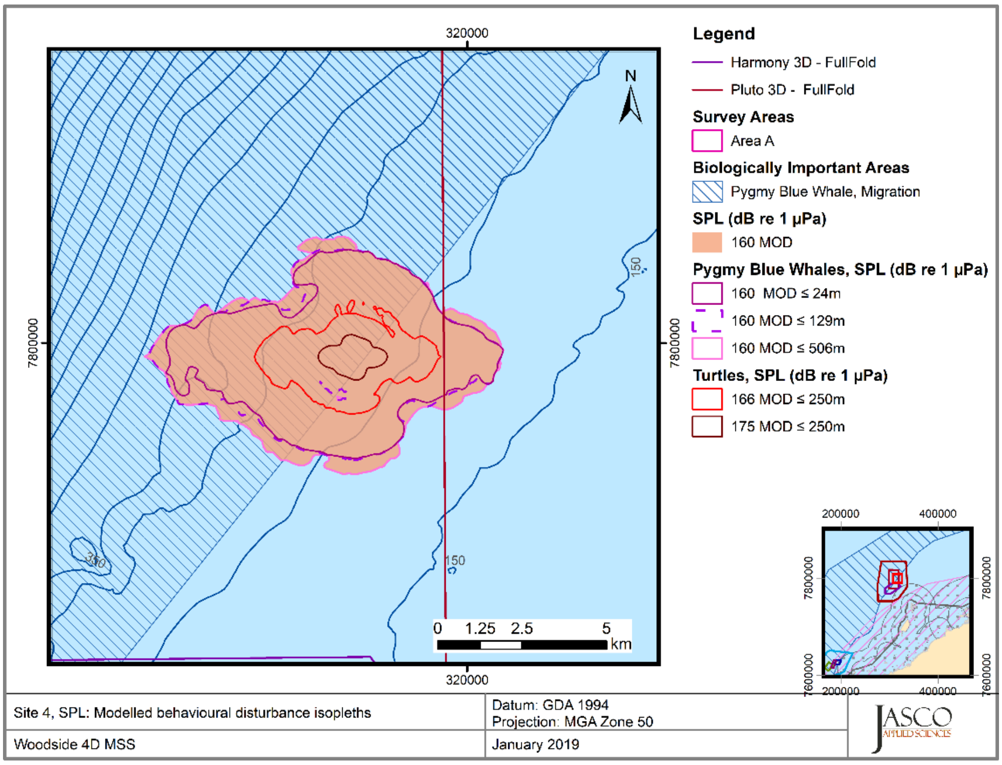

Figure 31. *Site 4, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

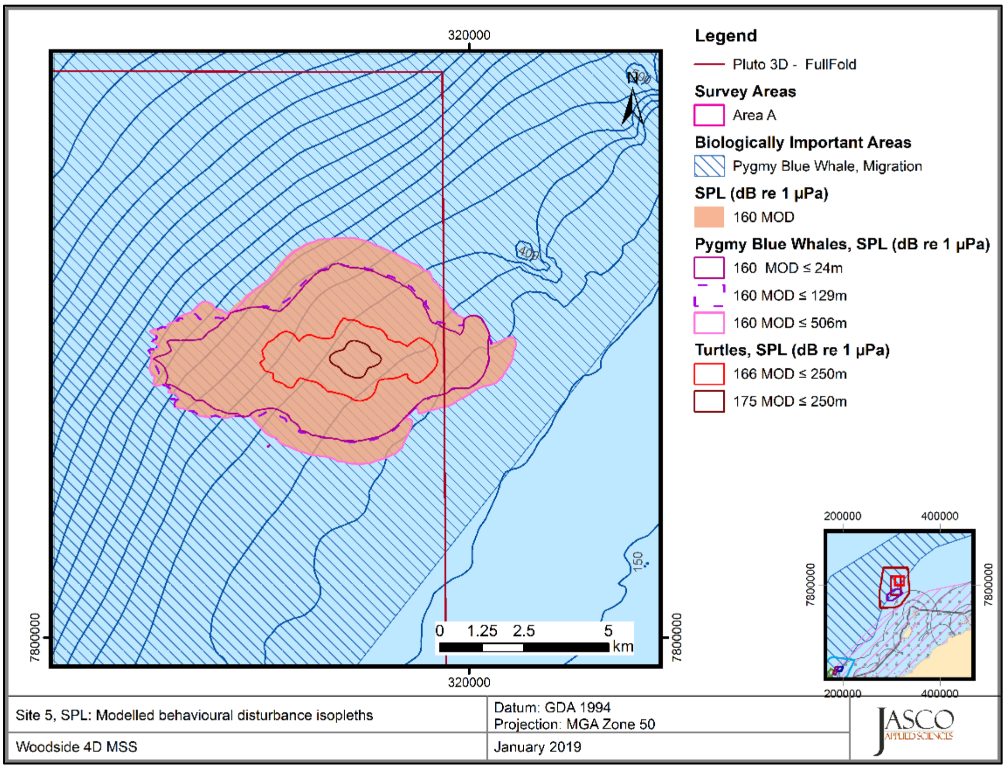

Figure 32. *Site 5, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

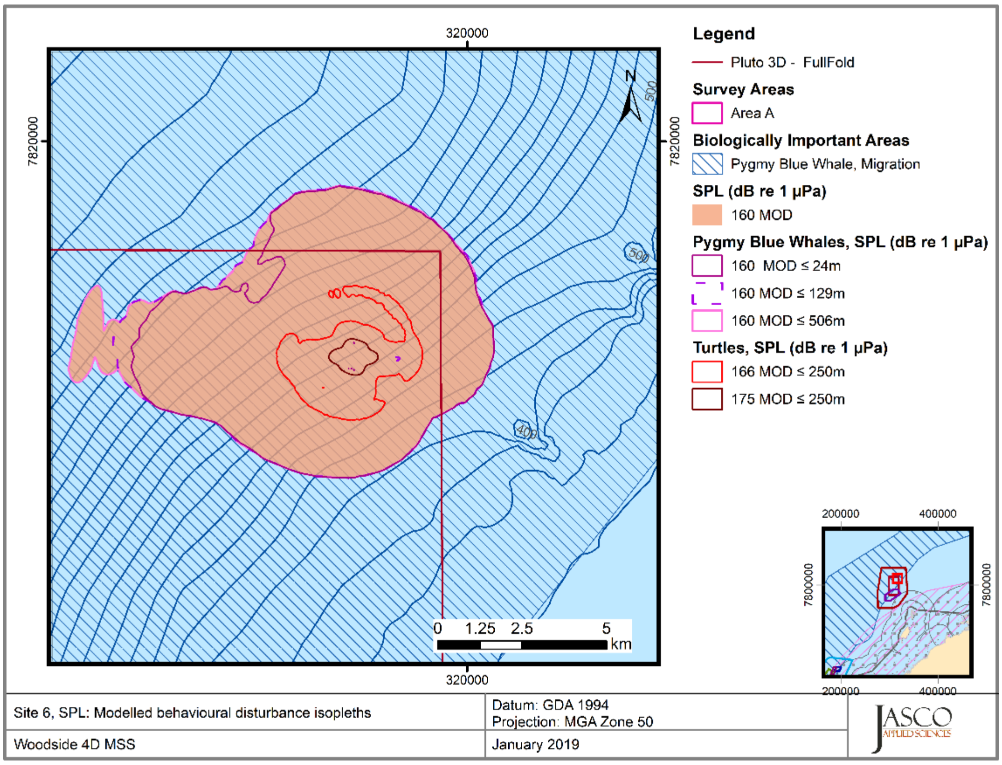

Figure 33. *Site 6, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

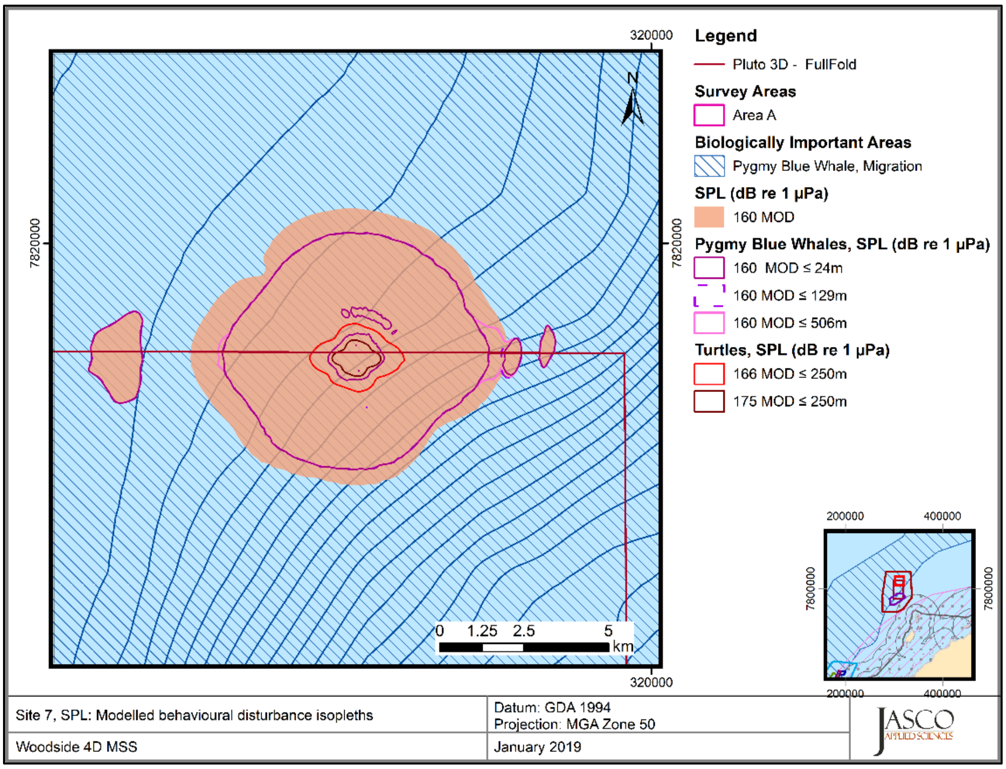

Figure 34. *Site 7, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

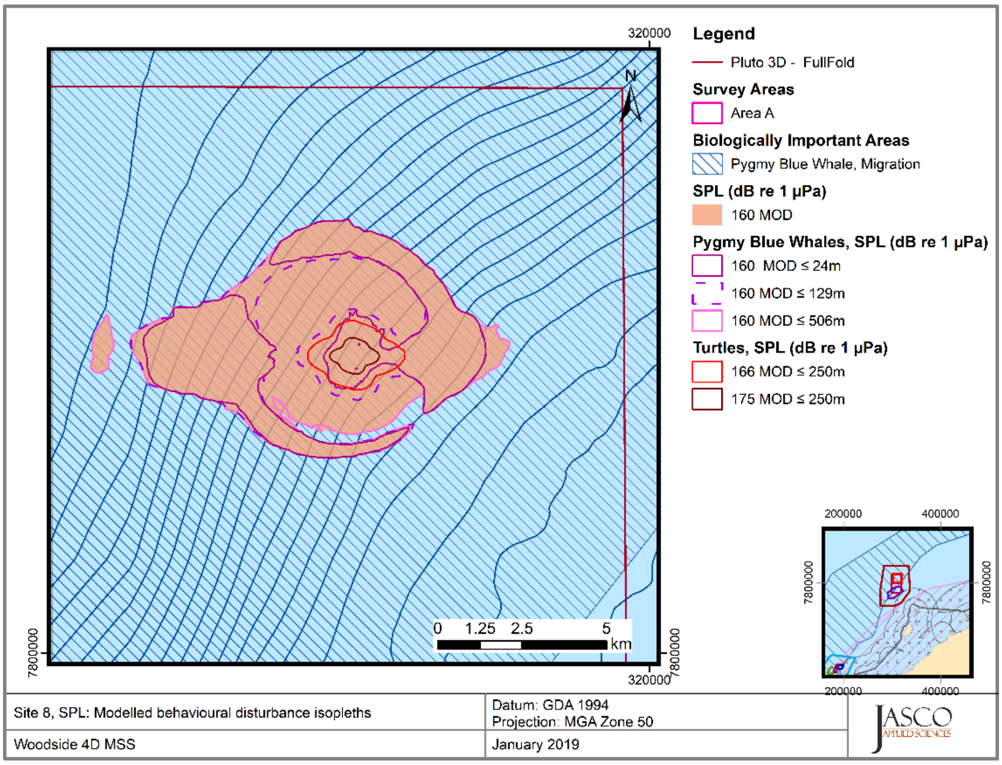

Figure 35. *Site 8, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

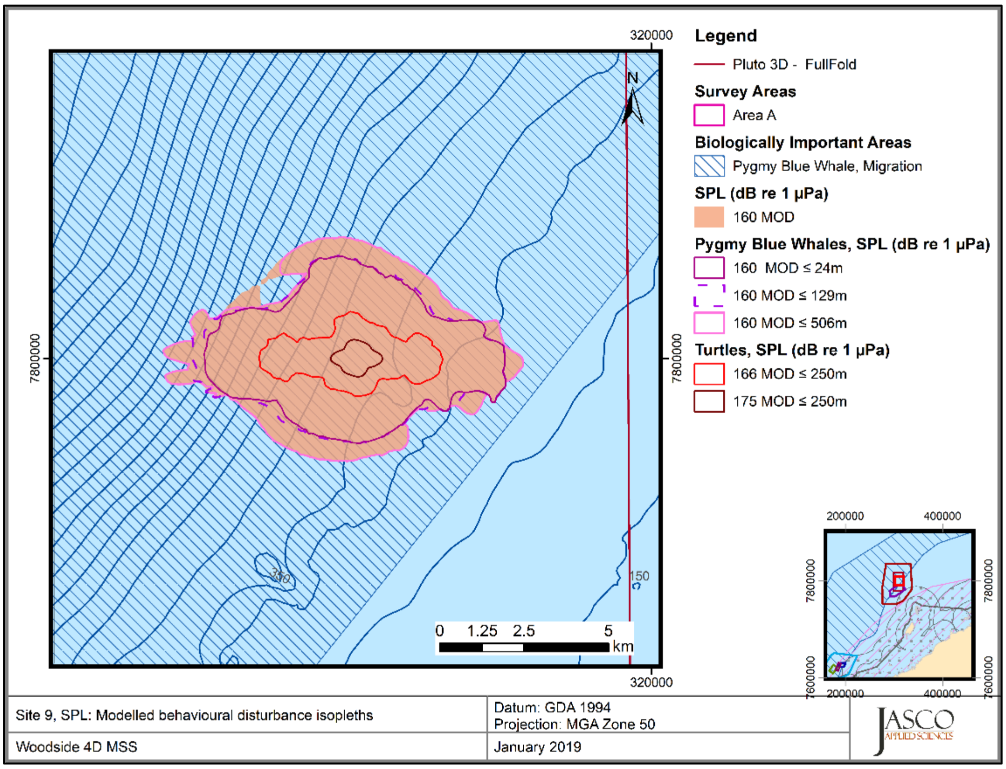

Figure 36. *Site 9, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

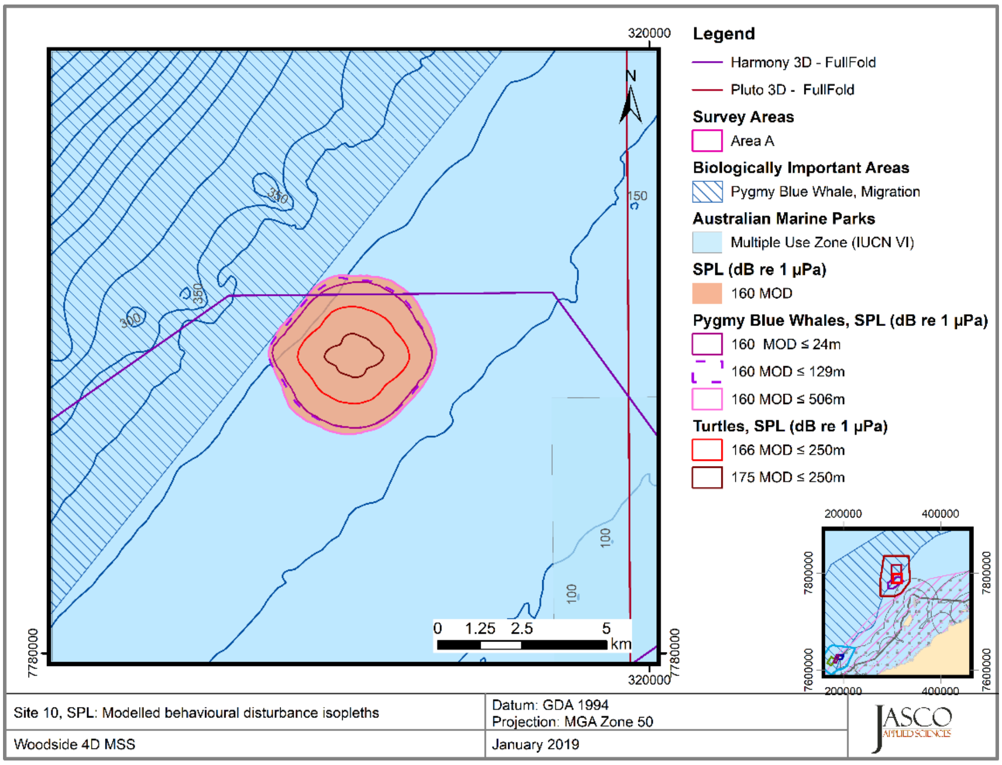

Figure 37. *Site 10, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

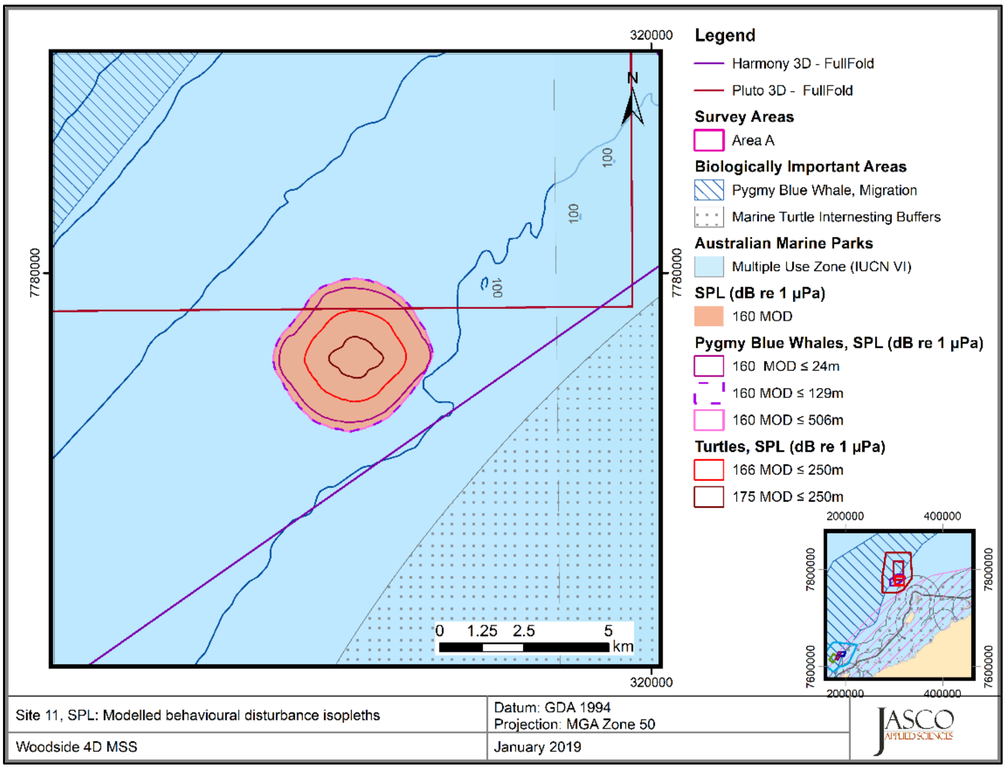

Figure 38. *Site11, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

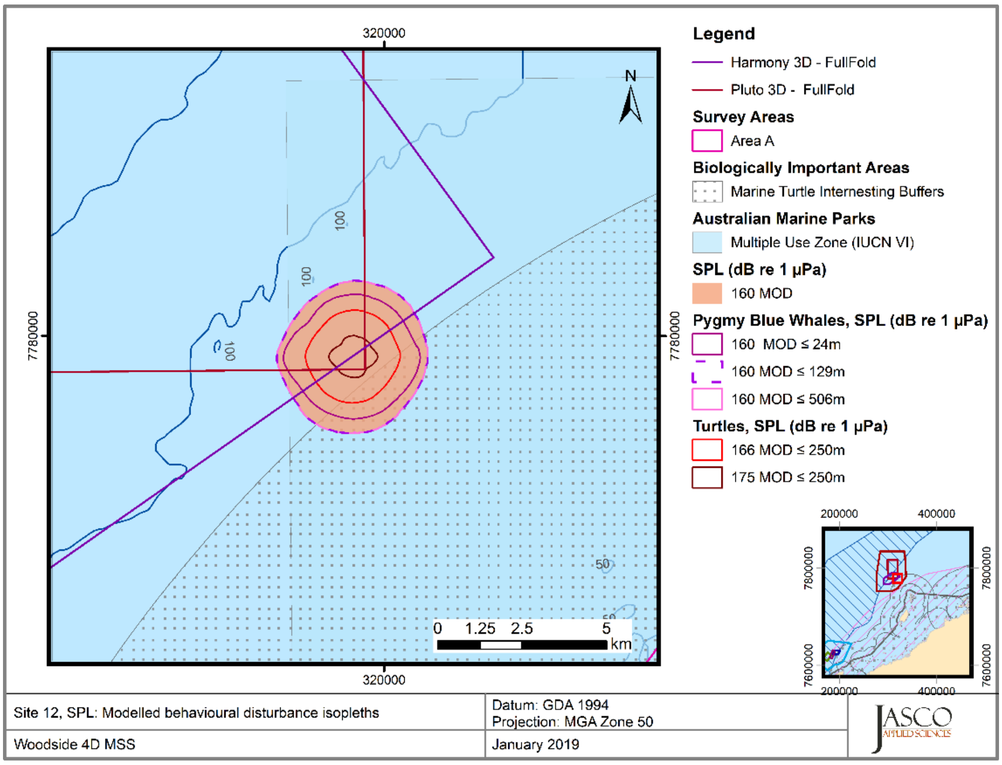

Figure 39. *Site 12, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

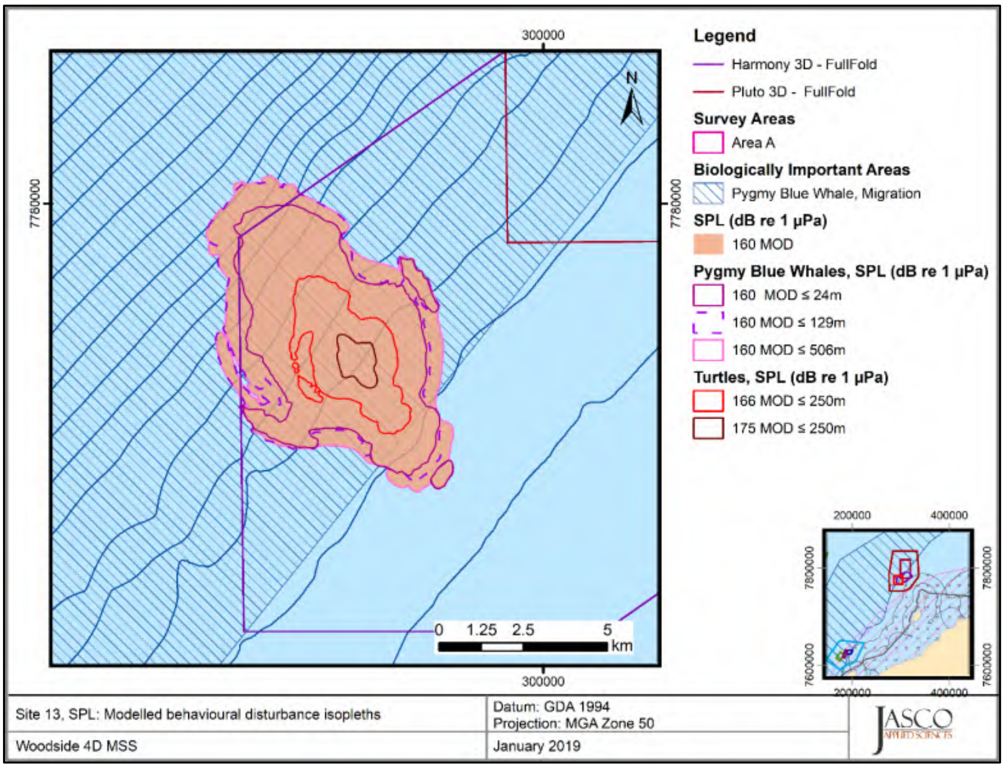

Figure 40. *Site 13, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

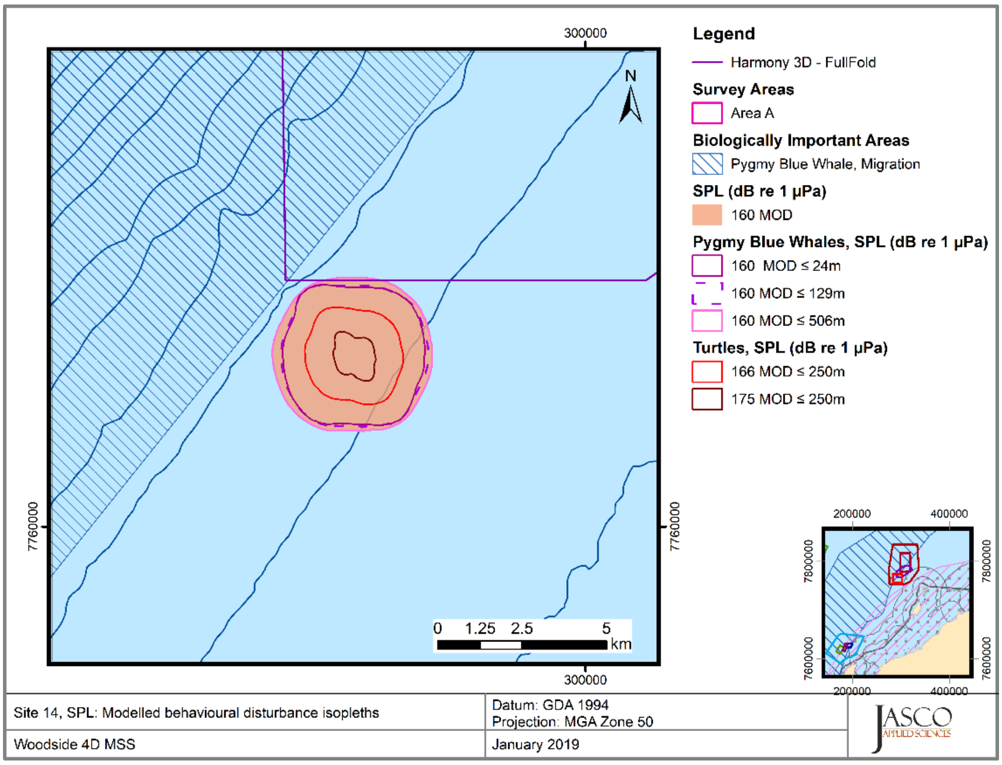

Figure 41. *Site 14, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

5.2.1.4. Vertical slices of modelled SPL sound fields

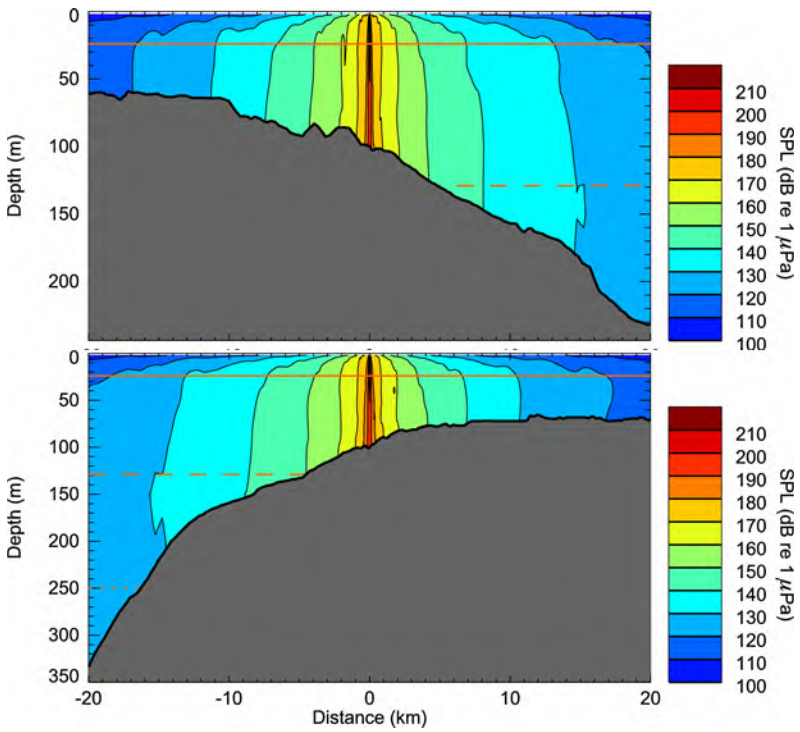

Figure 42. Site 1: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

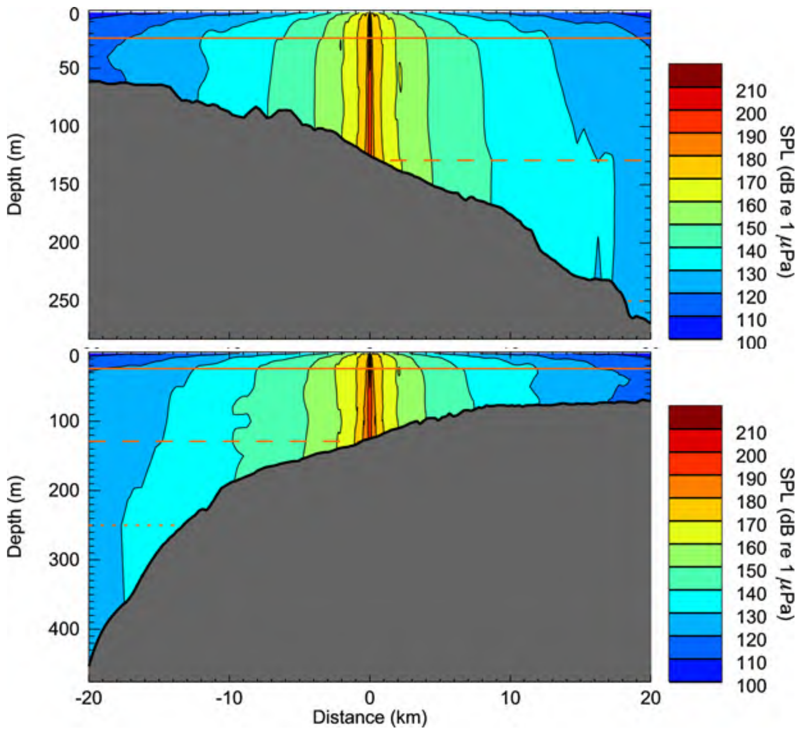

Figure 43. *Site 2*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

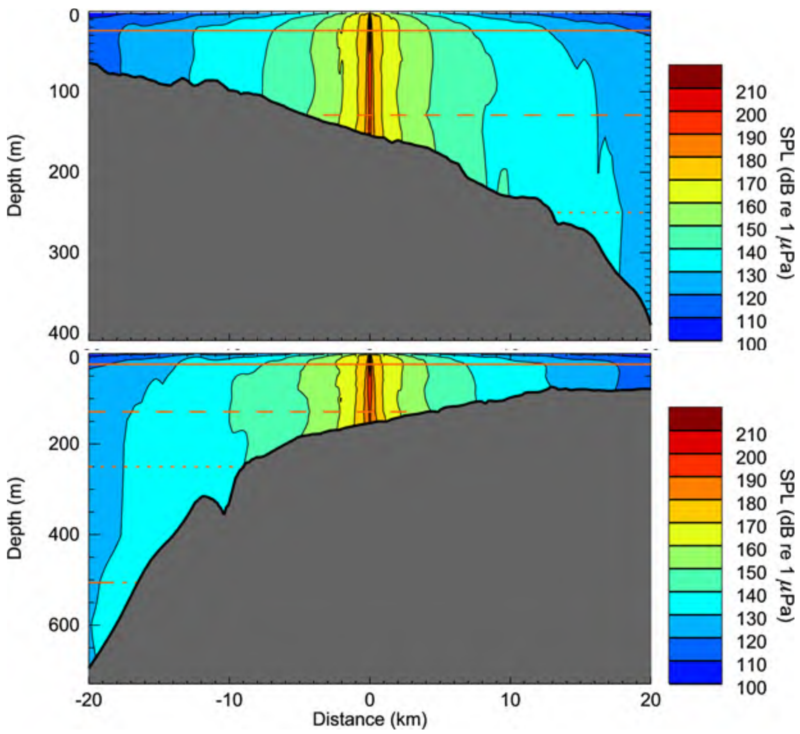

Figure 44. *Site 3*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

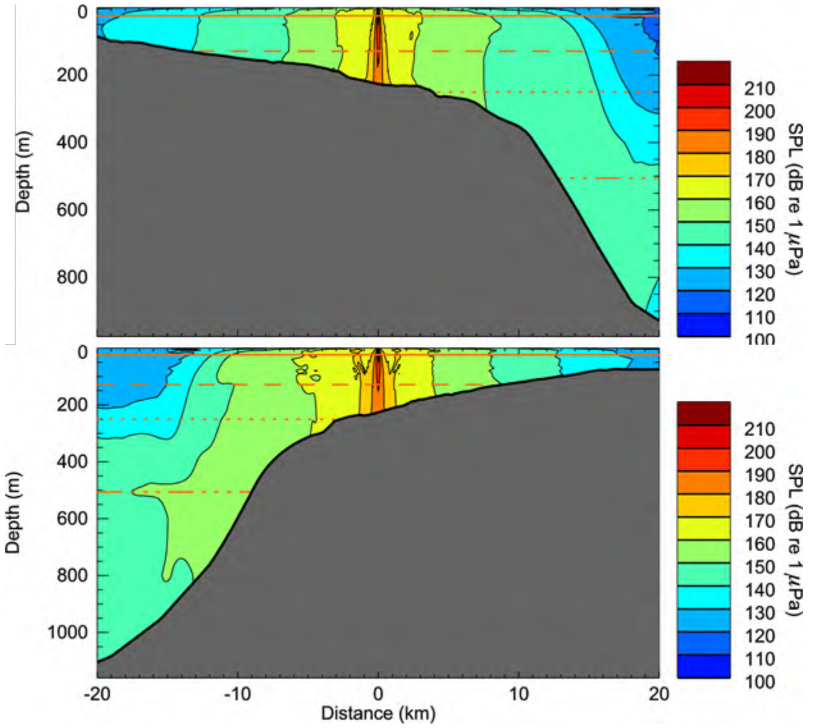

Figure 45. *Site 4*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

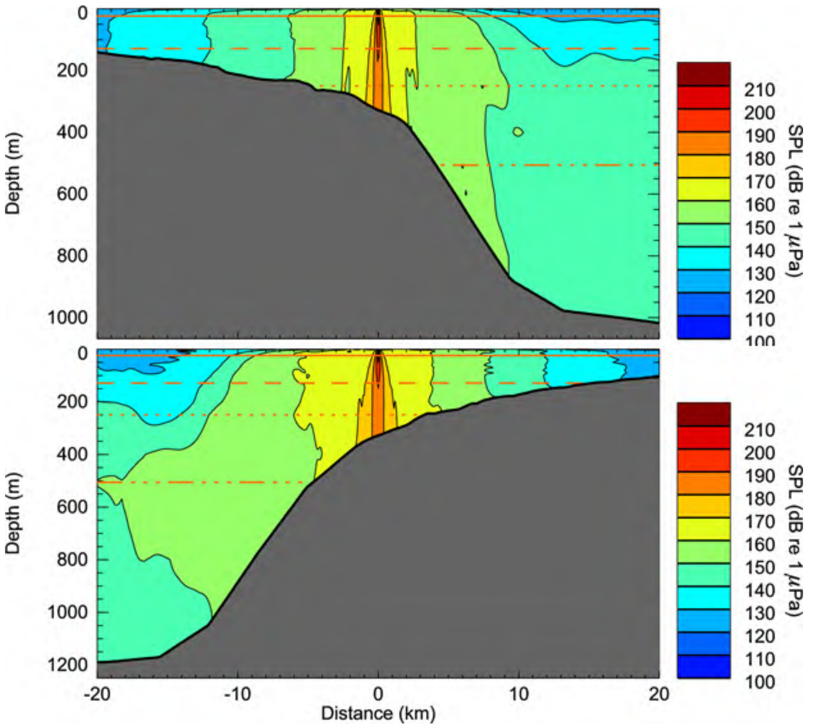

Figure 46. *Site 5*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

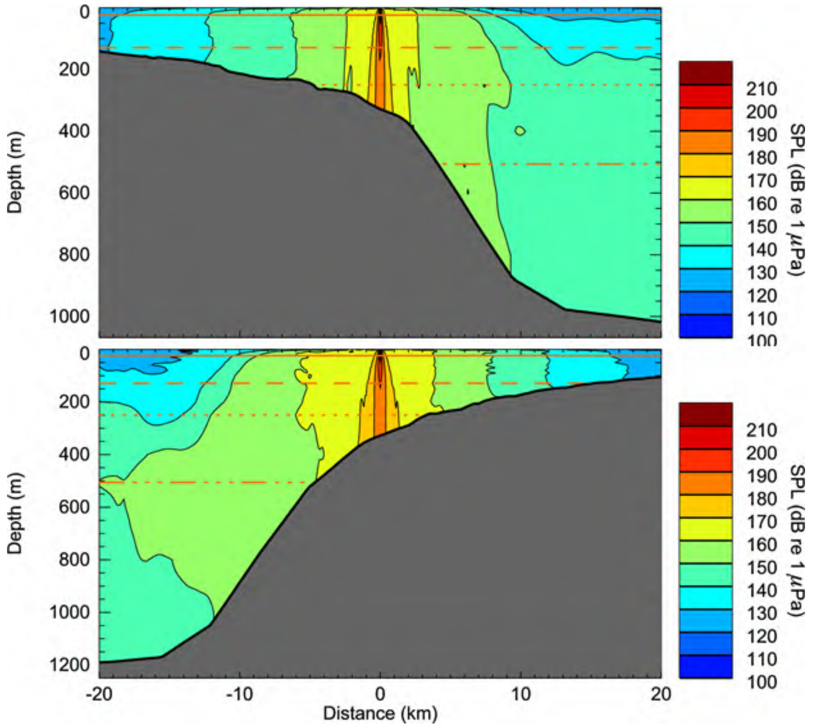

Figure 47. *Site 6*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

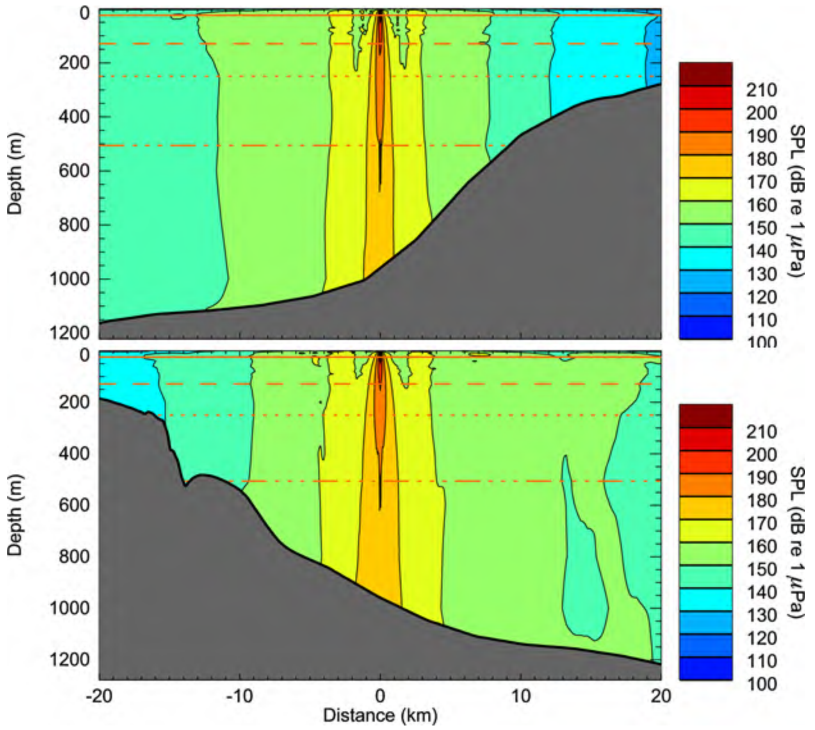

Figure 48. *Site 7*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

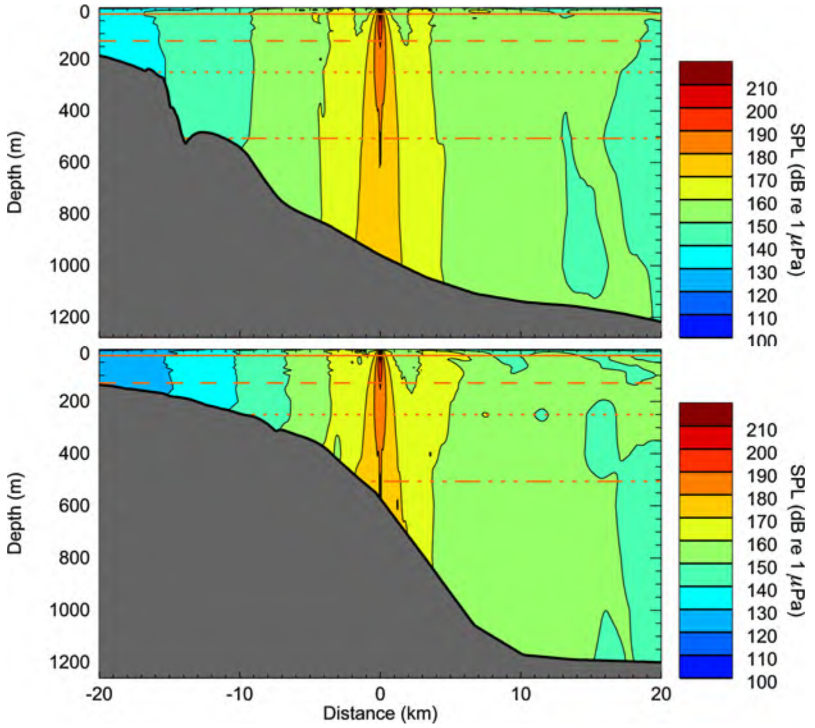

Figure 49. *Site 8*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

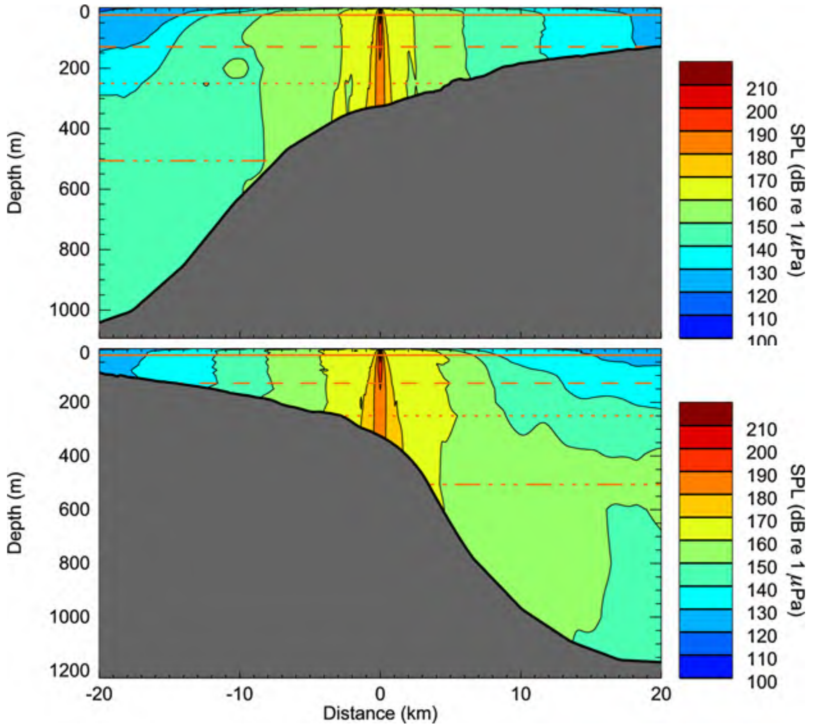

Figure 50. *Site 9*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

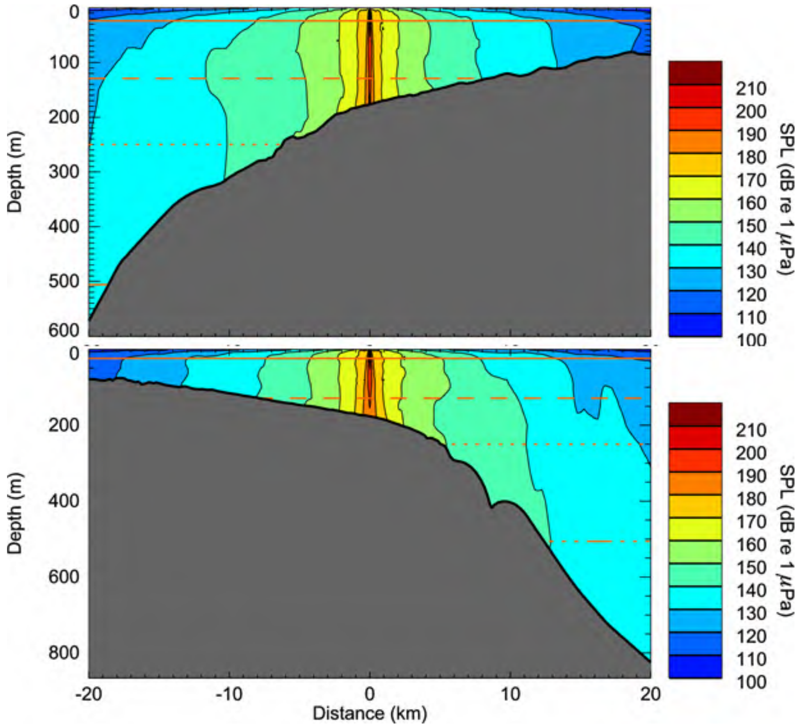

Figure 51. *Site 10*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

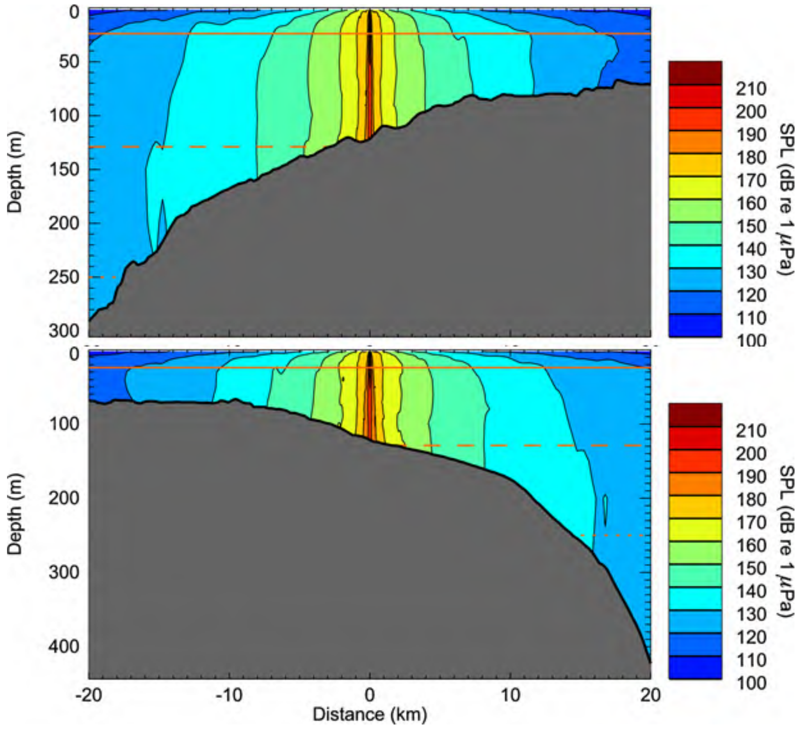

Figure 52. *Site 11*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

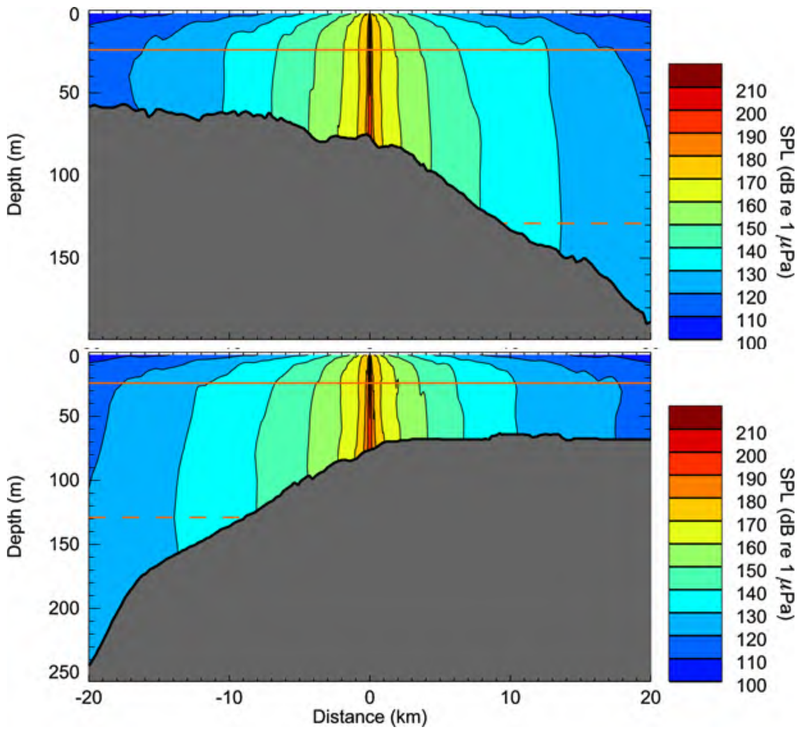

Figure 53. *Site 12*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

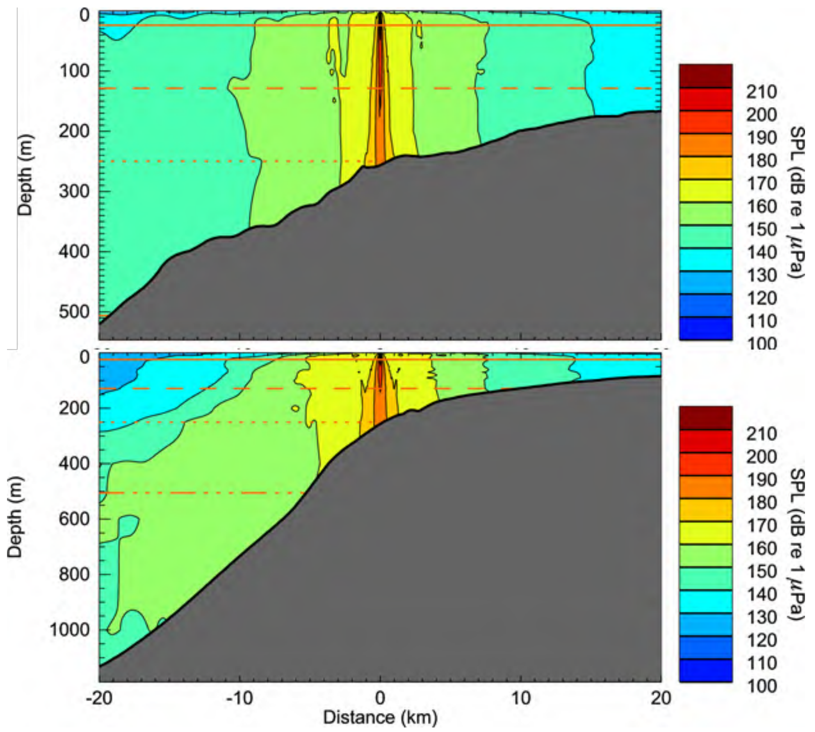

Figure 54. *Site 13*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

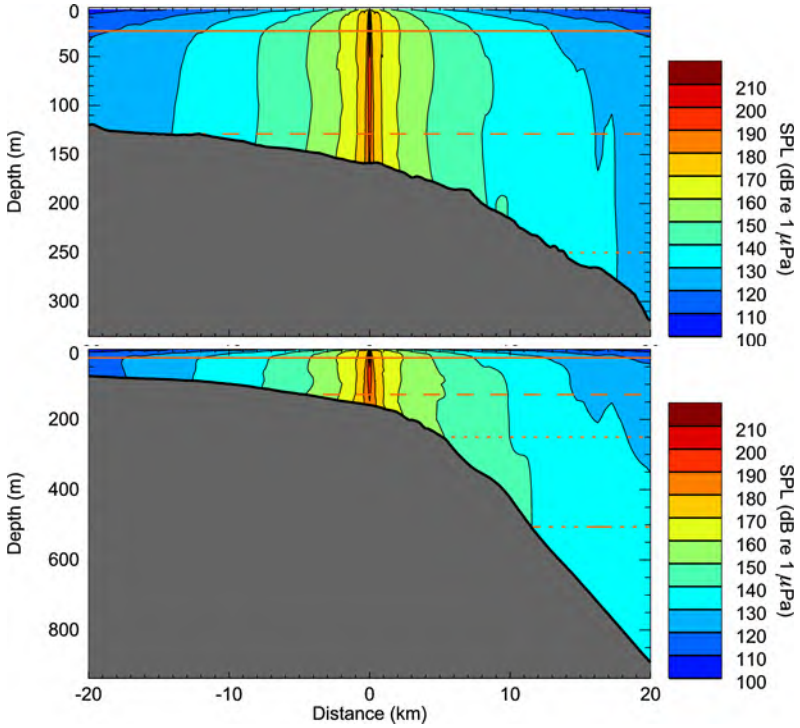

Figure 55. *Site 14*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

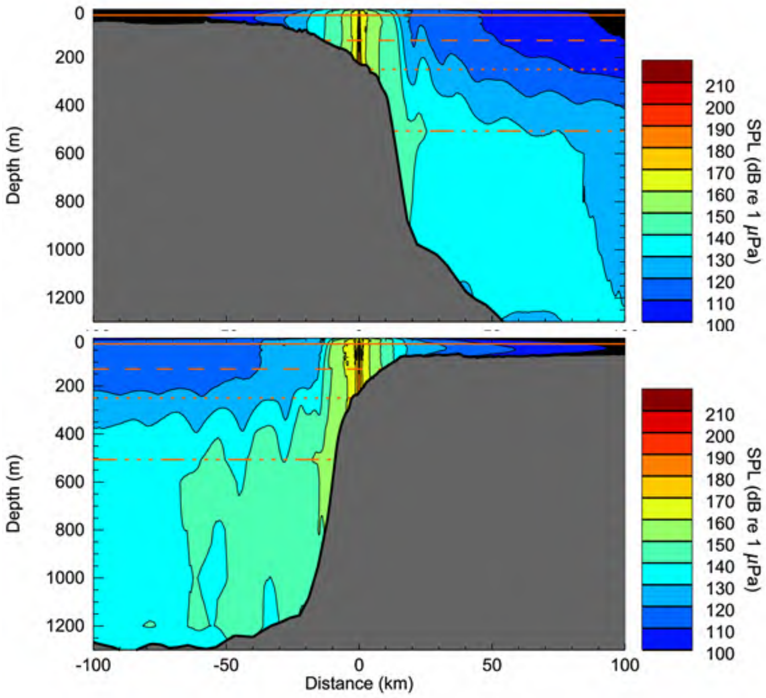

Figure 56. *Site 4*: Long-range vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown out to a maximum range of 100 km along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129 and 506 m) and turtle (250 m) depth limits shown. See expanded versions in Figure E-24 (endfire) and Figure E-25 (broadside).

5.2.2. Area B

Area B includes the Scarborough 4-D Acquisition Area (Figure 3)

5.2.2.1. Tabulated results for the water column

Table 24. *Area B*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the single impulse site. The water depth is presented in brackets below the site name.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	Site 15 (910 m)	
	R_{max}	$R_{95\%}$
190	<0.04	<0.04
180	0.14	0.14
170	0.50	0.43
160†	**2.1**	**1.7**
150	8.4	7.0
140	36.9	25.3
130	*	*
120	*	*

† Low power zone assessment criteria DEWHA (2008).
* R_{max} radii extend beyond the 100 km modelling boundary.

Table 25. *Area B*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth SPL isopleths from the single impulse site. The water depth is presented in brackets below the site name.

SPL (L_p; dB re 1 µPa)	Site 15 (910 m)	
	R_{max}	$R_{95\%}$
200	<0.04	<0.04
190	0.13	0.09
180	0.45	0.38
170	1.8	1.5
160‡	**6.8**	**5.9**
150	23.1	17.0
140	72.9	52.1
130	*	*

* R_{max} radii extend beyond the 100 km modelling boundary.
‡ Marine mammal behavioural threshold for impulsive sound sources (NMFS 2014)

Table 26. *Area B*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 3150 in^3 array to modelled SPL isopleths from the single impulse site within the specified biologically relevant depths. The chosen depths are related to mean dive depths for pygmy blue whales and turtles (Section 2.1 and 2.2).

SPL (L_p; dB re 1 µPa)	Depth limit (m)	Site 15 (910 m)	
		R_{max}	$R_{95\%}$
160‡	24	6.8	6.1
	129	6.8	6.1
	506	6.8	6.0
166†	250	1.5	1.2
175#		0.74	0.63

‡ Marine mammal behavioural threshold for impulsive sound sources (NMFS 2014).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011b).
# Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).

Table 27. *Area B*: Maximum (R_{max}) horizontal distances (km) from the 3150 in^3 array to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for marine mammals, and Popper et al. (2014) for fish and Finneran et al. (2017) for turtles. The water depth is presented in brackets below the site name.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)
		Site 15 (910 m)
Low-frequency cetaceans (PTS)	219	0.03
Low-frequency cetaceans (TTS)	213	0.05
Mid-frequency cetaceans (PTS)	230	<0.02
Mid-frequency cetaceans (TTS)	224	<0.02
High-frequency cetaceans (PTS)	202	0.19
High-frequency cetaceans (TTS)	196	0.38
Fish: No swim bladder (also applied to sharks)	213	0.05
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.11
Turtles (PTS)	232	<0.02
Turtles (TTS)	226	<0.02

Table 28. *Area B*: Maximum (R_{max}) horizontal distances (in km) from the 3150 in^3 array to modelled maximum-over-depth 178 dB re 1µPa PK-PK , assessed along the four FWRAM modelling transects (maximum presented) at a single modelling site (Table 8). The water depth is presented in brackets below the site name.

PK-PK ($L_{pk\text{-}pk}$; dB re 1 µPa)	Distance R_{max} (km)
	Site 15
178	9.57

Table 29. *Area B*: Received SPL at sound field sampling receivers (Table 10) from the closest modelling site for maximum-over-depth (MOD) and specified biologically relevant depths for pygmy blue whales (Section 2.1).

Receiver name	Relevant modelling site	Depth limit	Distance (km)	Location		Water Depth (m)	Received SPL (L_p; dB re 1 µPa)
				Latitude (S)	Longitude (E)		
Pygmy Blue Whale BIA, Migration	15	MOD	58.5	20° 03' 49.48" S	113° 41' 21.42" E	1111	141.6
		24					141.2
		129					
		506					141.6

5.2.2.2. Sound level contour maps

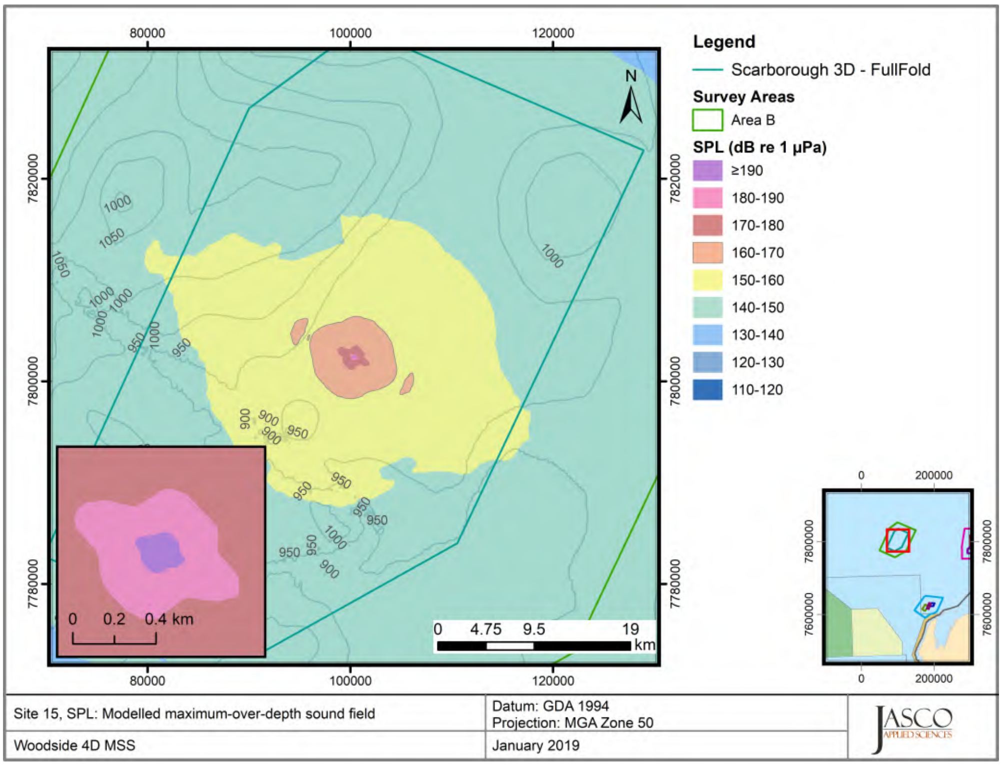

Figure 57. *Site 15, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

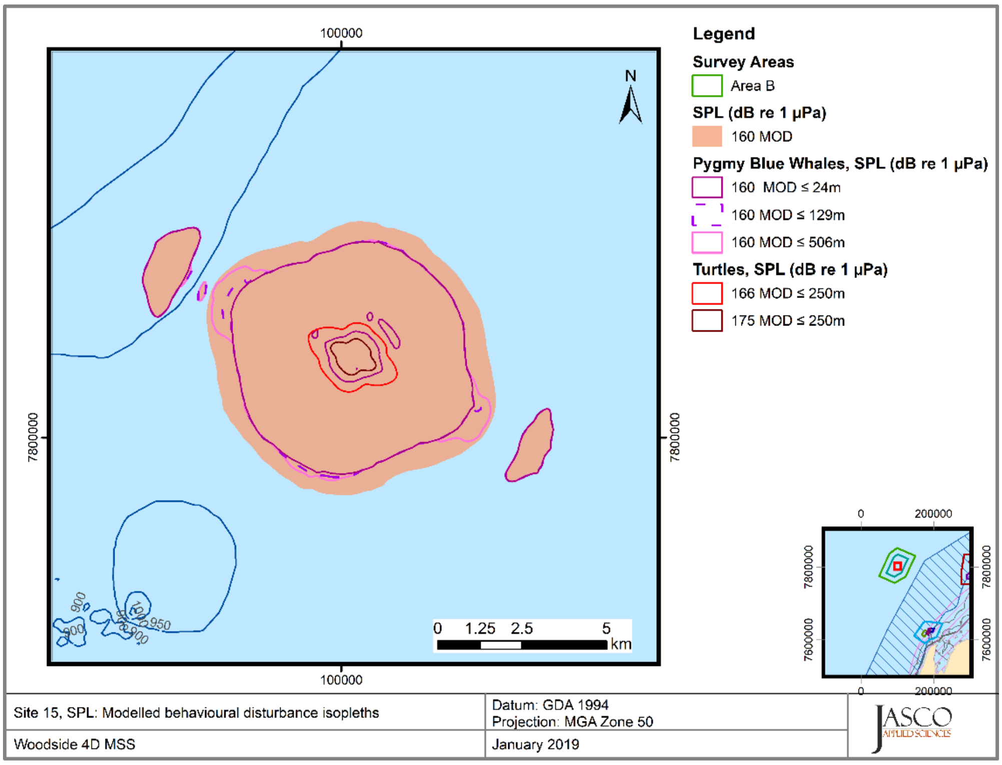

Figure 58. *Site 15, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

5.2.2.3. Vertical slices of modelled SPL sound fields

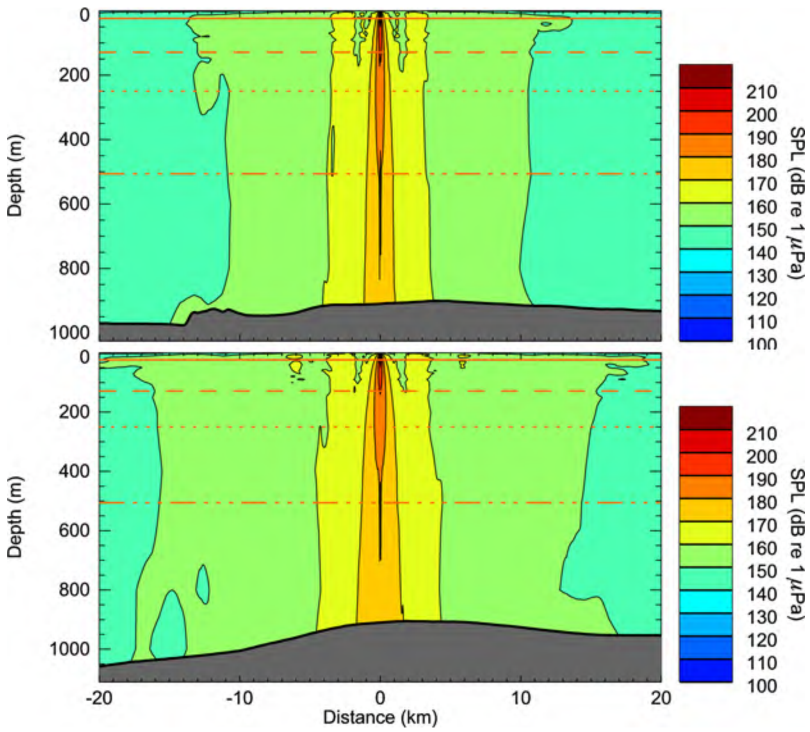

Figure 59. *Site 15*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

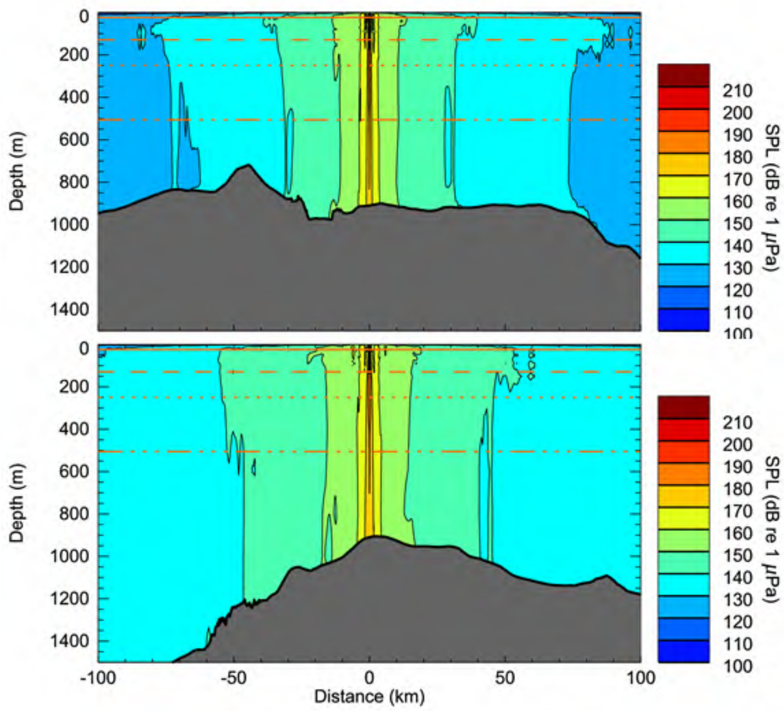

Figure 60. *Site 15*: Long range vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown out to a maximum range of 100 km along the broadside, (top) and endfire (bottom) directions, with the pygmy blue whale (24, 129 and 506 m) and turtle (250 m) depth limits shown.

5.2.3. Area C

Area C includes the Laverda, Cimatti, and Vincent 4-D Acquisition Areas (Figure 4). The Laverda 4-D Survey is different to all other surveys, as the seismic source is a 2650 in³ array towed at 5 m. For all other surveys, the source is a 3150 in³ array towed at 6 m.

5.2.3.1. Tabulated results for the water column

Table 30. *Area C*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2650 and 3150 in³ arrays to modelled maximum-over-depth unweighted per-pulse SEL isopleths from the single impulse sites. The water depth at each site is presented in brackets below the site name.

Per-pulse SEL (L_E; dB re 1 µPa²·s)	Site 16◊ (788 m)		Site 17◊ (903 m)		Site 18◊ (769 m)		Site 19▲ (615 m)	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
180	0.11	0.09	0.11	0.09	0.11	0.09	0.14	0.13
170	0.37	0.31	0.37	0.31	0.38	0.31	0.48	0.42
160†	**1.6**	**1.4**	**1.5**	**1.3**	**1.6**	**1.4**	**2.3**	**2.0**
150	6.8	5.3	6.6	4.6	7.0	5.3	8.1	6.7
140	29.6	19.7	23.1	17.9	27.4	20.9	27.5	21.6
130	91.5	64.6	79.7	63.3	87.1	67.3	82.4	56.7
120	*	*	*	*	*	*	*	*
Per-pulse SEL (L_E; dB re 1 µPa²·s)	**Site 20▲ (505 m)**		**Site 21▲ (283 m)**		**Site 22▲ (535 m)**		**Site 23▲ (275 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	<0.04	<0.04	0.04	0.04	0.04	0.04	0.04	0.04
180	0.14	0.13	0.13	0.12	0.13	0.12	0.13	0.12
170	0.48	0.43	0.68	0.56	0.48	0.42	0.72	0.57
160†	**2.2**	**1.8**	**2.1**	**1.8**	**2.1**	**1.8**	**2.1**	**1.8**
150	7.7	6.5	7.3	5.7	6.8	5.8	7.3	5.9
140	36.7	26.5	21.5	18.1	20.8	16.7	21.3	17.9
130	90.2	73.1	52.0	41.8	50.6	44.5	51.1	42.1
120	*	*	*	*	*	*	*	*

† Low power zone assessment criteria DEWHA (2008).
◊ 2650 in³ array towed at 5 m
▲ 3150 in³ array towed at 6 m
* R_{max} radii extend beyond the 100 km modelling boundary.

Table 31. *Area C*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 2650 and 3150 in^3 arrays to modelled maximum-over-depth SPL isopleths from the single impulse sites. The water depth at each site is presented in brackets below the site name.

SPL (L_p; dB re 1 µPa)	**Site 16◊ (788 m)**		**Site 17◊ (903 m)**		**Site 18◊ (769 m)**		**Site 19▲ (615 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
190	0.09	0.09	0.09	0.09	0.09	0.09	0.13	0.13
180	0.32	0.28	0.31	0.28	0.32	0.28	0.45	0.37
170	1.3	1.1	1.1	0.9	1.4	1.1	2.2	1.9
160‡	**4.0**	**3.4**	**4.2**	**3.6**	**4.1**	**3.3**	**6.2**	**5.0**
150	17.0	12.1	14.4	11.0	16.8	13.4	19.4	13.9
145♦	**34.1**	**28.4**	**33.6**	**21.9**	**34.2**	**28.0**	**36.3**	**28.3**
140	62.0	45.6	55.4	44.5	56.1	49.1	52.0	45.0
130	*	*	*	*	*	*	*	*

SPL (L_p; dB re 1 µPa)	**Site 20▲ (505 m)**		**Site 21▲ (283 m)**		**Site 22▲ (535 m)**		**Site 23▲ (275 m)**	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	<0.04	<0.04	0.04	0.04	0.04	0.04	0.04	0.04
190	0.13	0.13	0.12	0.12	0.12	0.12	0.12	0.12
180	0.43	0.36	0.52	0.41	0.44	0.37	0.52	0.44
170	2.0	1.7	2.0	1.3	2.0	1.8	1.9	1.3
160‡	**6.5**	**5.2**	**6.0**	**4.7**	**5.9**	**4.8**	**6.2**	**4.9**
150	26.4	17.2	17.8	13.5	16.2	13.2	16.8	13.3
145♦	**37.9**	**34.0**	**28.0**	**23.0**	**26.2**	**21.3**	**27.7**	**22.6**
140	66.7	57.9	45.0	33.7	39.4	35.5	41.1	34.9
130	*	*	*	*	*	*	*	*

* R_{max} radii extend beyond the 100 km modelling boundary.
‡ Marine mammal behavioural threshold for impulsive sound sources (NMFS 2014)
♦ Threshold for divers from Parvin (2005)
◊ 2650 in^3 array towed at 5 m
▲ 3150 in^3 array towed at 6 m

Table 32. *Area C*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) the 2650 and 3150 in^3 arrays to modelled SPL isopleths from the single impulse sites within the specified biologically relevant depths. The chosen depths are related to mean dive depths for pygmy blue whales and turtles (Section 2.1 and 2.2).

SPL (L_p; dB re 1 µPa)	Depth limit (m)	Site 16◊ (788 m)		Site 17◊ (903 m)		Site 18◊ (769 m)		Site 19▲ (615 m)	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
160‡	24	3.1	2.8	3.2	2.9	3.1	2.7	6.1	5.3
	129	3.1	2.7	3.2	2.9	3.1	2.7	6.1	5.3
	506	3.7	2.9	3.2	2.8	3.6	2.9	6.1	5.0
166†	250	1.3	1.1	1.3	1.1	1.3	1.1	1.5	1.3
175#		0.60	0.51	0.60	0.51	0.60	0.51	0.75	0.63
SPL (L_p; dB re 1 µPa)	**Depth limit (m)**	**Site 20▲ (505 m)**		**Site 21▲ (283 m)**		**Site 22▲ (535 m)**		**Site 23▲ (275 m)**	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
160‡	24	6.1	5.3	5.8	4.7	5.9	4.6	5.6	4.7
	129	6.5	5.4	6.0	4.8	5.9	4.5	6.2	4.9
	506	6.5	5.2	6.0	4.7	5.9	4.5	6.2	4.9
166†	250	3.3	1.5	2.8	2.4	3.2	2.9	2.7	2.4
175#		0.74	0.63	0.80	0.68	0.76	0.64	0.80	0.69

‡ Marine mammal behavioural threshold for impulsive sound sources (NMFS 2014).
† Threshold for turtle behavioural response to impulsive noise (NSF 2011b).
# Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).
◊ 2650 in^3 array towed at 5 m
▲ 3150 in^3 array towed at 6 m

Table 33. *Area C:* Maximum (R_{max}) horizontal distances (km) from the 2650 and 3150 in^3 arrays to modelled maximum-over-depth peak pressure level (PK) thresholds based on the NOAA Technical Guidance (NMFS 2018) for marine mammals, and Popper et al. (2014) for fish and Finneran et al. (2017) for turtles. The water depth at each site is presented in brackets below the site name.

Hearing group	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (km)		
		Site 16◊ (788 m)	Site 19▲ (615 m)	Site 21▲ (283 m)
Low-frequency cetaceans (PTS)	219	0.03	0.03	0.03
Low-frequency cetaceans (TTS)	213	0.06	0.05	0.05
Mid-frequency cetaceans (PTS)	230	<0.02	<0.02	<0.02
Mid-frequency cetaceans (TTS)	224	<0.02	<0.02	<0.02
High-frequency cetaceans (PTS)	202	0.19	0.19	0.19
High-frequency cetaceans (TTS)	196	0.39	0.39	0.38
Fish: No swim bladder (also applied to sharks)	213	0.06	0.05	0.05
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing Fish eggs, and larvae	207	0.11	0.11	0.11
Turtles (PTS)	232	<0.02	<0.02	<0.02
Turtles (TTS)	226	<0.02	<0.02	<0.02

◊ 2650 in^3 array towed at 5 m
▲ 3150 in^3 array towed at 6 m

Table 34. *Area C*: Maximum (R_{max}) horizontal distances (in km) from the 2650 and 3150 in^3 arrays to modelled maximum-over-depth 178 dB re 1µPa PK-PK , assessed along the four FWRAM modelling transects (maximum presented) at three modelling sites (Table 8). The water depth at each site is presented in brackets below the site name.

PK-PK (L_{pk-pk}; dB re 1 µPa)	Distance R_{max} (km)		
	Site 16◊ (788 m)	Site 19▲ (615 m)	Site 21▲ (283 m)
178	9.04	8.07	6.25

◊ 2650 in^3 array towed at 5 m
▲ 3150 in^3 array towed at 6 m

Table 35. *Area C*: Received maximum-over-depth SPL at sound field sampling receivers (Table 10) from the nearest modelling sites.

Receiver name	Relevant modelling site	Distance (km)	Location		Water Depth (m)	Received SPL (L_p; dB re 1 µPa)
			Latitude (S)	Longitude (E)		
Gascoyne Marine Park (Commonwealth)	17	2.1	21° 33' 25.75"	113° 45' 00.00"	929	161.0
Ningaloo Marine Park (WA)	18	26.9	21° 46' 57.12"	114° 01' 29.08"	51	121.8
Ningaloo Marine Park (WA)	20	28.2	21° 42' 37.97"	114° 10' 00.82"	36	118.5
Gascoyne Marine Park (Commonwealth)		12.6	21° 39' 55.36"	113° 53' 56.17"	416	145.8
Commonwealth waters adjacent to Ningaloo Reef KEF	23	21.2	21° 39' 55.36"	114° 05' 08.24"	134	136.3
Muiron Islands Marine Management Area (WA)		29	21° 35' 20.75"	114° 20' 25.66"	80	120.1

5.2.3.2. Tabulated results for the seafloor

Table 36. *Area C*: Maximum (R_{max}) horizontal distances (in m) from the 3150 in^3 array to modelled seafloor PK from one single-impulse modelling site (Table 8). The water depth at each site is presented in brackets below the site name.

Hearing group/animal type	PK threshold (L_{pk}; dB re 1 µPa)	Distance R_{max} (m)
		Site 23 (275 m)
Sound levels for sponges and corals†	226	–
Fish: No swim bladder (also applied to sharks)	213	–
Fish: Swim bladder not involved in hearing, Swim bladder involved in hearing	207	47

† Heyward et al. (2018)
A dash indicates the level was not reached.

Table 37. *Area C*: Maximum (R_{max}) horizontal distances (in m) from the 3150 in^3 array to modelled seafloor PK-PK from a single modelling site (Table 8). Results included in relation to benthic invertebrates (Section 3.3). The water depth at each site is presented in brackets below the site name.

PK-PK ($L_{pk\text{-}pk}$; dB re 1 µPa)	Distance R_{max} (m) Site 23 (275 m)
213	31
212	72
211	99
210	127
209	154
202	424

5.2.3.3. Sound level contour maps

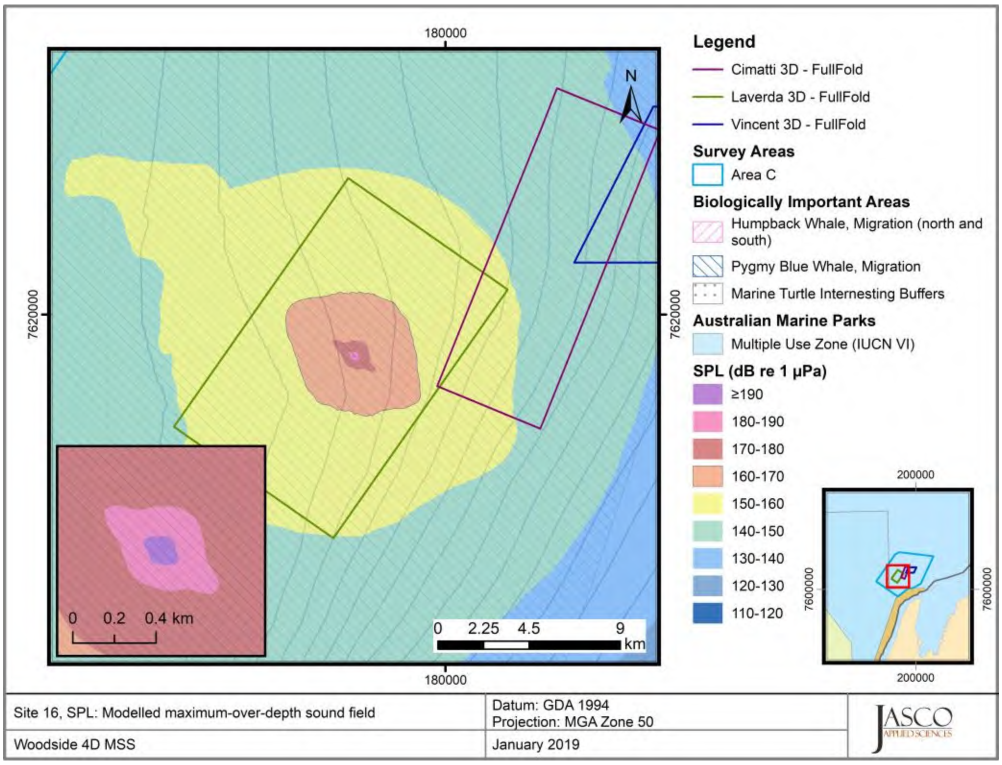

Figure 61. *Site 16 (2650 in^3), SPL:* Sound level contour map showing unweighted maximum-over-depth results.

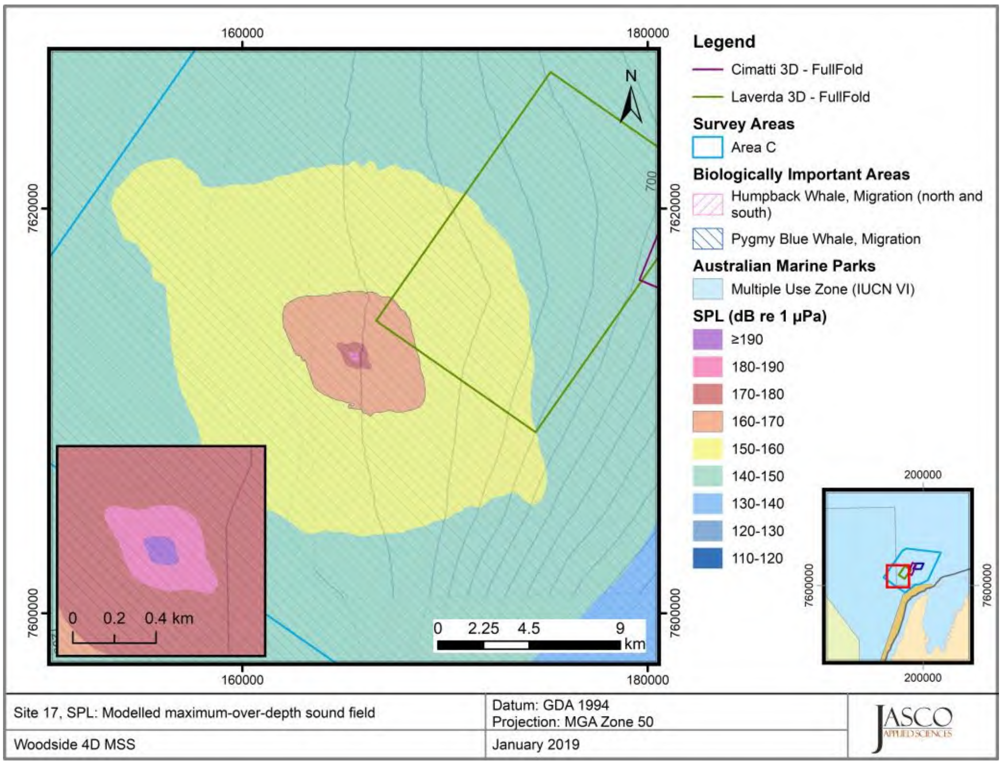

Figure 62. *Site 17 (2650 in³), SPL:* Sound level contour map showing unweighted maximum-over-depth results.

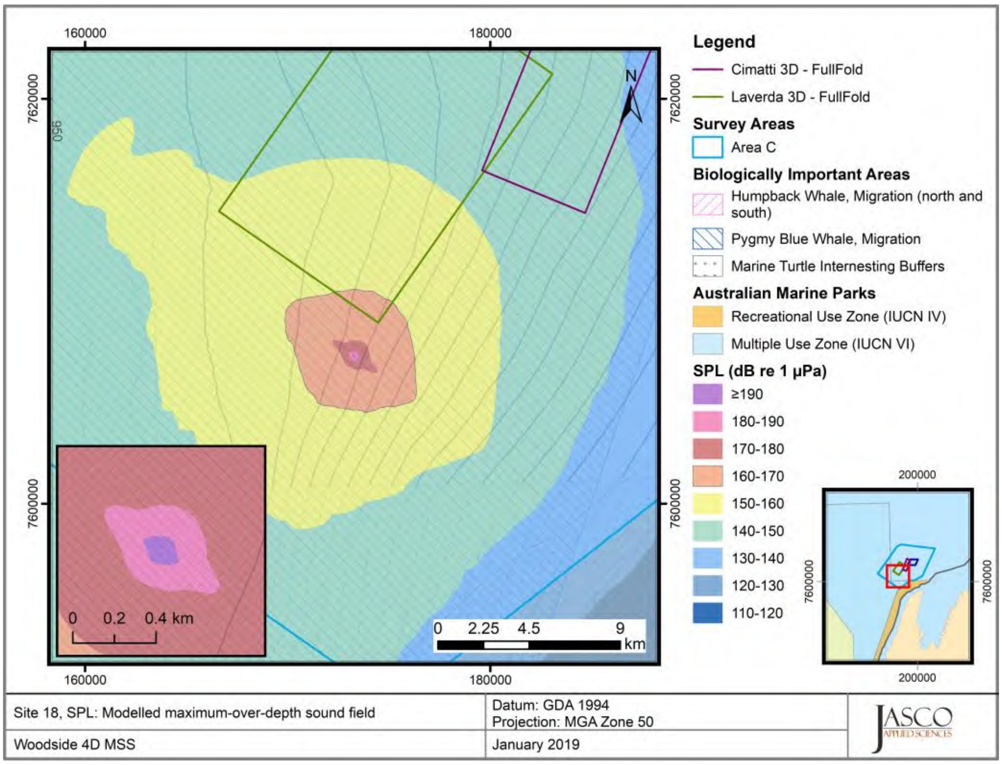

Figure 63. *Site 18 (2650 in³), SPL:* Sound level contour map showing unweighted maximum-over-depth results.

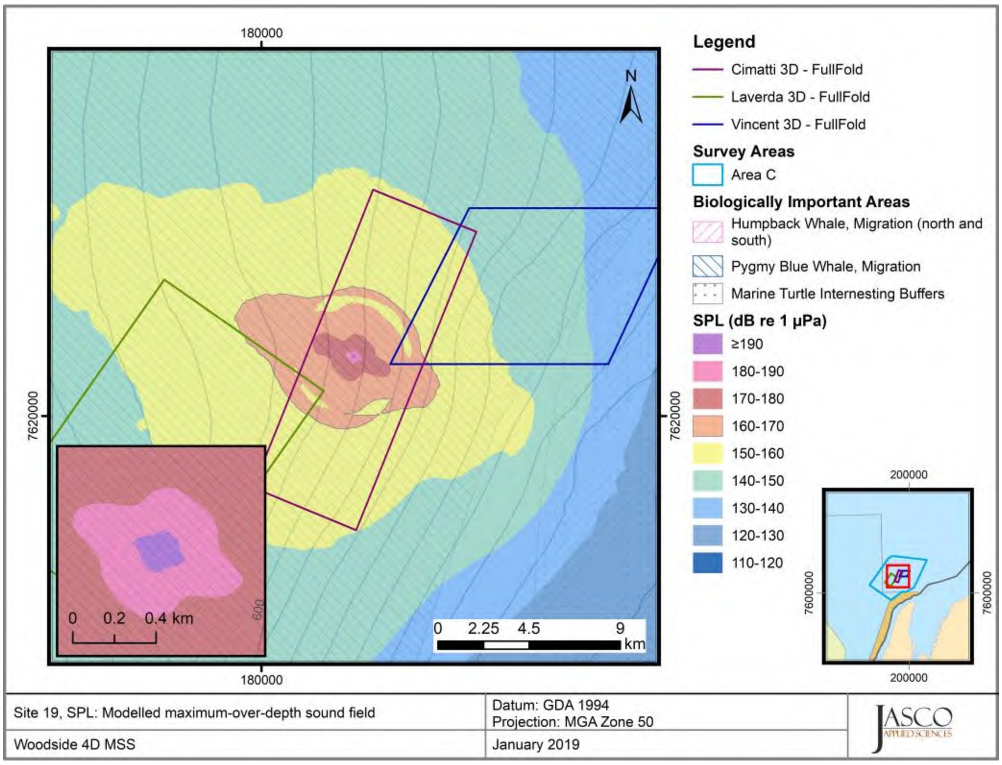

Figure 64. *Site 19, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

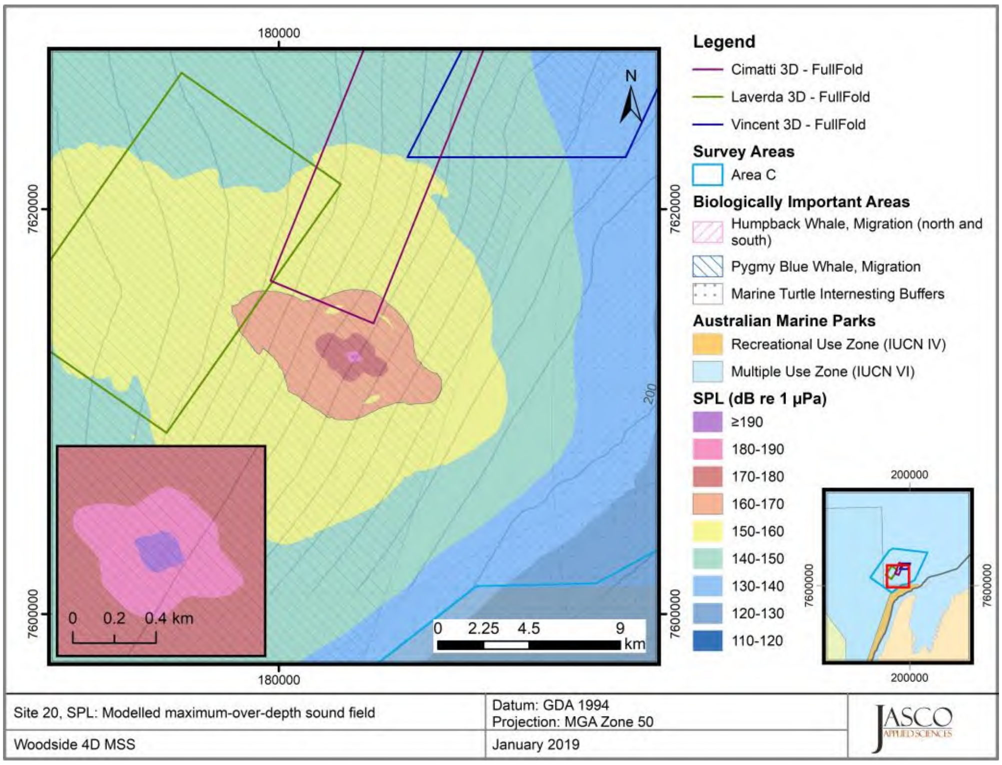

Figure 65. *Site 20, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

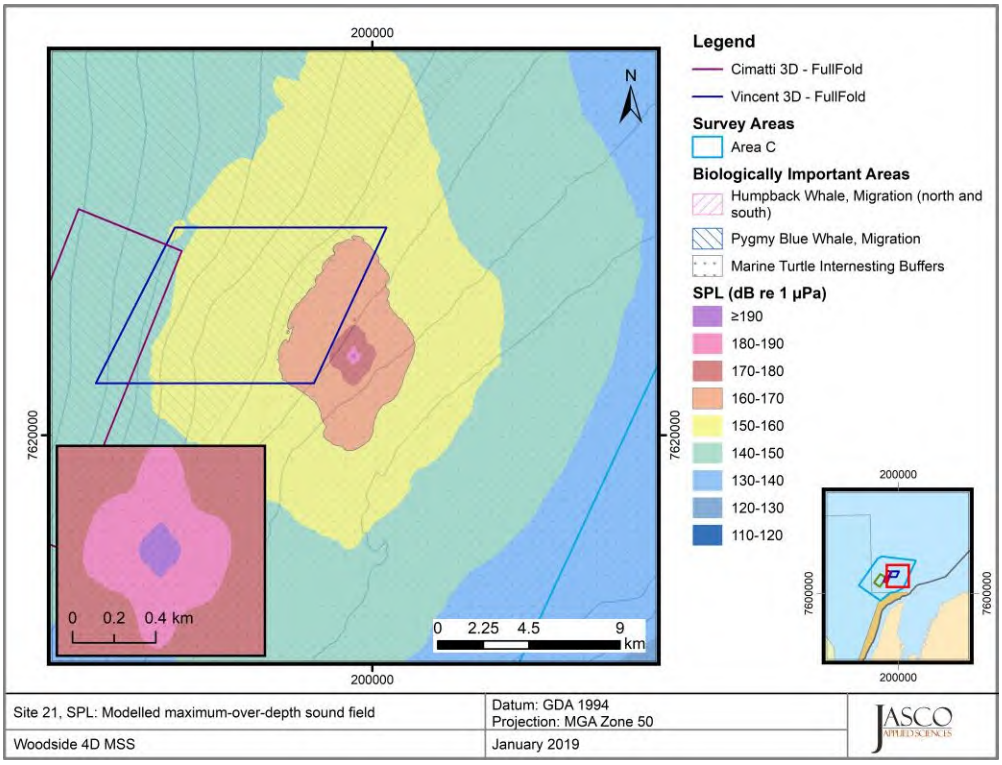

Figure 66. *Site 21, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

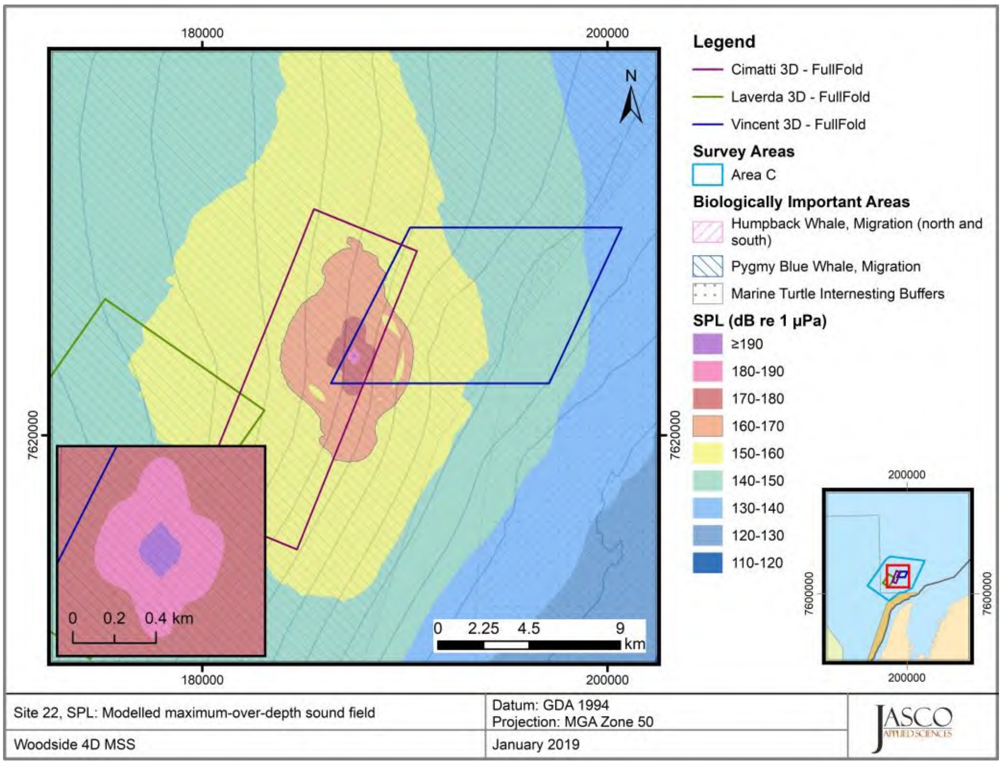

Figure 67. *Site 22, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

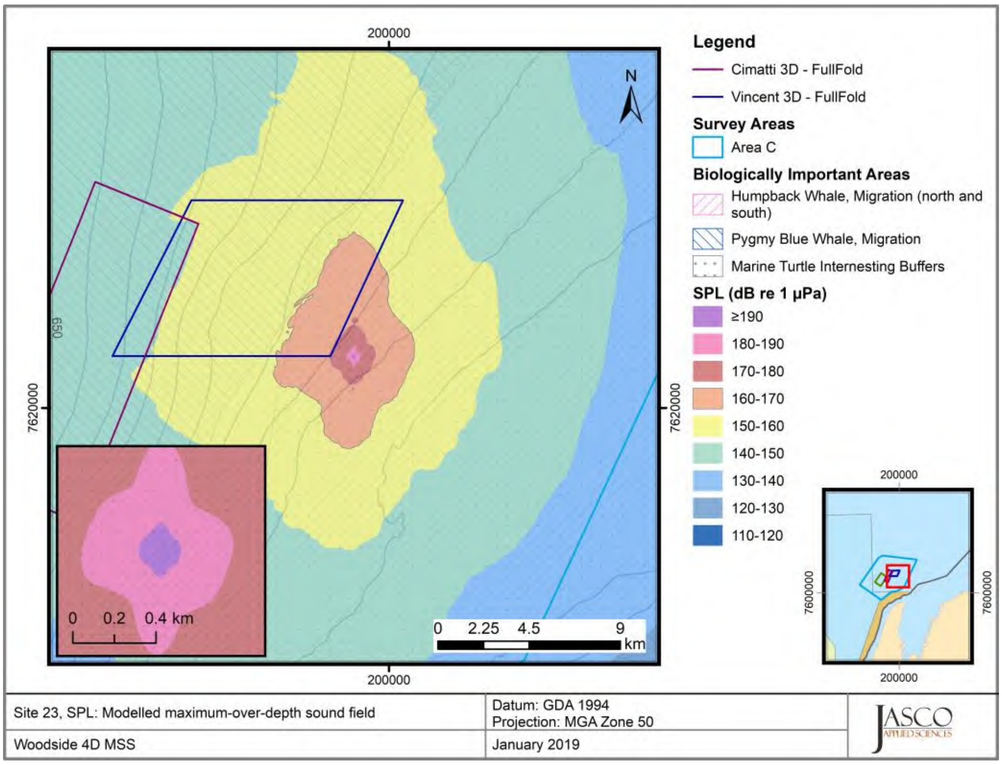

Figure 68. *Site 23, SPL:* Sound level contour map showing unweighted maximum-over-depth results.

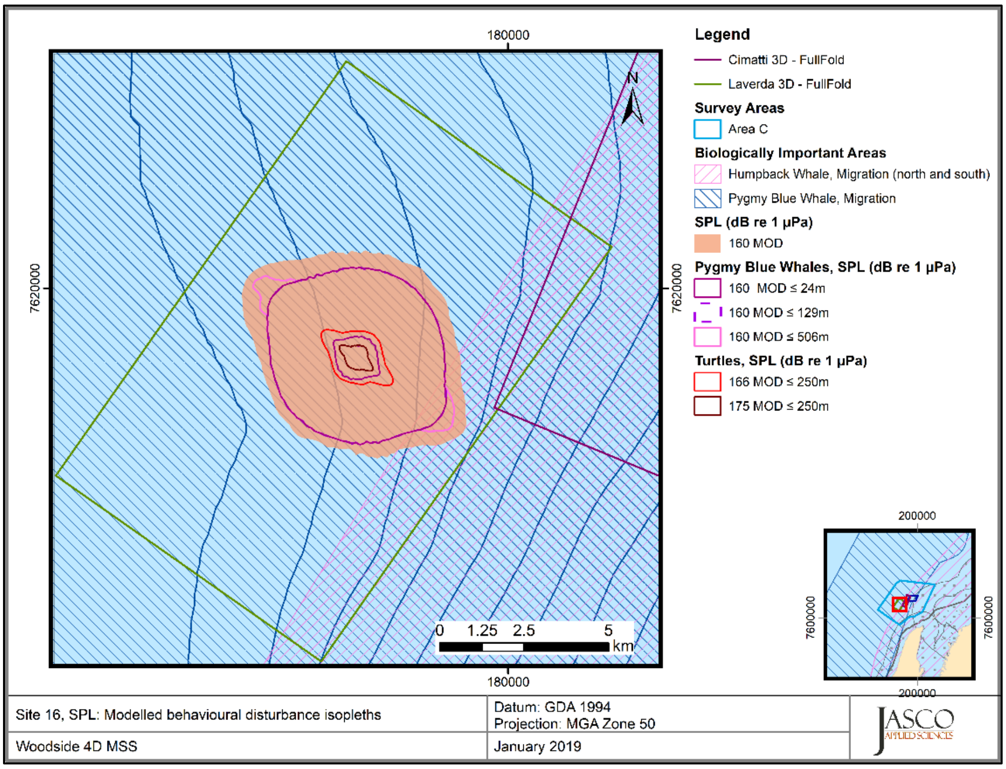

Figure 69. *Site 16 (2650 in³), SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

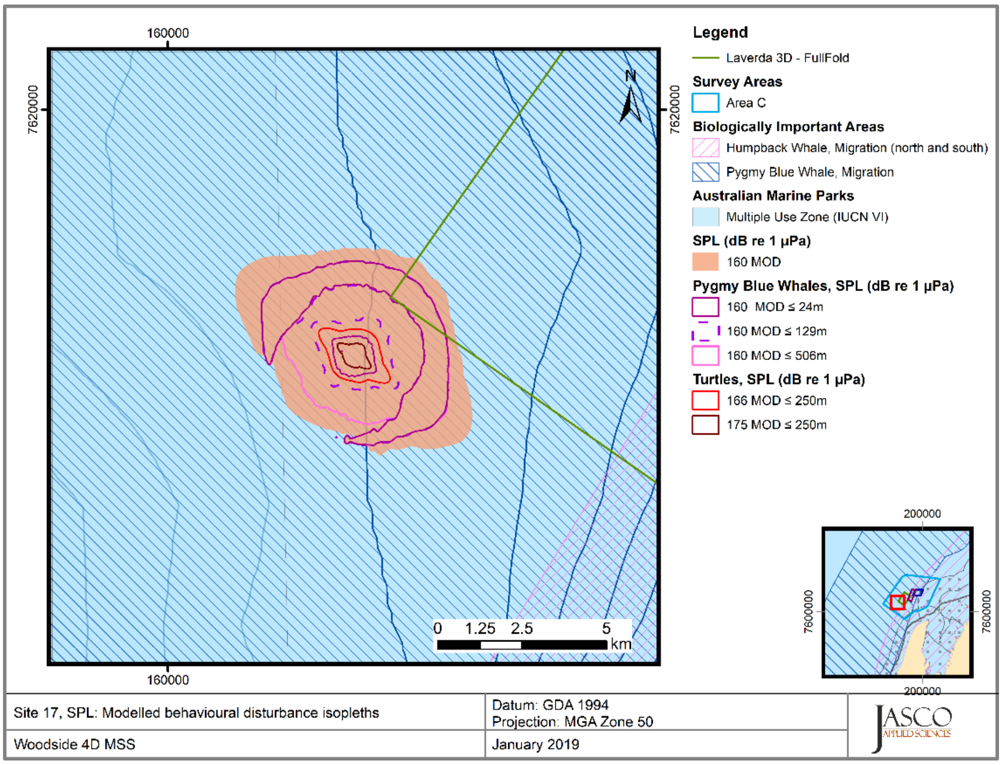

Figure 70. *Site 17 (2650 in^3), SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

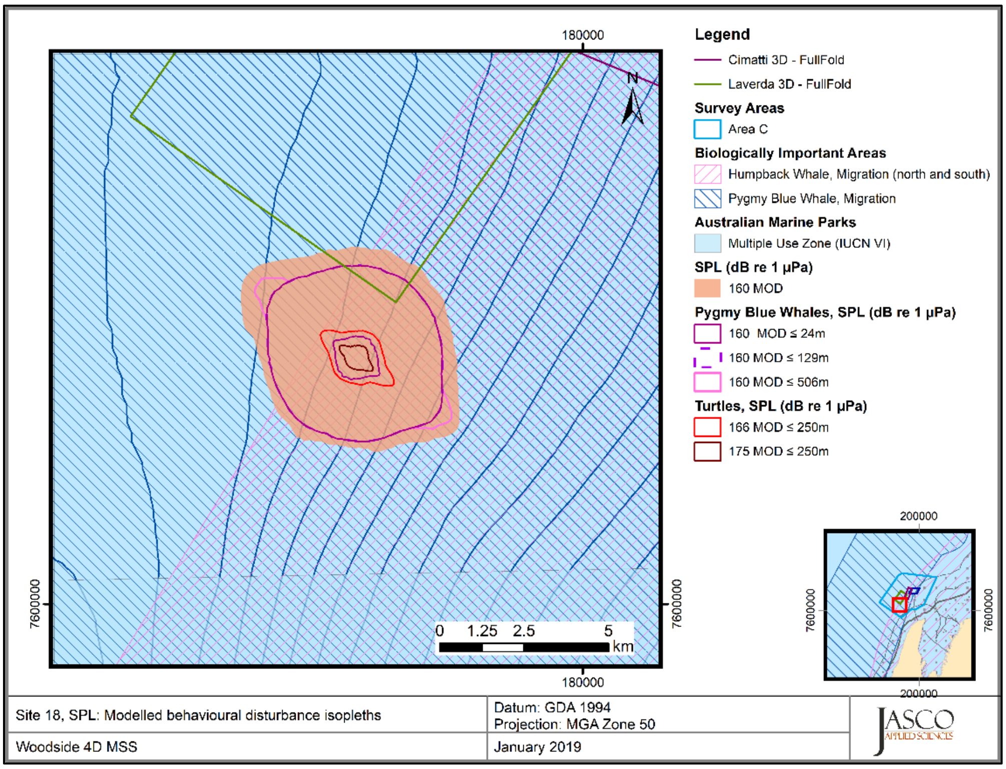

Figure 71. *Site 18 (2650 in^3), SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

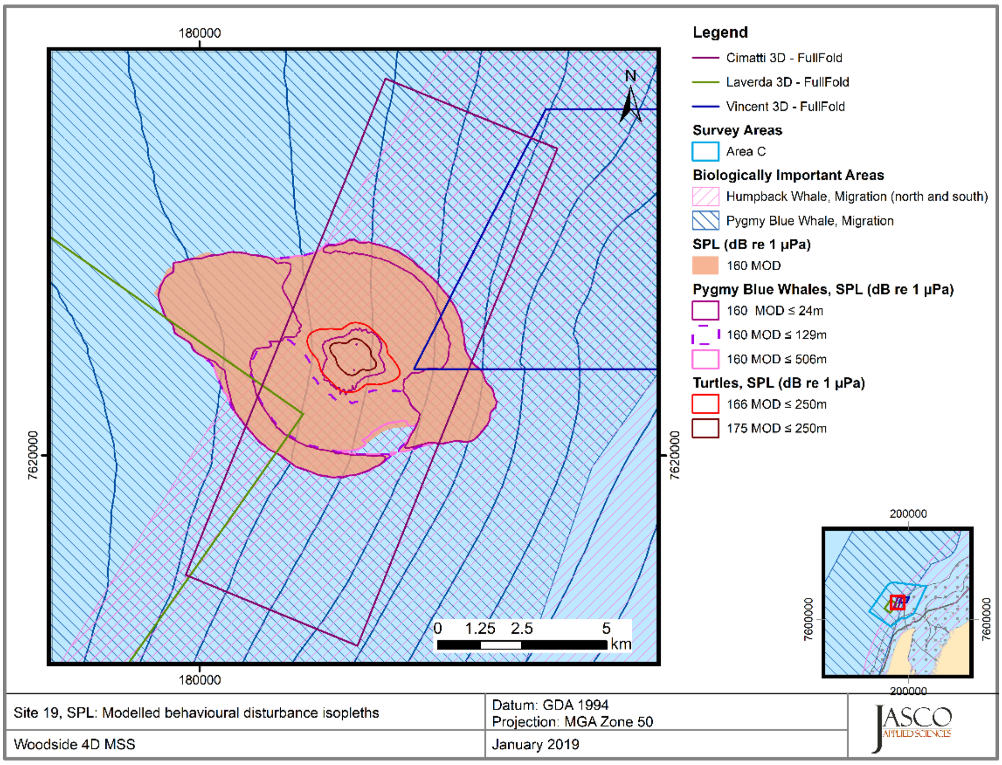

Figure 72. *Site 19, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

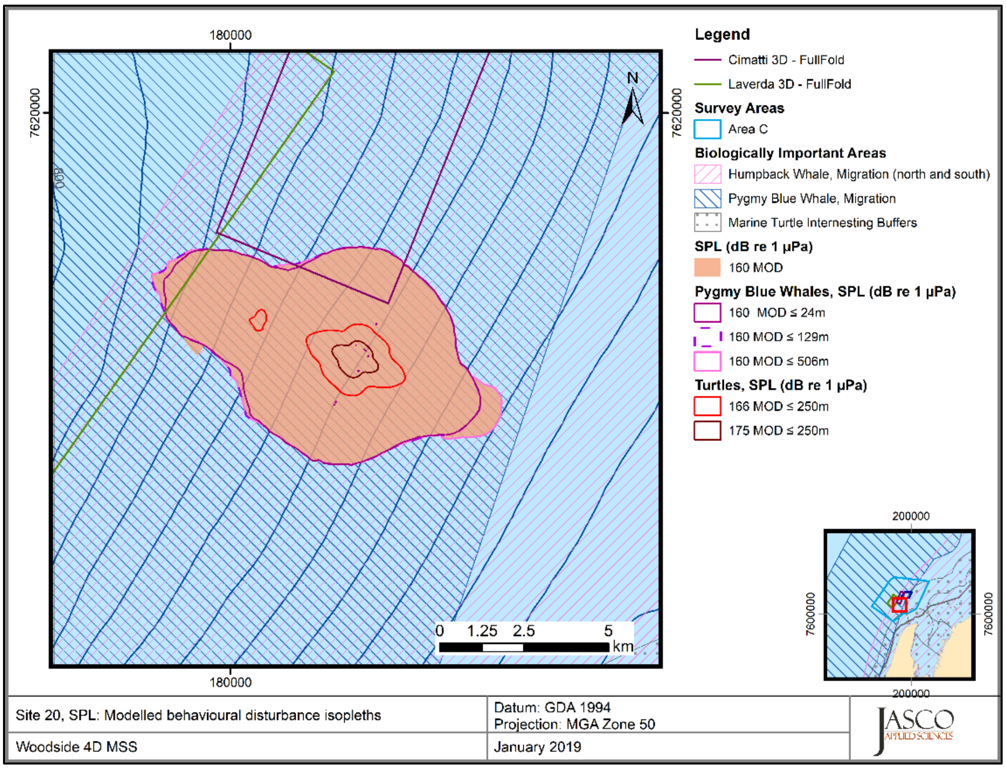

Figure 73. *Site 20, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

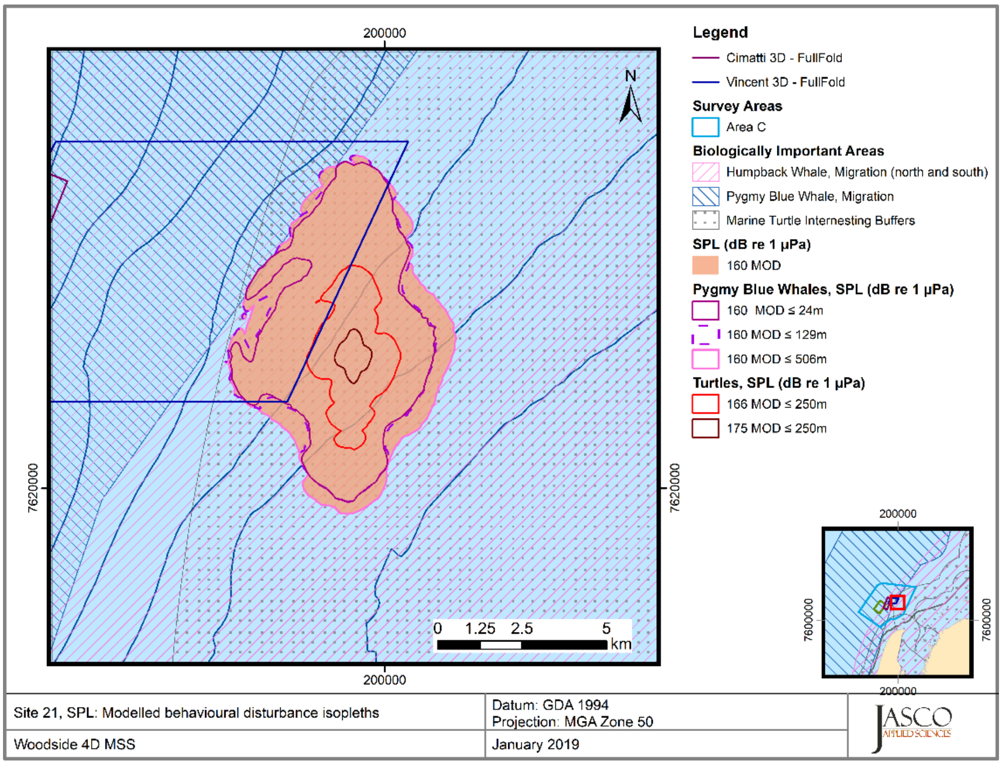

Figure 74. *Site 21, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

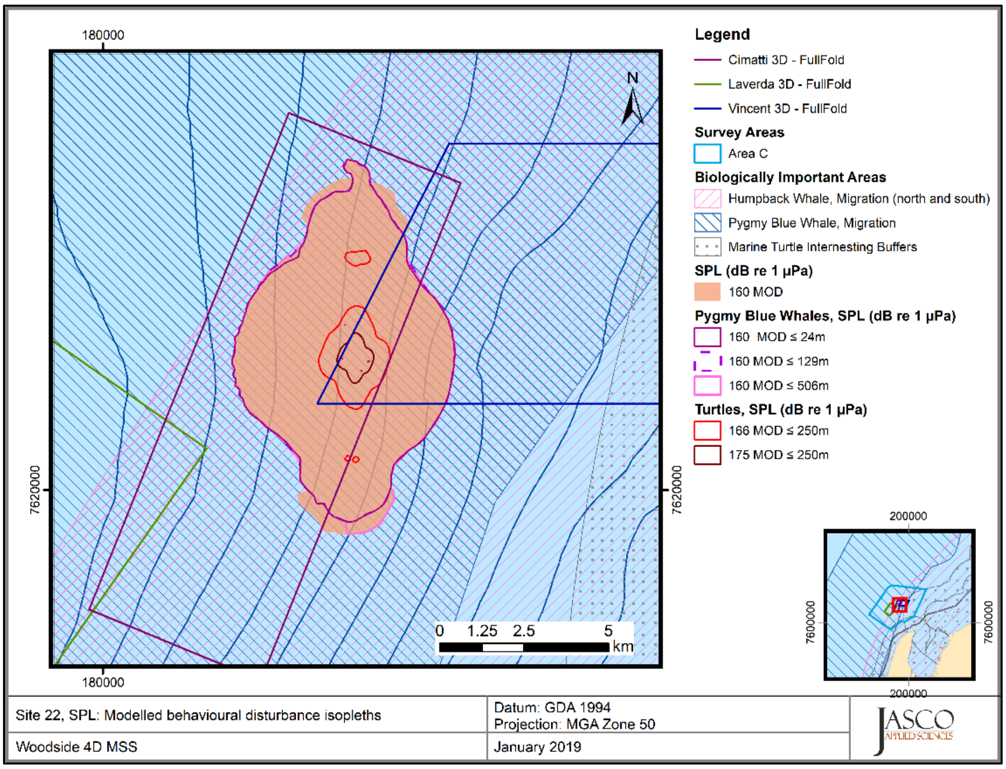

Figure 75. *Site 22, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

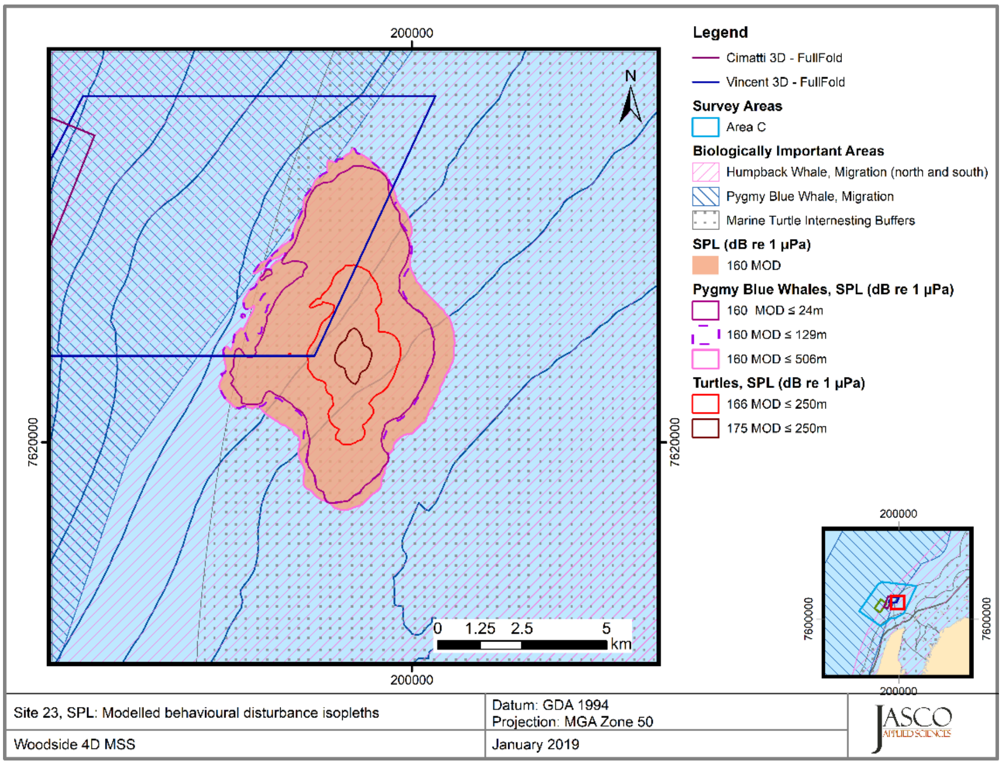

Figure 76. *Site 23, SPL:* Sound level contour map showing marine mammal and turtle behavioural disturbance related isopleths for maximum-over-depth (MOD) and depth limited results.

5.2.3.4. Vertical slices of modelled SPL sound fields

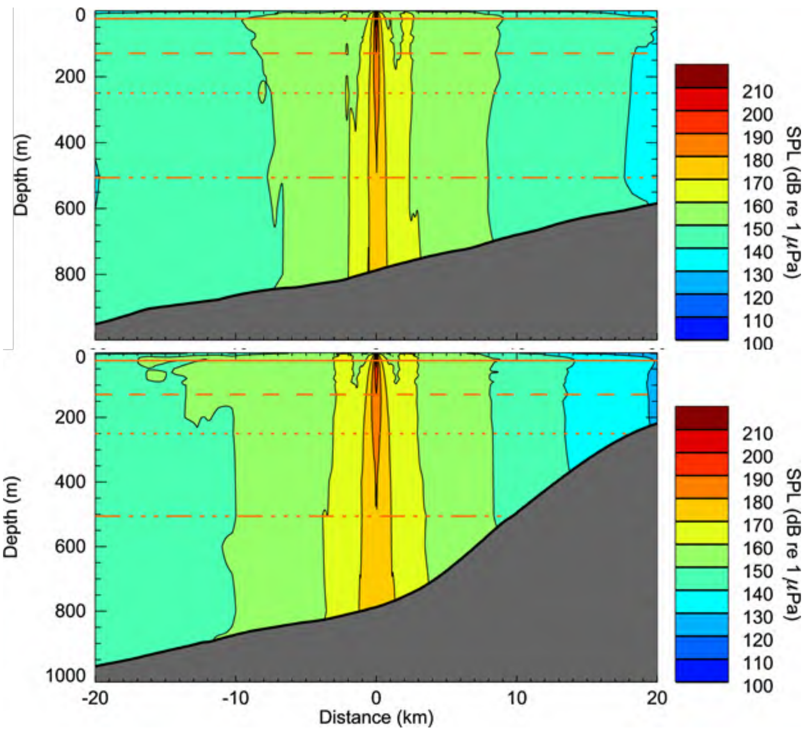

Figure 77. *Site 16, SPL*: Vertical slice of the predicted SPL for the 2650 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

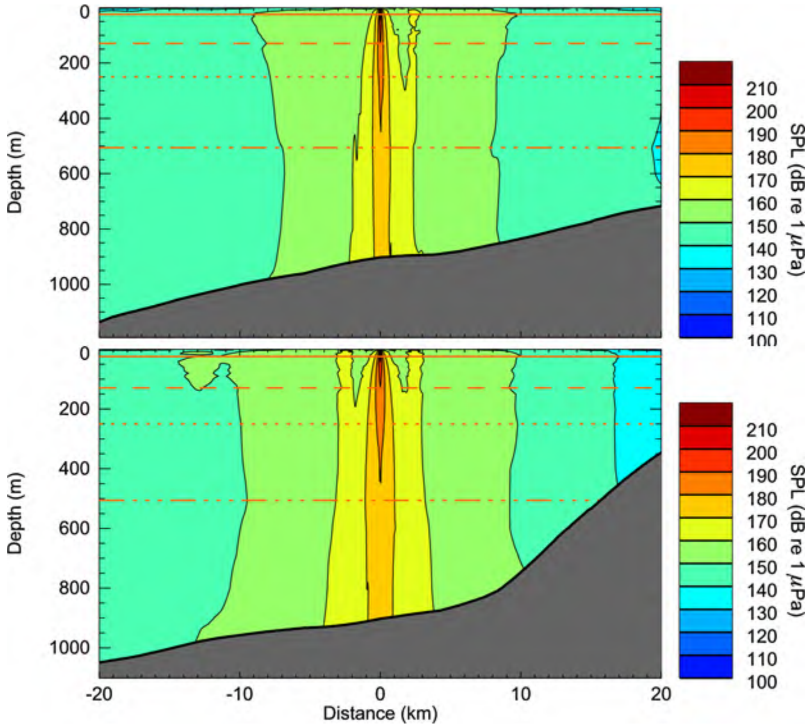

Figure 78. *Site 17, SPL*: Vertical slice of the predicted SPL for the 2650 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

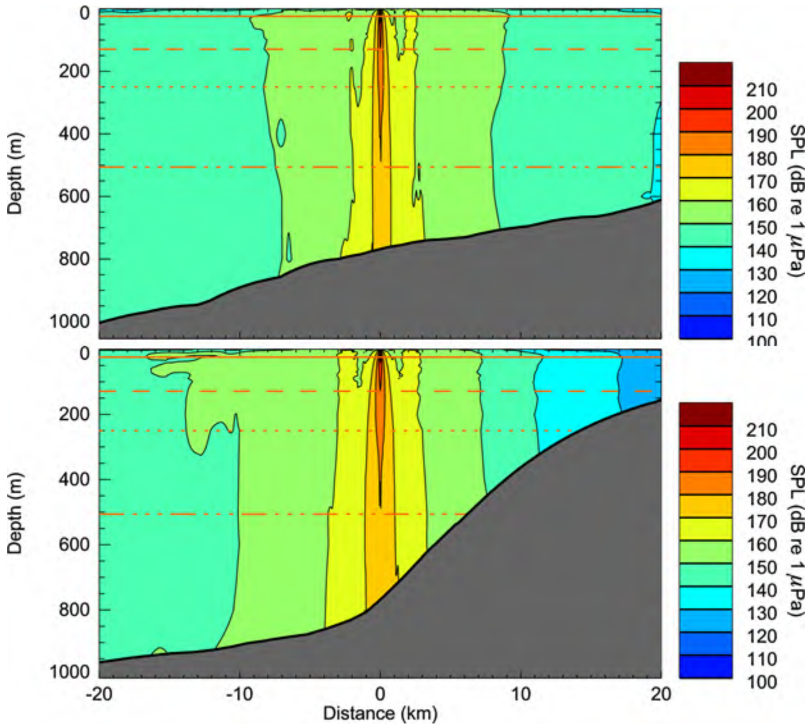

Figure 79. *Site 18, SPL*: Vertical slice of the predicted SPL for the 2650 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

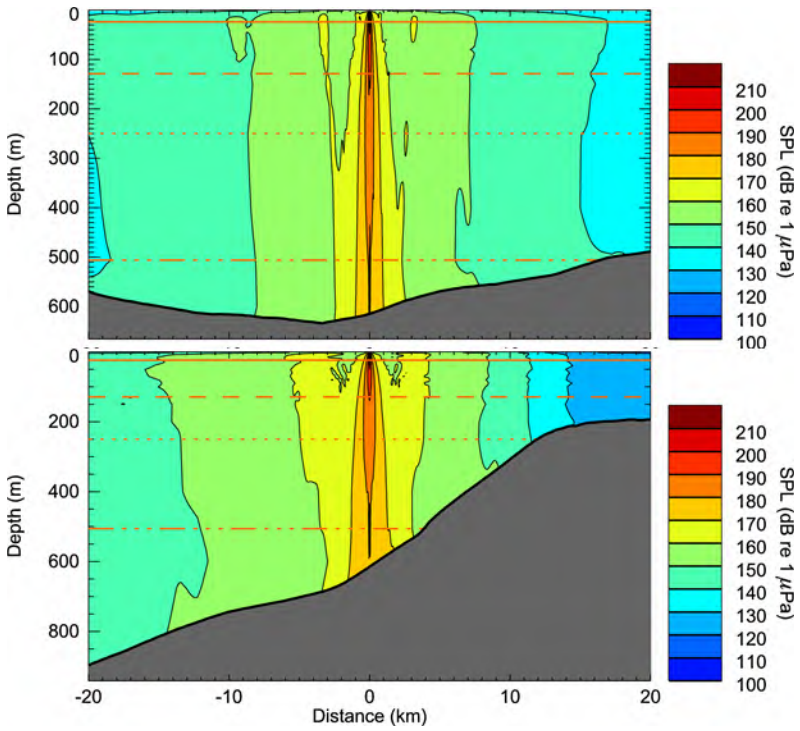

Figure 80. *Site 19, SPL*: Vertical slice of the predicted SPL for the 2650 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

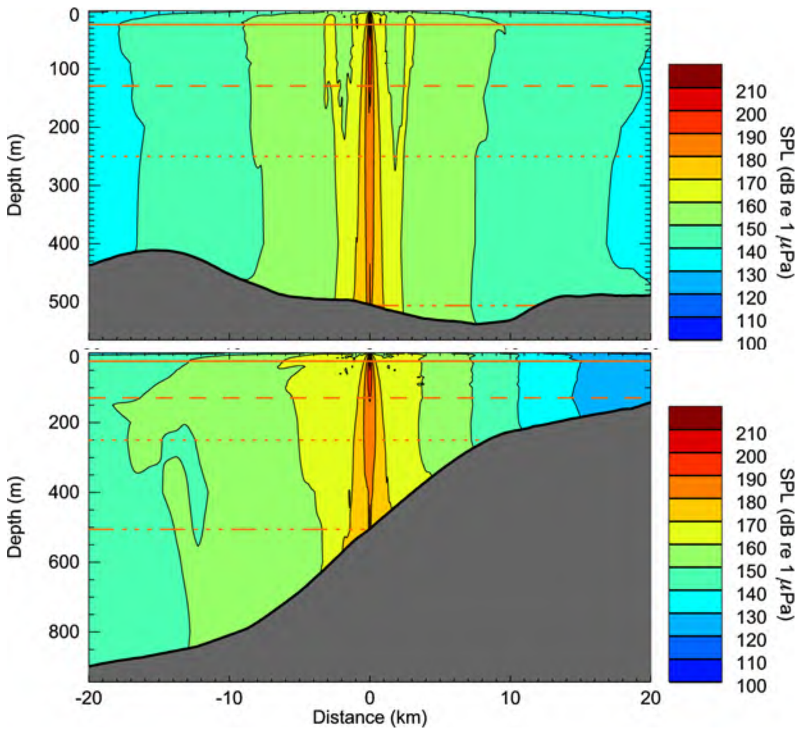

Figure 81. *Site 20*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

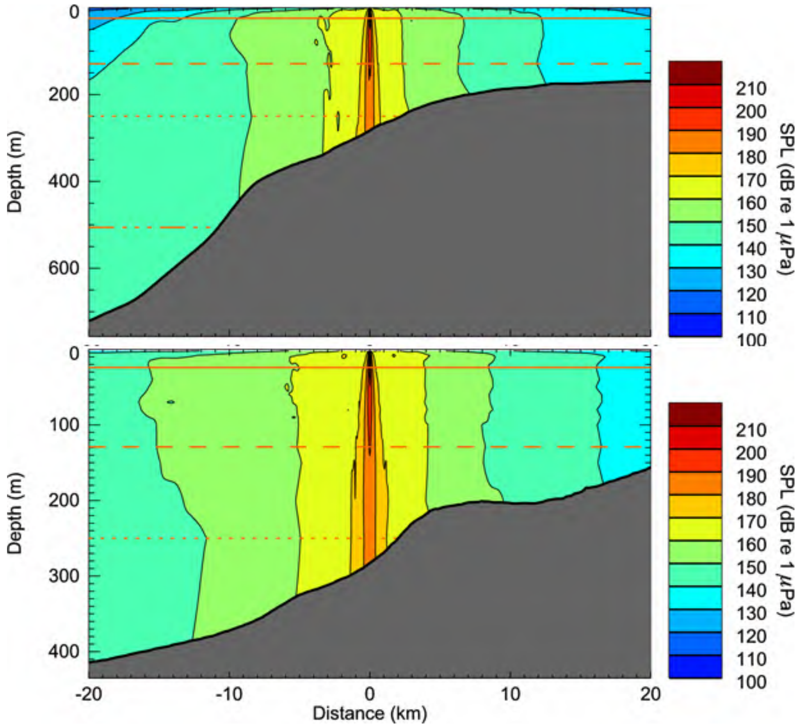

Figure 82. *Site 21*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

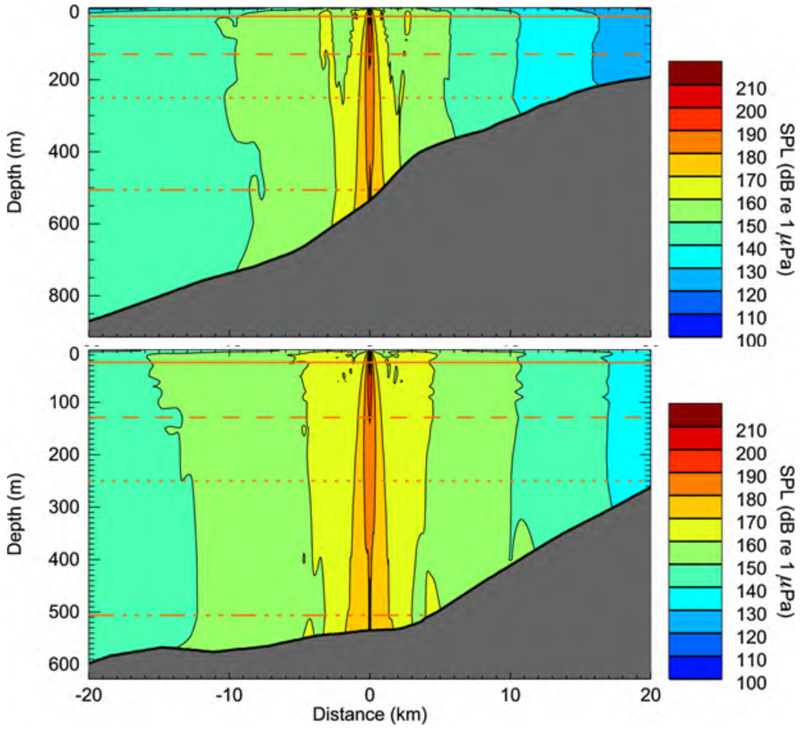

Figure 83. *Site 22*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

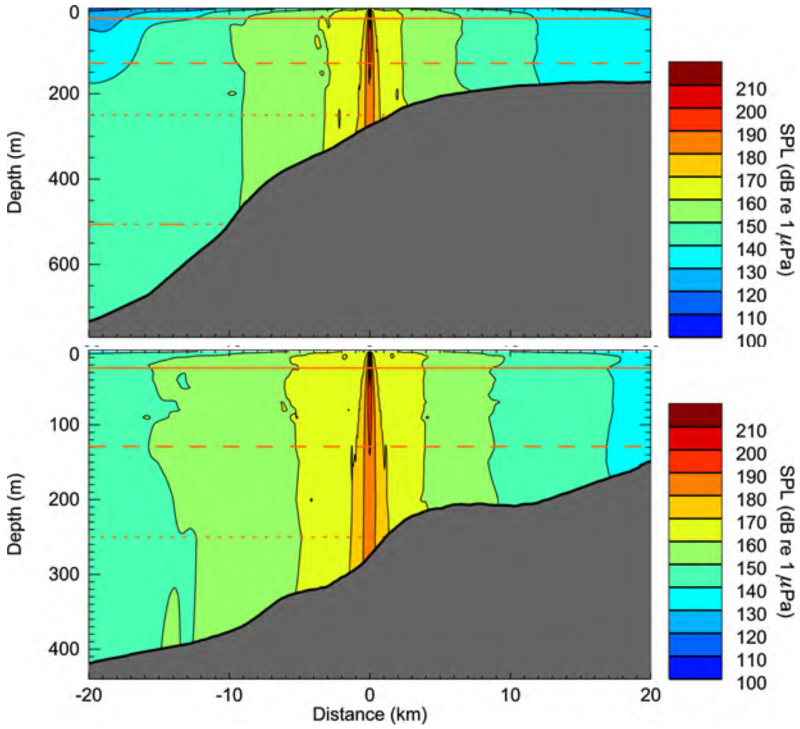

Figure 84. *Site 23*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown.

5.3. Multiple Pulse Sound Fields

The SEL_{24h} results for each survey (Tables 7 and 9) are presented for one possible operational scenario within each survey fullfold area, described in Section 2. The estimated ranges to the appropriate cumulative exposure criterion contour for the various marine fauna groups considered, and the corresponding ensonified areas are included in tables for each survey. The ranges in this section are the perpendicular distance from the closest survey line to the relevant isopleth. Maps of the estimated sound field, threshold contours, and isopleths of interest for the cumulative noise scenarios are also included.

The tables in this section are:

- Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds for Pluto 4-D Survey (Table 38), Harmony 4-D Survey (Table 41), Scarborough 4-D Survey (Table 44), Laverda 4-D Survey (Table 47), Cimatti 4-D Survey (Table 50), and Vincent 4-D Survey (Table 53).
- Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds for pygmy blue whales for Pluto 4-D Survey (Table 39), Harmony 4-D Survey (Table 42), Scarborough 4-D Survey (Table 45), Laverda 4-D Survey (Table 48), Cimatti 4-D Survey (Table 51), and Vincent 4-D Survey (Table 54).
- Distances to SEL_{24h} based fish criteria for Pluto 4-D Survey (Table 40), Harmony 4-D Survey (Table 43), Scarborough 4-D Survey (Table 46), Laverda 4-D Survey (Table 49), Cimatti 4-D Survey (Table 52), and Vincent 4-D Survey (Table 55).

The maps in this section are:

- Sound level contour map showing maximum-over-depth SEL_{24h} results for Pluto 4-D Survey (Figure 85), Harmony 4-D Survey (Figure 89), Scarborough 4-D Survey (Figure 93), Laverda 4-D Survey (Figure 97), Cimatti 4-D Survey (Figure 101), and Vincent 4-D Survey (Figure 105).
- Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales for Pluto 4-D Survey (Figure 86), Harmony 4-D Survey (Figure 90), Scarborough 4-D Survey (Figure 94), Laverda 4-D Survey (Figure 98), Cimatti 4-D Survey (Figure 102) ,and Vincent 4-D Survey (Figure 106).

5.3.1. Area A: Pluto 4-D Survey

Table 38. *Pluto 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018).

Hearing group	PTS		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	0.86	73.7
Mid-frequency cetaceans	185	–	–
High-frequency cetaceans	155	<0.04	4.1
Hearing group	**TTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	168	59.7	1869
Mid-frequency cetaceans	170	<0.04	1
High-frequency cetaceans	140	0.20	34

A dash indicates the threshold is not reached.

Table 39. *Pluto 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. The chosen depth limit is related to mean dive depths for pygmy blue whales (Section 2.1).

Species	**Depth limit (m)**	**PTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted.	506	183	0.86	73.4
	129	183	0.40	57.7
	24	183	0.22	33.6
Species	**Depth limit (m)**	**TTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted.	506	168	43.3	1555
	129	168	19.8	950
	24	168	8.16	777

Table 40. *Pluto 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria.

Marine fauna group	**Threshold for SEL24h (L_E,24h; dB re 1 µPa²·s)**	**Maximum-over-depth**	
		R_{max} (km)	Area (km²)
Mortality and potential mortal injury			
I	219	<0.04	4.34
II, fish eggs and fish larvae	210	0.04	5.84
III	207	0.04	5.84
Fish recoverable injury			
I	216	<0.04	4.92
II, III	203	0.04	5.84
Fish TTS			
I, II, III	186	2.54	204

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

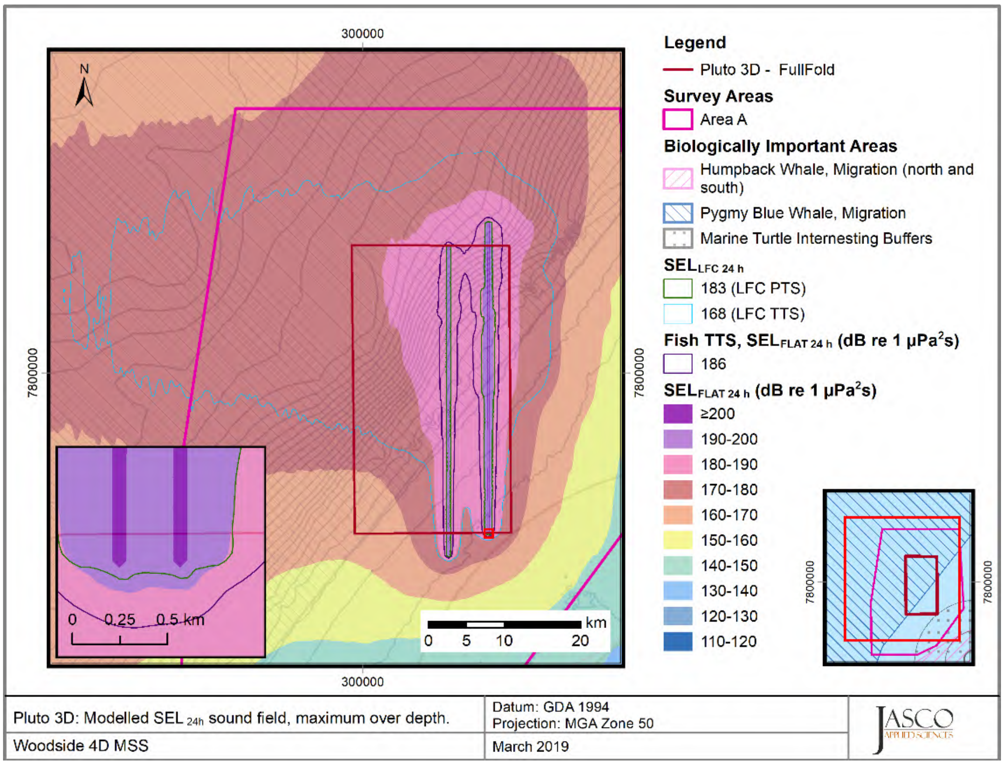

Figure 85. *Pluto 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results.

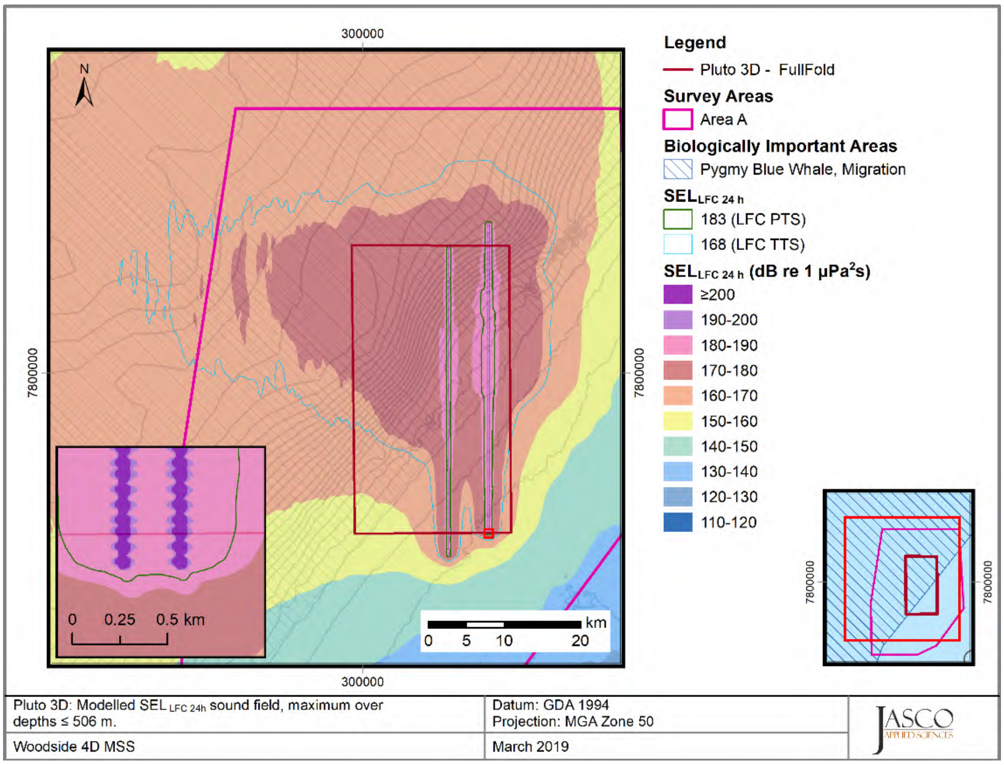

Figure 86. *Pluto 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales.

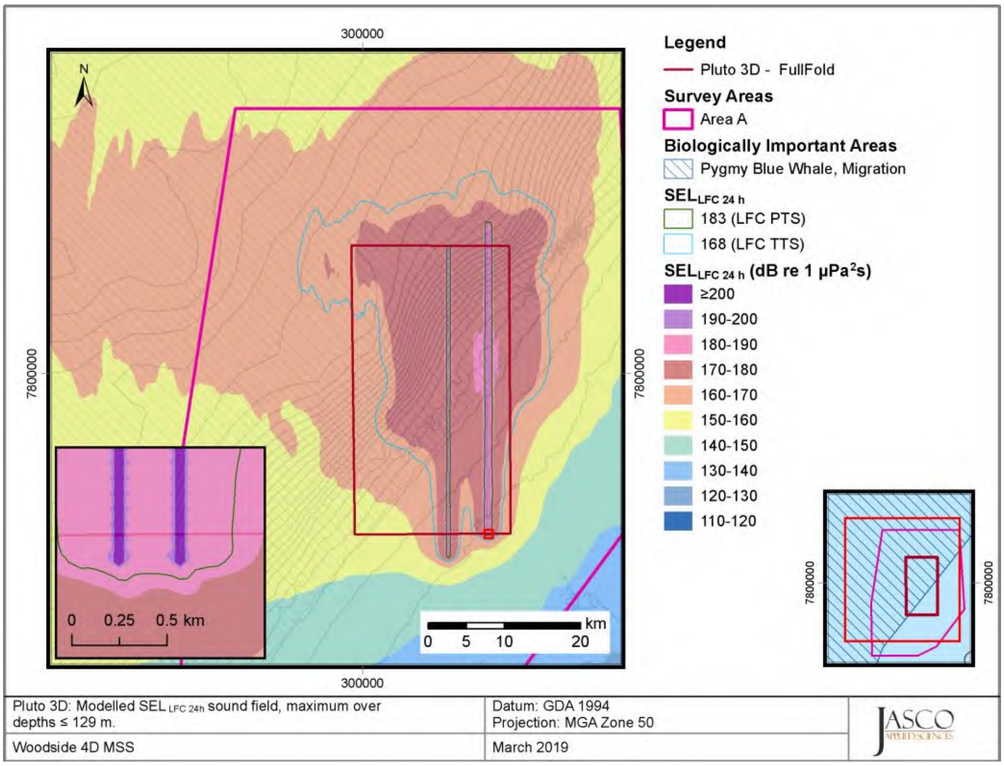

Figure 87. *Pluto 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales.

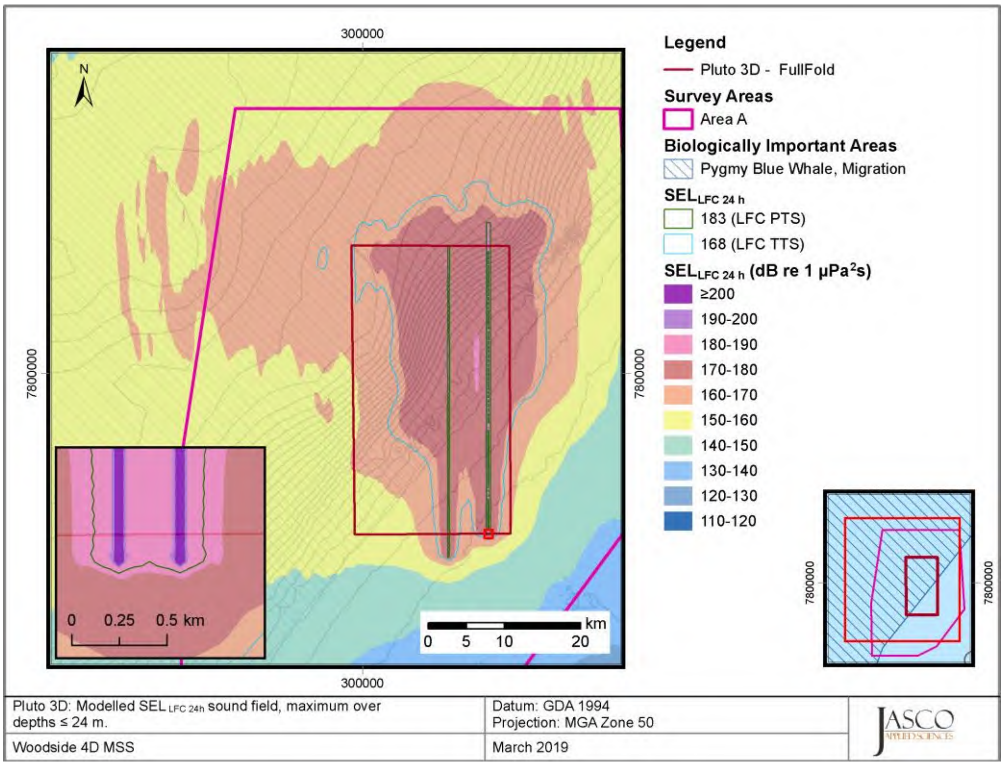

Figure 88. *Pluto 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales.

5.3.2. Area A: Harmony 4-D Survey

Table 41. *Harmony 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018).

Hearing group	**PTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	1.10	96.4
Mid-frequency cetaceans	185	–	–
High-frequency cetaceans	155	<0.04	0.37
Hearing group	**TTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	168	38.8	1029
Mid-frequency cetaceans	170	–	–
High-frequency cetaceans	140	0.4	56.2

A dash indicates the threshold was not reached.

Table 42. *Harmony 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. The chosen depth limit is related to mean dive depths for pygmy blue whales (Section 2.1).

Species	**Depth limit (m)**	**PTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted.	506	183	1.10	96.4
	129	183	0.50	73.0
	24	183	0.24	45.1
Species	**Depth limit (m)**	**TTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted.	506	168	35.6	878
	129	168	9.55	585
	24	168	7.42	510

Table 43. *Harmony 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria.

Marine fauna group	Threshold for SEL24h (L_E,24h; dB re 1 µPa²·s)	Maximum-over-depth	
		R_{max} (km)	Area (km²)
Mortality and potential mortal injury			
I	219	<0.06	9.61
II, Turtles, fish eggs and fish larvae	210	0.06	9.68
III	207	0.06	9.68
Fish recoverable injury			
I	216	<0.06	9.64
II, III	203	0.06	9.68
Fish TTS			
I, II, III	186	2.37	189

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

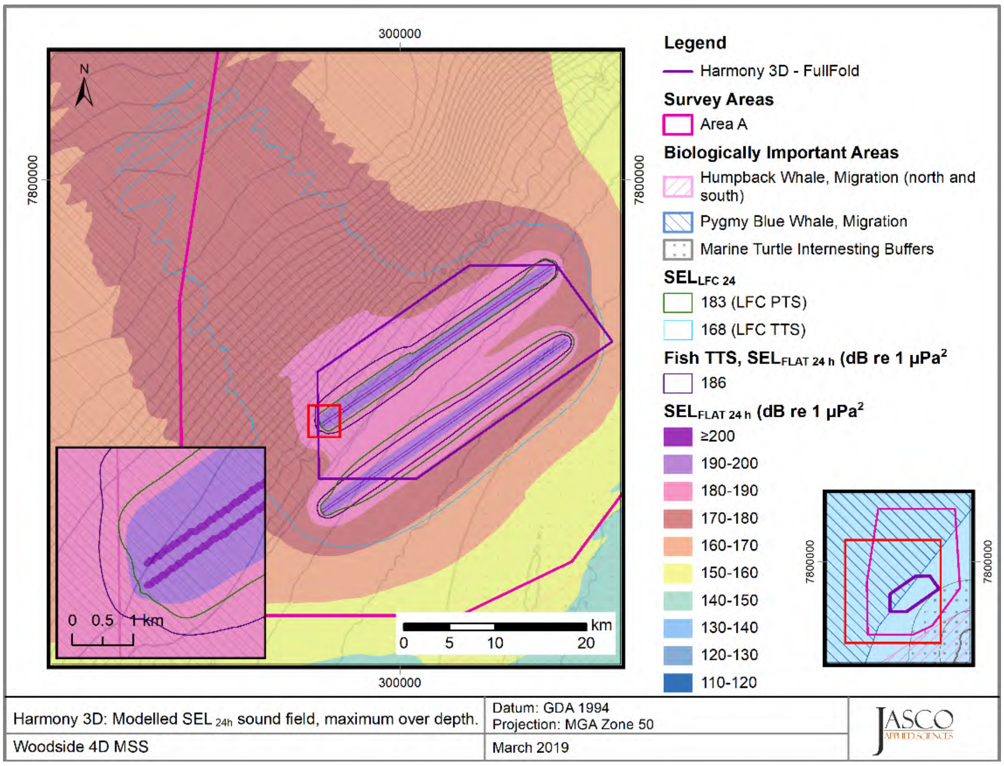

Figure 89. *Harmony 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results.

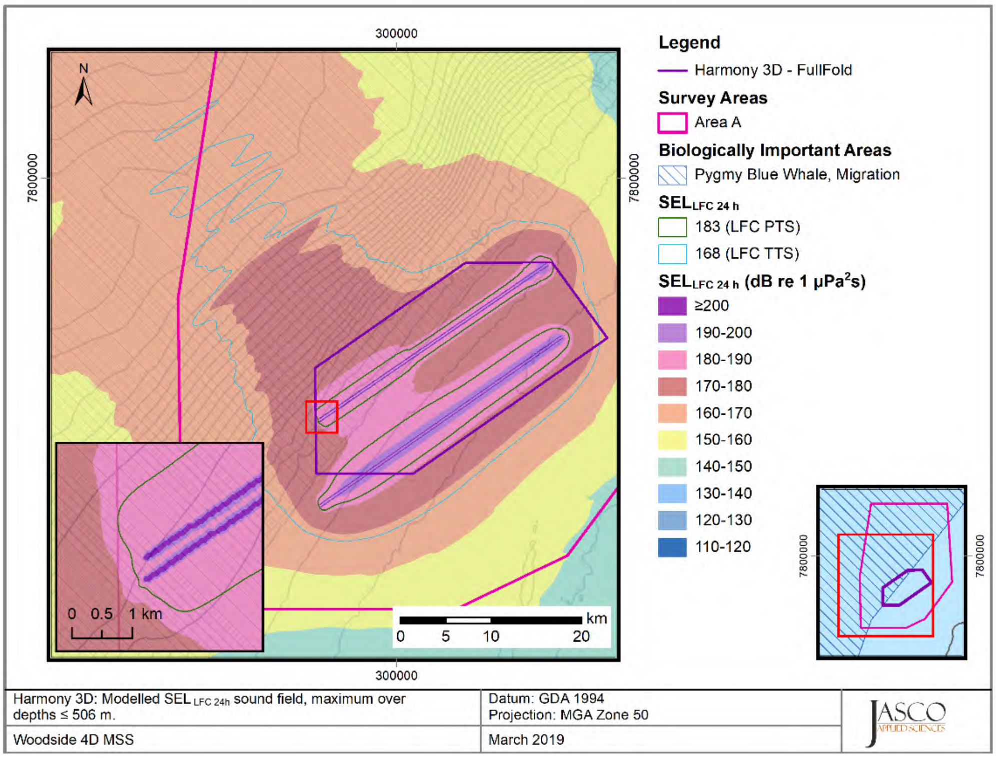

Figure 90. *Harmony 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales.

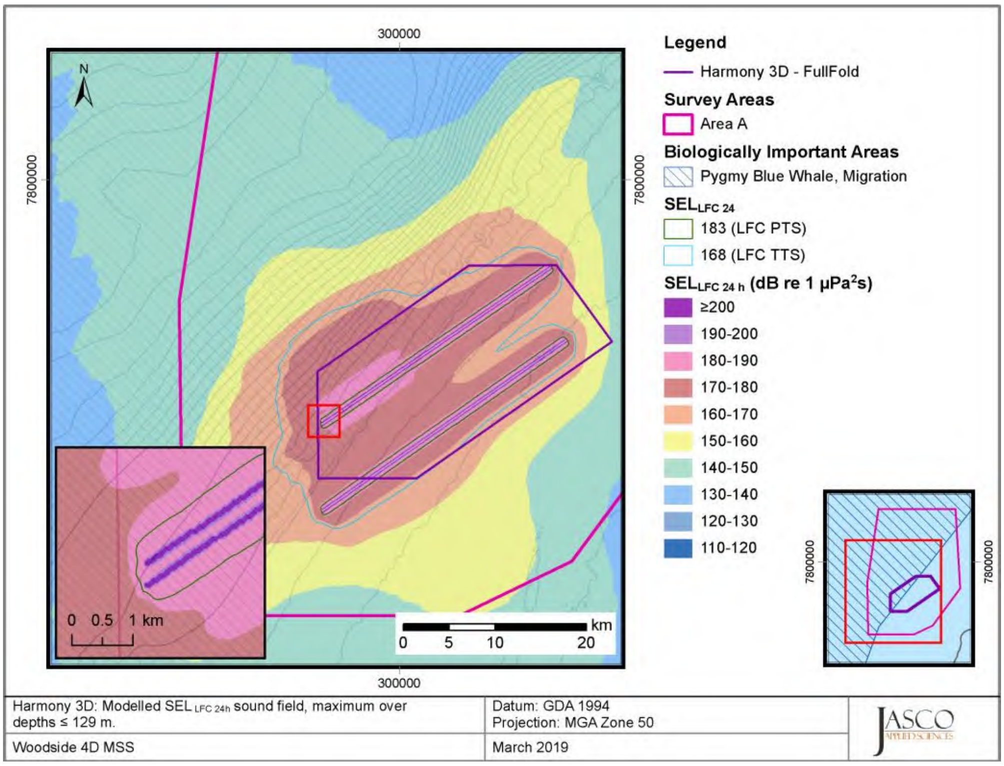

Figure 91. *Harmony 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales.

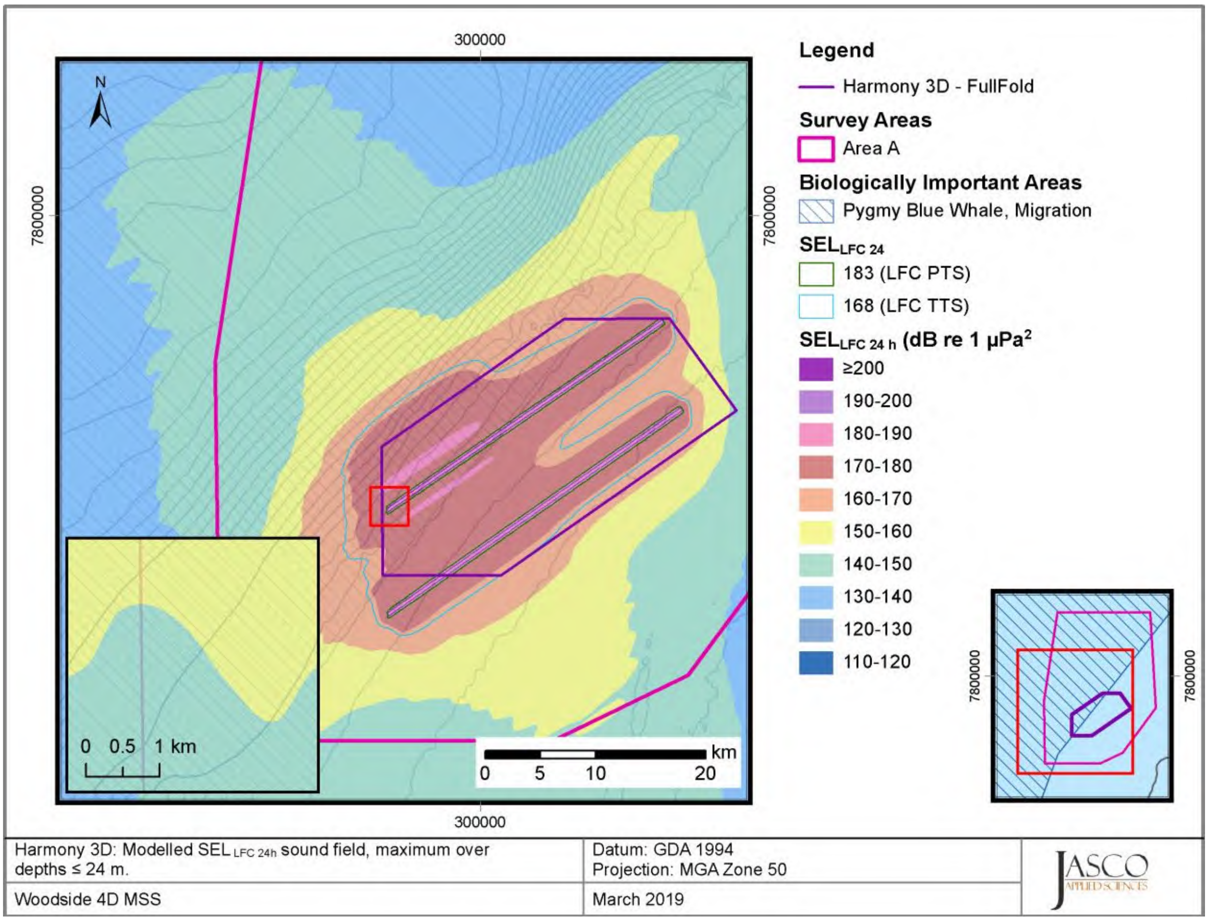

Figure 92. *Harmony 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales.

5.3.3. Area B: Scarborough 4-D Survey

Table 44. *Scarborough 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018).

Hearing group	PTS		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	5.96	816
Mid-frequency cetaceans	185	–	–
High-frequency cetaceans	155	0.07	13.3
Hearing group	**TTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	168	92.3	15673
Mid-frequency cetaceans	170	–	–
High-frequency cetaceans	140	2.30	280

A dash indicates the threshold was not reached.

Table 45. *Scarborough 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. The chosen depth limit is related to mean dive depths for pygmy blue whales (Section 2.1).

Species	**Depth limit (m)**	**PTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted	506	183	5.95	528
	129	183	5.93	341
	24	183	4.50	160
Hearing group	**Depth limit (m)**	**TTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted	506	168	91.6	15310
	129	168	89.3	14218
	24	168	86.8	11906

Table 46. *Scarborough 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria.

Marine fauna group	**Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)**	**Maximum-over-depth**	
		R_{max} (km)	Area (km²)
Mortality and potential mortal injury			
I	219	<0.09	<23.0
II, Turtles, fish eggs and fish larvae	210	0.09	23.0
III	207	0.09	23.0
Fish recoverable injury			
I	216	<0.09	<23.0
II, III	203	0.09	23.0
Fish TTS			
I, II, III	186	14.0	1995

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

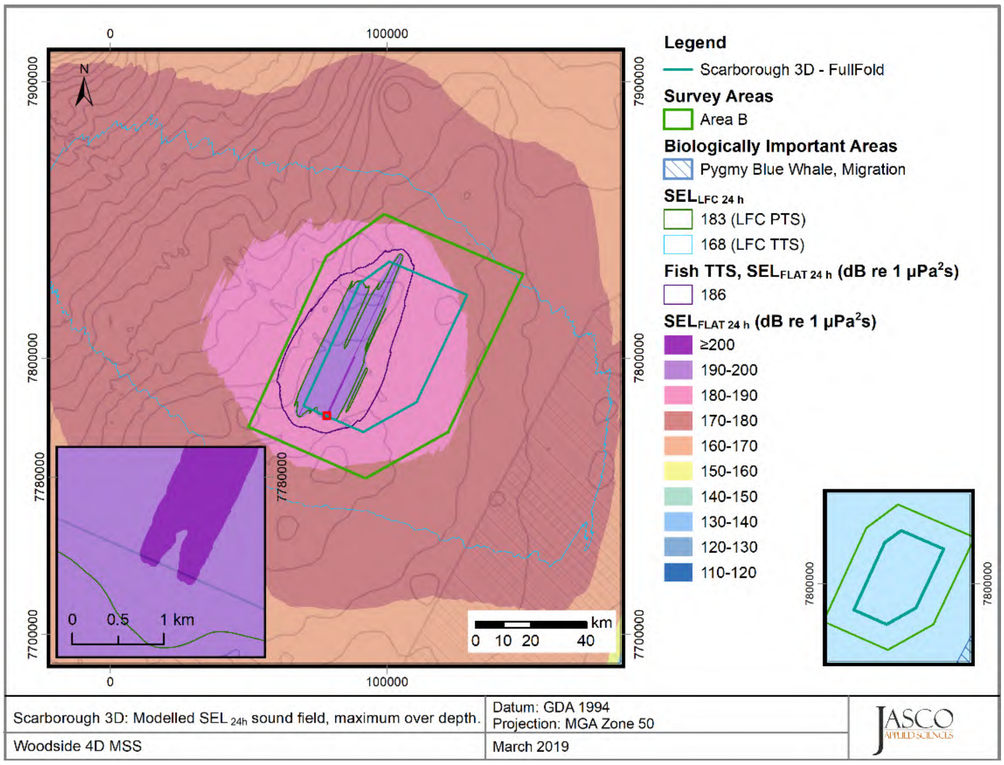

Figure 93. *Scarborough 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results.

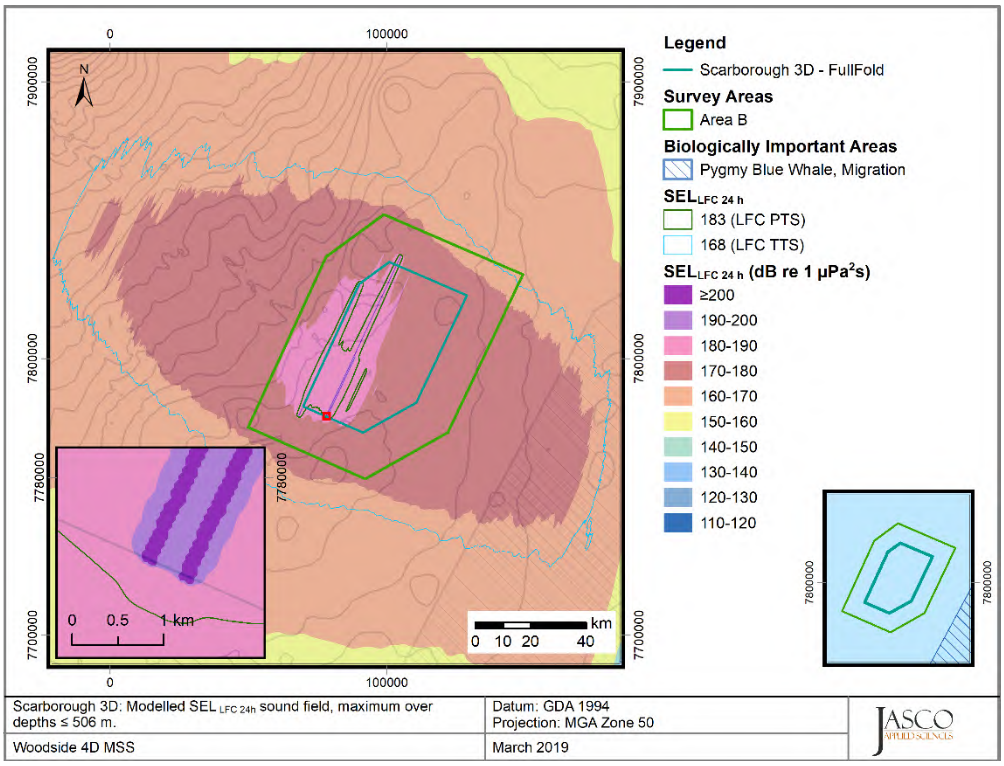

Figure 94. *Scarborough 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales.

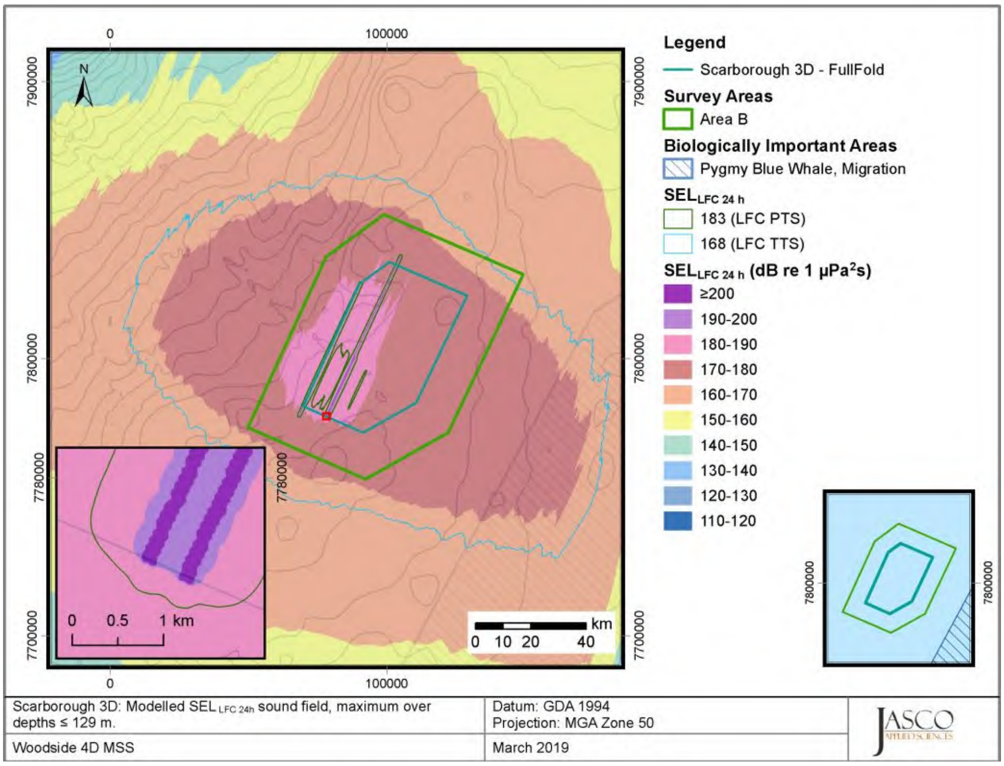

Figure 95. *Scarborough 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales.

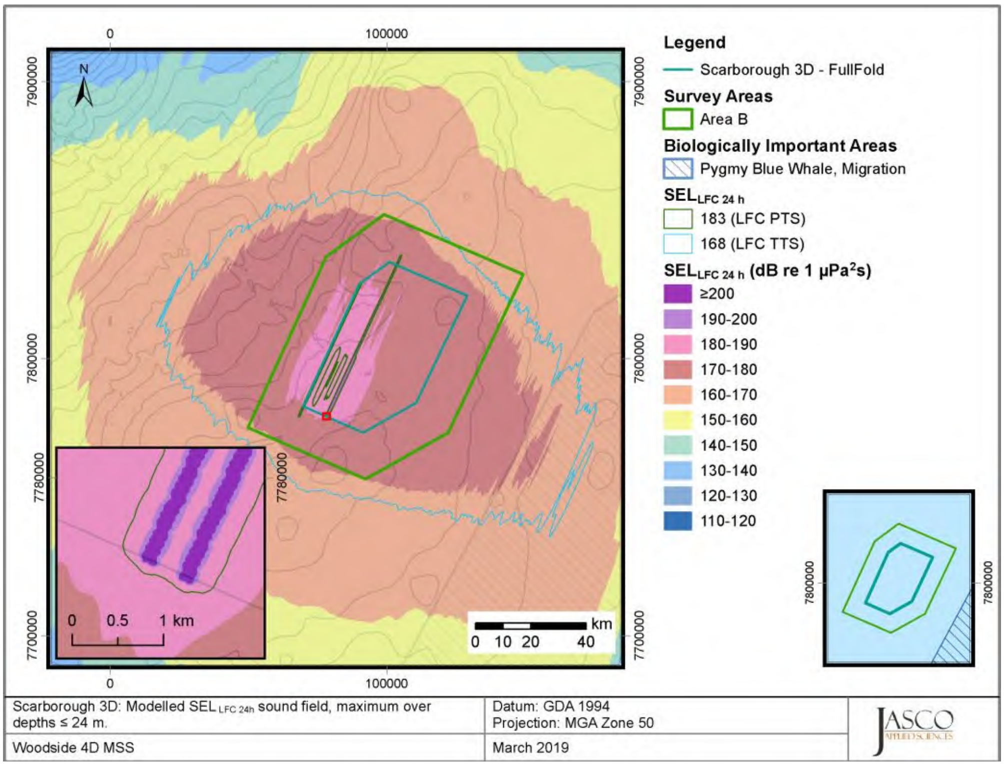

Figure 96. *Scarborough 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales.

5.3.4. Area C: Laverda 4-D Survey

Table 47. *Laverda 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018).

Hearing group	PTS		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	0.70	49.4
Mid-frequency cetaceans	185	–	–
High-frequency cetaceans	155	0.05	5.45
Hearing group	**TTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	168	55.3	2105
Mid-frequency cetaceans	170	–	–
High-frequency cetaceans	140	0.18	26.3

A dash indicates the threshold was not reached.

Table 48. *Laverda 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. The chosen depth limit is related to mean dive depths for pygmy blue whales (Section 2.1).

Hearing group	Depth limit (m)	PTS		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted	506	183	0.44	42.8
	129	183	0.35	38.2
	24	183	0.20	27.2
Hearing group	**Depth limit (m)**	**TTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted	506	168	55.2	2028
	129	168	43.4	1713
	24	168	36.7	1351

Table 49. *Laverda 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria.

Marine fauna group	Threshold for SEL24h ($L_{E,24h}$; dB re 1 µPa²·s)	Maximum-over-depth	
		R_{max} (km)	Area (km²)
Mortality and potential mortal injury			
I	219	<0.05	<7.41
II, Turtles, fish eggs and fish larvae	210	0.05	7.49
III	207	0.05	7.49
Fish recoverable injury			
I	216	<0.05	<7.41
II, III	203	0.05	7.49
Fish TTS			
I, II, III	186	2.98	166

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

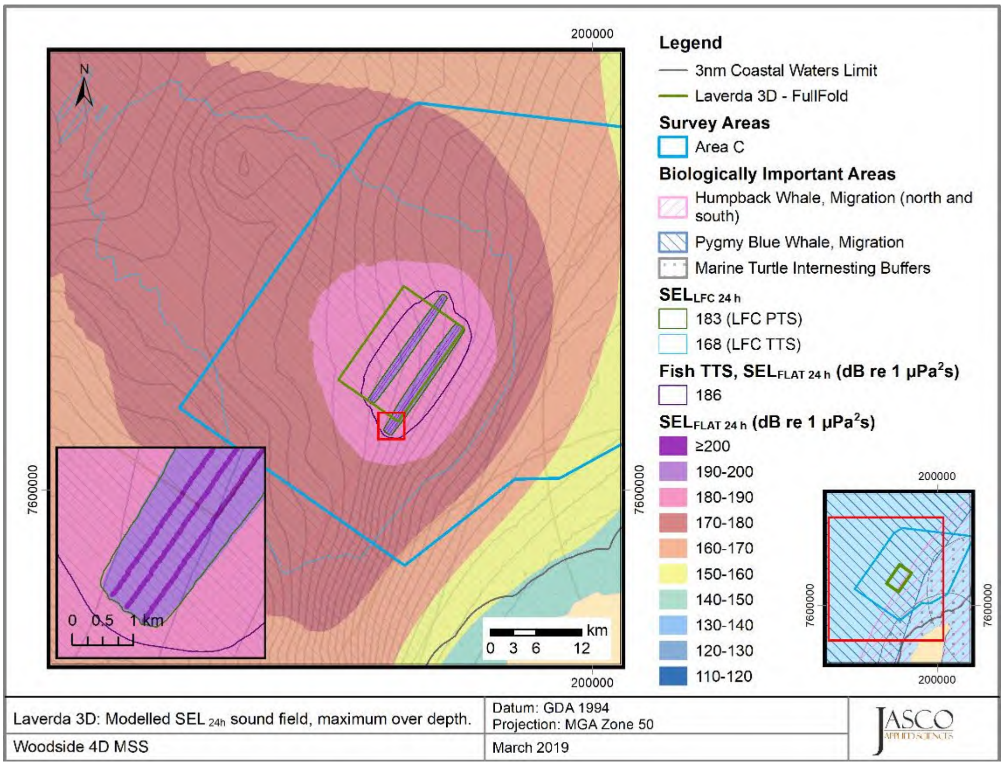

Figure 97. *Laverda 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results.

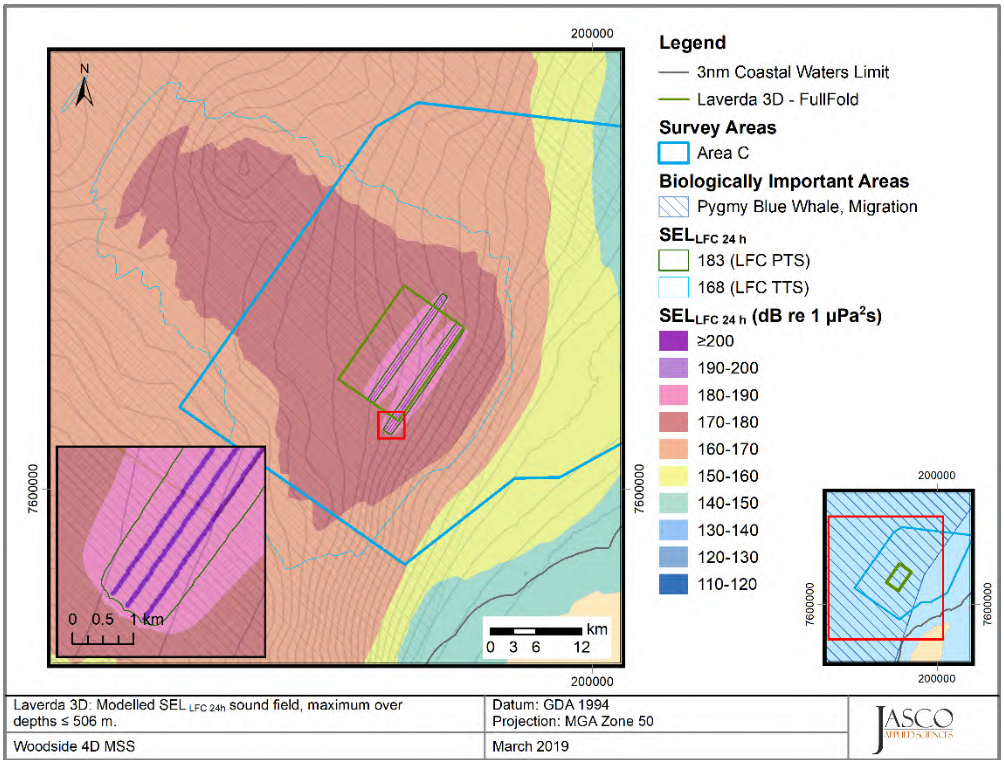

Figure 98. *Laverda 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales.

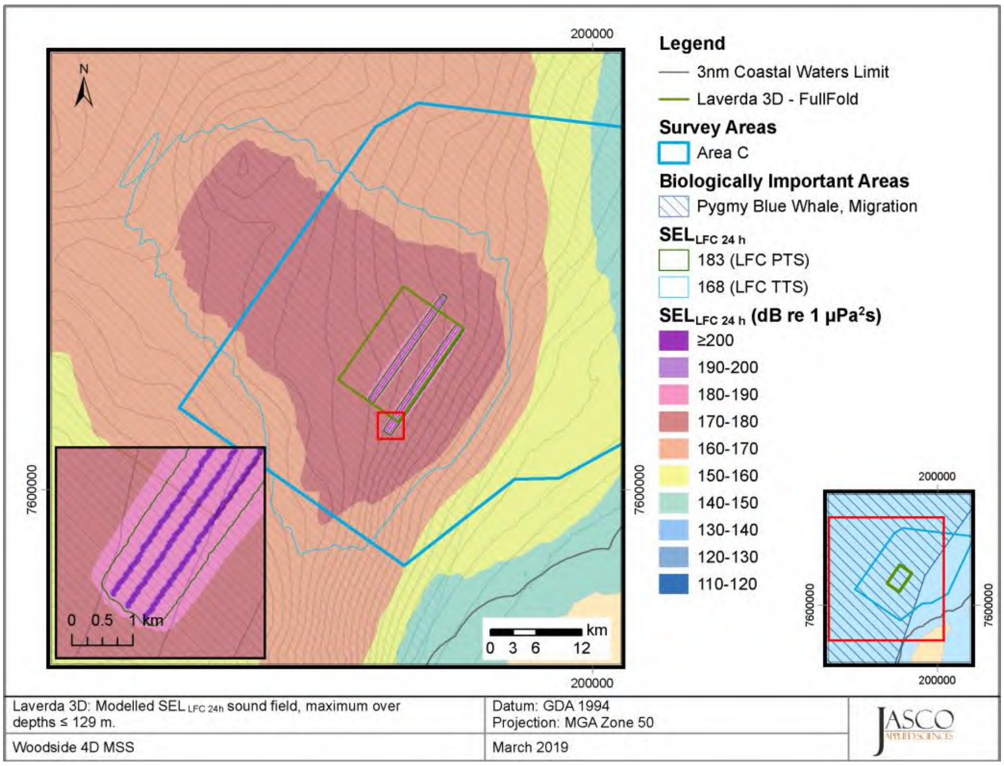

Figure 99. *Laverda 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales.

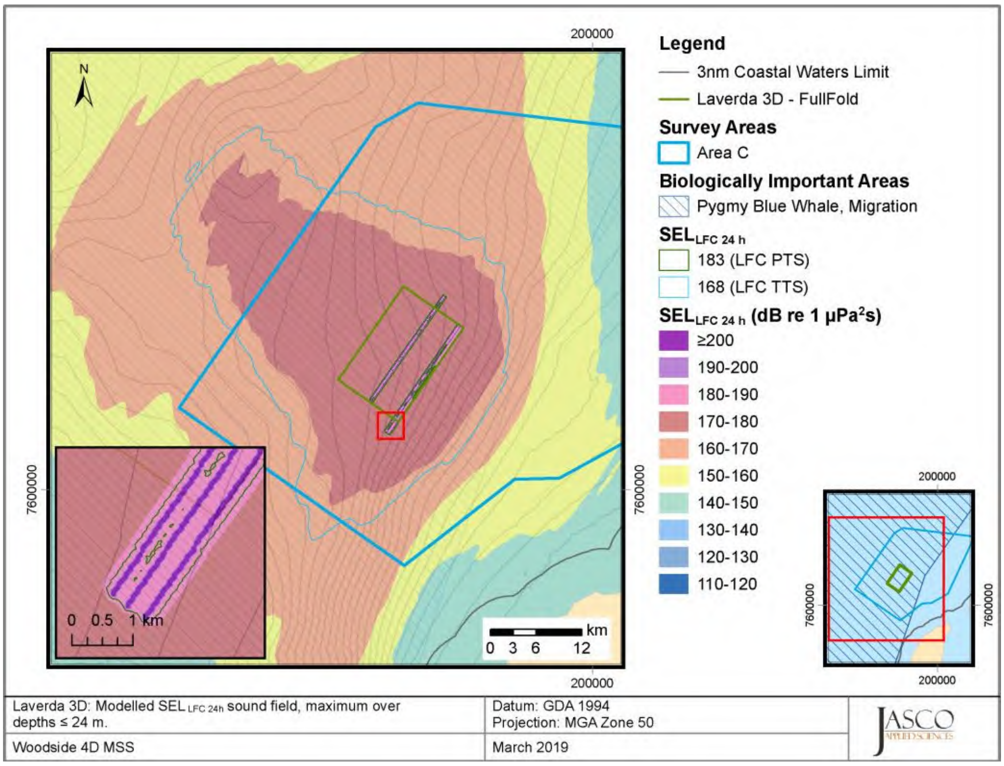

Figure 100. *Laverda 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales.

5.3.5. Area C: Cimatti 4-D Survey

Table 50. *Cimatti 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018).

Hearing group	PTS		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	2.14	115
Mid-frequency cetaceans	185	–	–
High-frequency cetaceans	155	0.03	2.40
Hearing group	**TTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	168	47.2	1866
Mid-frequency cetaceans	170	–	–
High-frequency cetaceans	140	0.97	69.7

A dash indicates the threshold was not reached.

Table 51. *Cimatti 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. The chosen depth limit is related to mean dive depths for pygmy blue whales (Section 2.1).

Species	Depth limit (m)	PTS		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted	506	183	1.35	88.1
	129	183	0.58	54.3
	24	183	0.25	36.7
Species	**Depth limit (m)**	**TTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted	506	168	46.9	1826
	129	168	39.8	1591
	24	168	34.6	1250

Table 52. *Cimatti 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria.

Marine fauna group	Threshold for SEL24h (L_E,24h; dB re 1 µPa²·s)	Maximum-over-depth	
		R_{max} (km)	Area (km²)
Mortality and potential mortal injury			
I	219	<0.06	<7.74
II, Turtles, fish eggs and fish larvae	210	0.06	7.74
III	207	0.06	7.74
Fish recoverable injury			
I	216	<0.06	<7.74
II, III	203	0.06	7.74
Fish TTS			
I, II, III	186	5.16	189

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

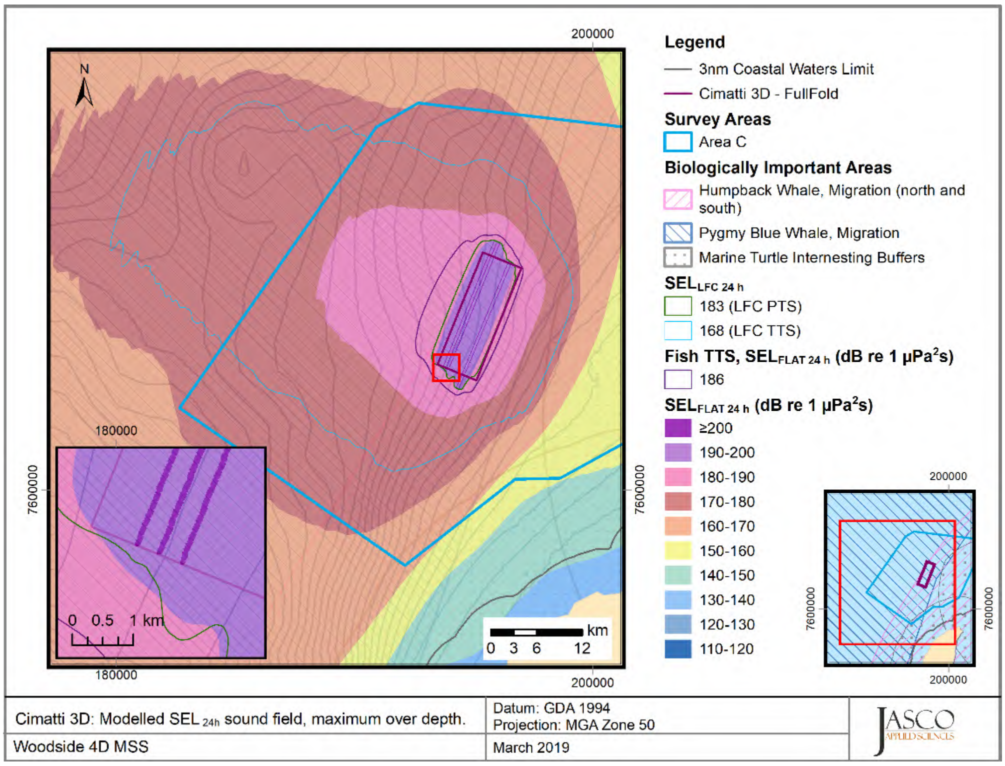

Figure 101. *Cimatti 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results.

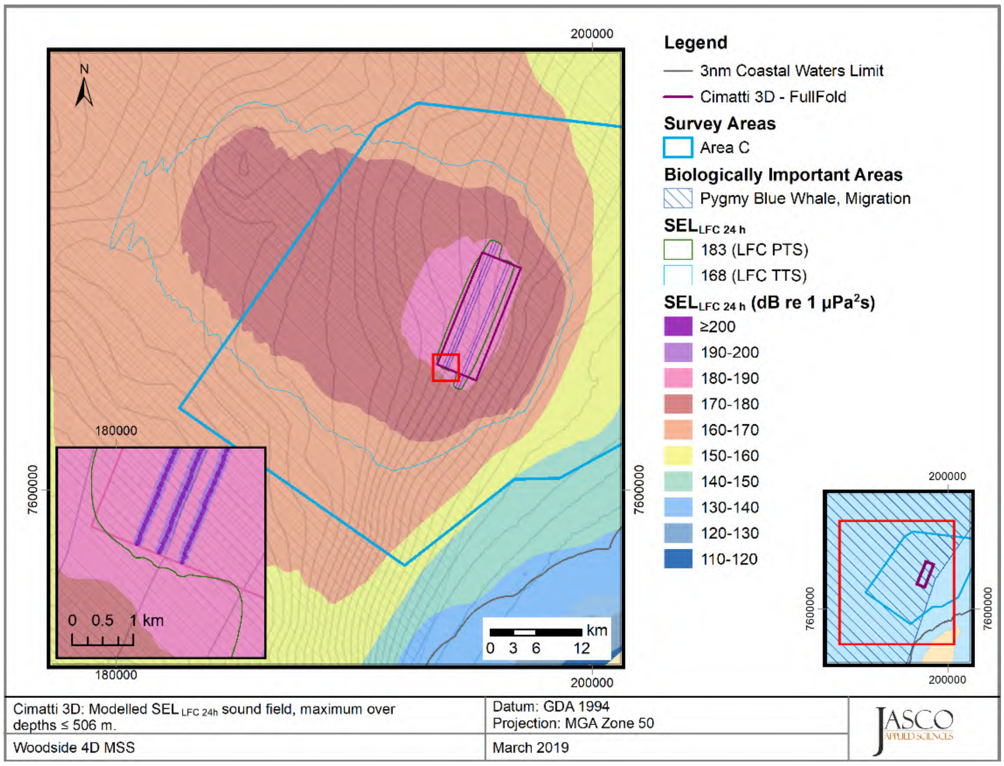

Figure 102. *Cimatti 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales.

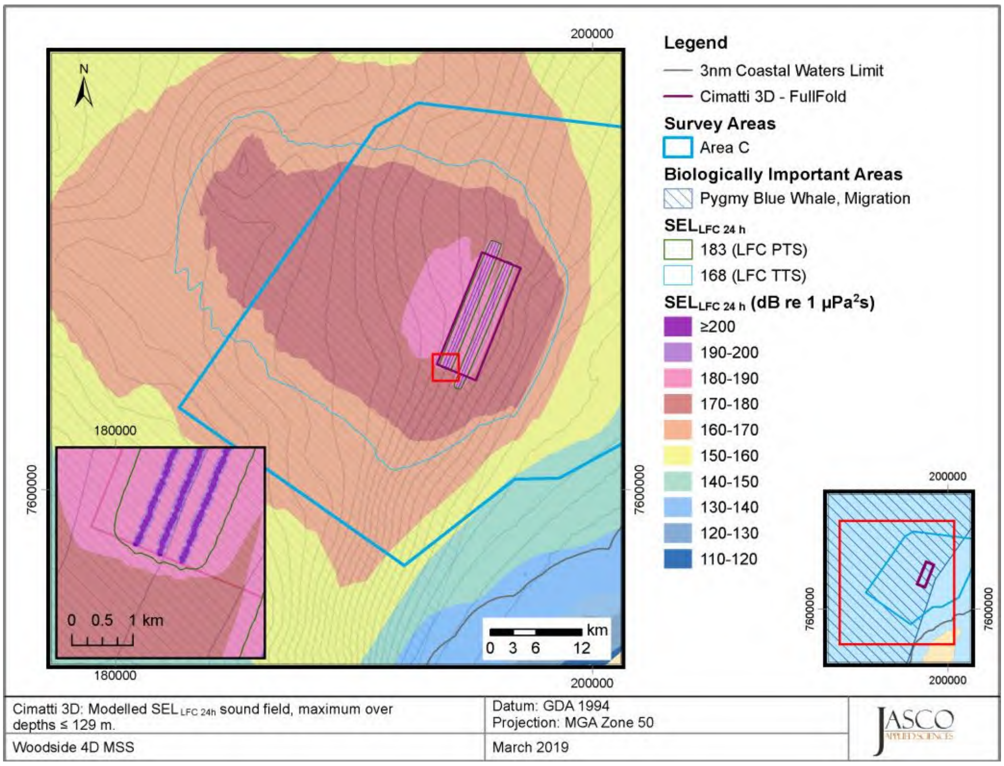

Figure 103. *Cimatti 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales.

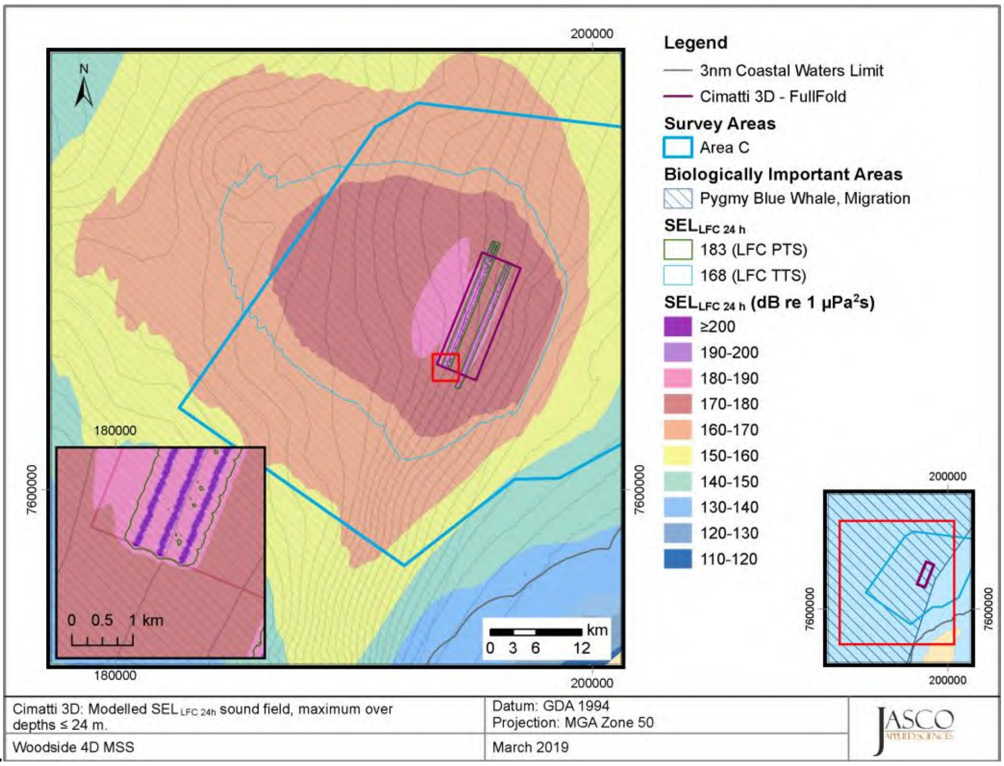

Figure 104. *Cimatti 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales.

5.3.6. Area C: Vincent 4-D Survey

Table 53. *Vincent 4-D Survey*: Maximum-over-depth distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018).

Hearing group	**PTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	183	2.07	101
Mid-frequency cetaceans	185	–	–
High-frequency cetaceans	155	0.03	2.23
Hearing group	**TTS**		
	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Low-frequency cetaceans	168	32.4	1261
Mid-frequency cetaceans	170	–	–
High-frequency cetaceans	140	1.26	61.4

A dash indicates the threshold was not reached.

Table 54. *Vincent 4-D Survey*: Maximum to depth limit distances to SEL_{24h} based marine mammal PTS and TTS thresholds (NMFS 2018) for pygmy blue whales. The chosen depth limit is related to mean dive depths for pygmy blue whales (Section 2.1).

Species	**Depth limit (m)**	**PTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted	506	183	2.03	95.7
	129	183	2.00	77.5
	24	183	1.38	50.8
Species	**Depth limit (m)**	**TTS**		
		Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	R_{max} (km)	Area (km²)
Pygmy blue whales, Low-frequency cetacean weighted	506	168	32.4	1247
	129	168	29.6	1065
	24	168	26.3	886

Table 55. *Vincent 4-D Survey*: Distances to SEL_{24h} based fish and turtle criteria.

Marine fauna group	Threshold for SEL24h (L_E,24h; dB re 1 µPa²·s)	Maximum-over-depth	
		R_{max} (km)	Area (km²)
Mortality and potential mortal injury			
I	219	<0.05	<3.92
II, Turtles, fish eggs and fish larvae	210	0.05	3.92
III	207	0.05	3.92
Fish recoverable injury			
I	216	<0.05	<3.92
II, III	203	0.05	3.92
Fish TTS			
I, II, III	186	4.11	148

Fish I–No swim bladder; Fish II–Swim bladder not involved with hearing; Fish III–Swim bladder involved with hearing.

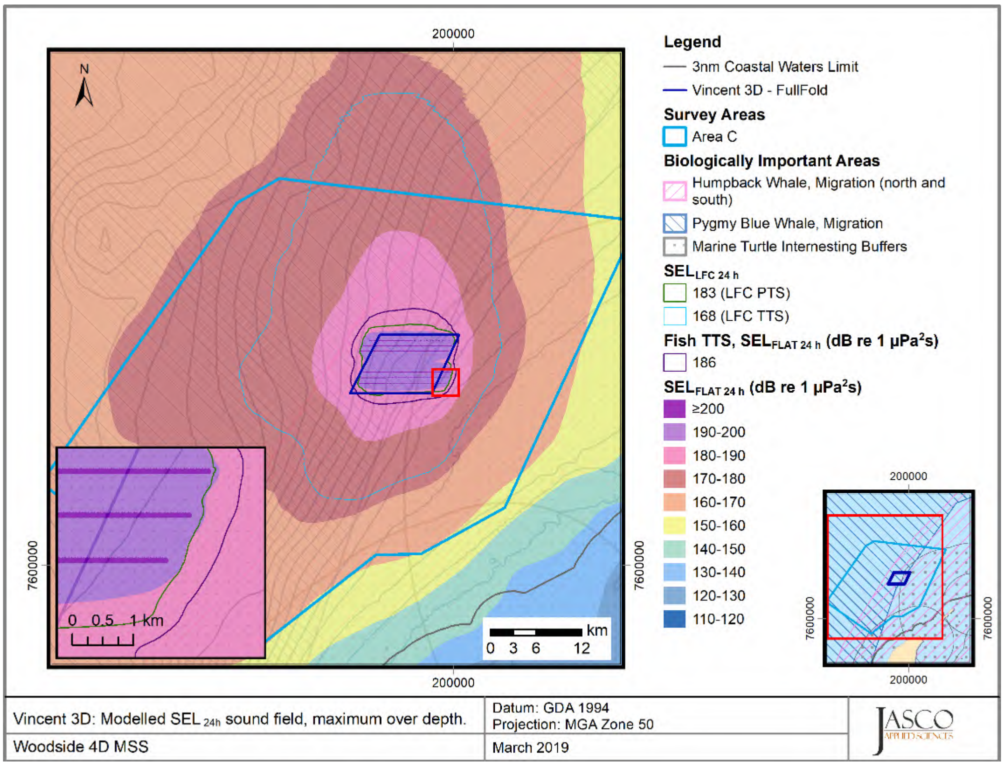

Figure 105. *Vincent 4-D Survey:* Sound level contour map showing maximum-over-depth SEL_{24h} results.

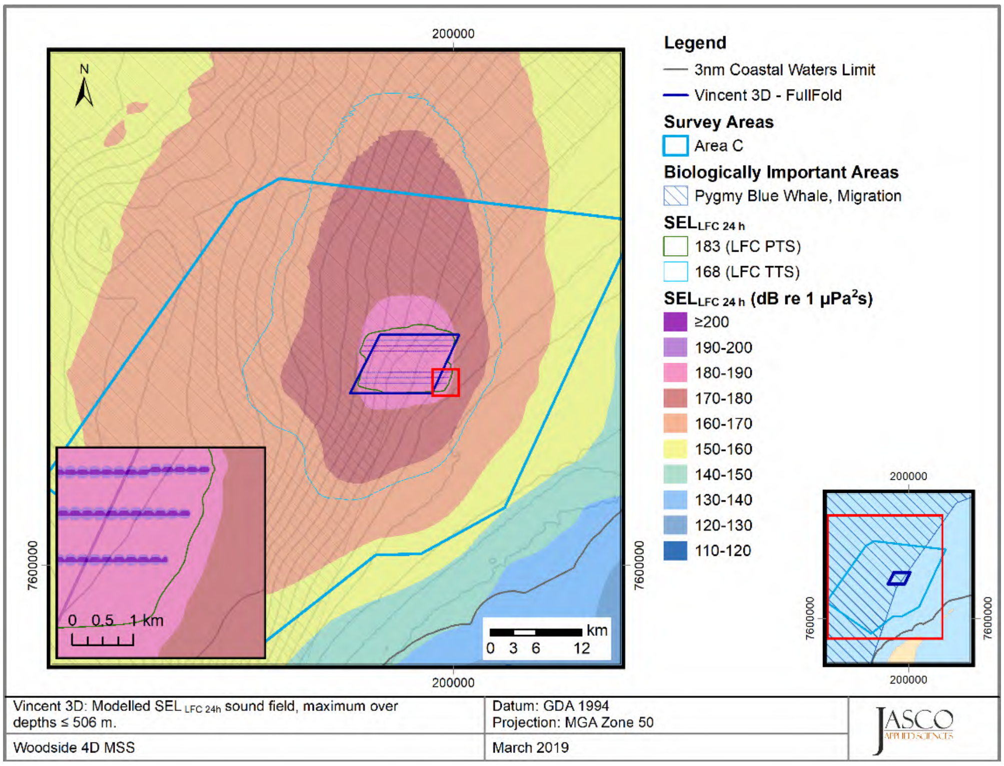

Figure 106. *Vincent 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤506 m SEL_{24h} results for pygmy blue whales.

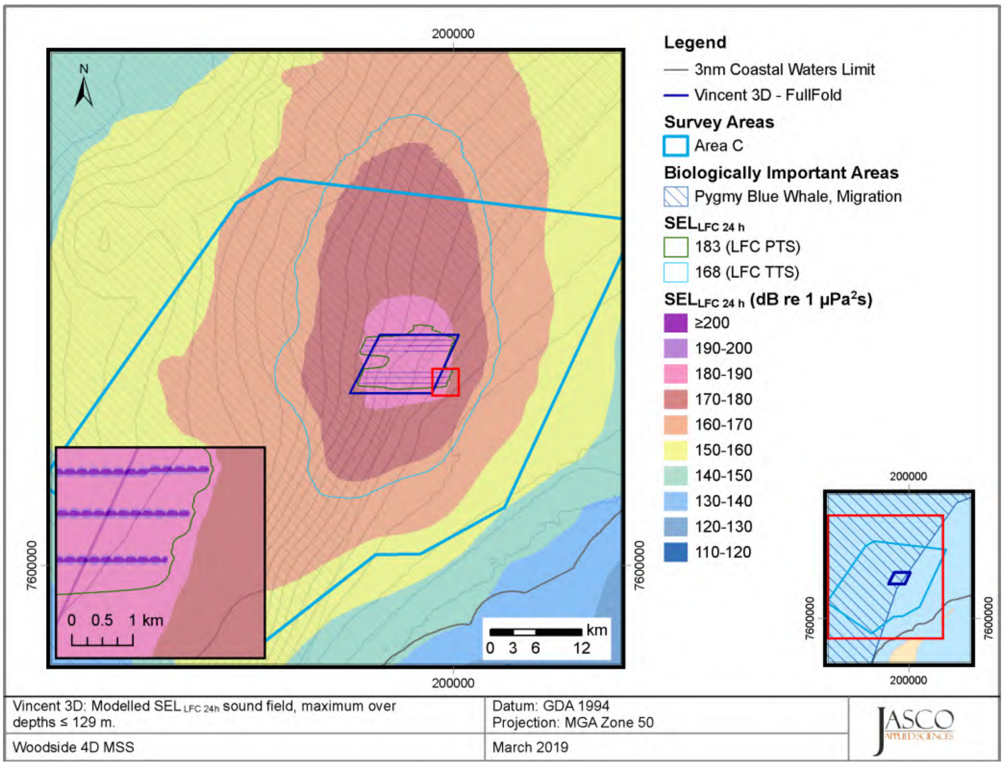

Figure 107. *Vincent 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤129 m SEL_{24h} results for pygmy blue whales.

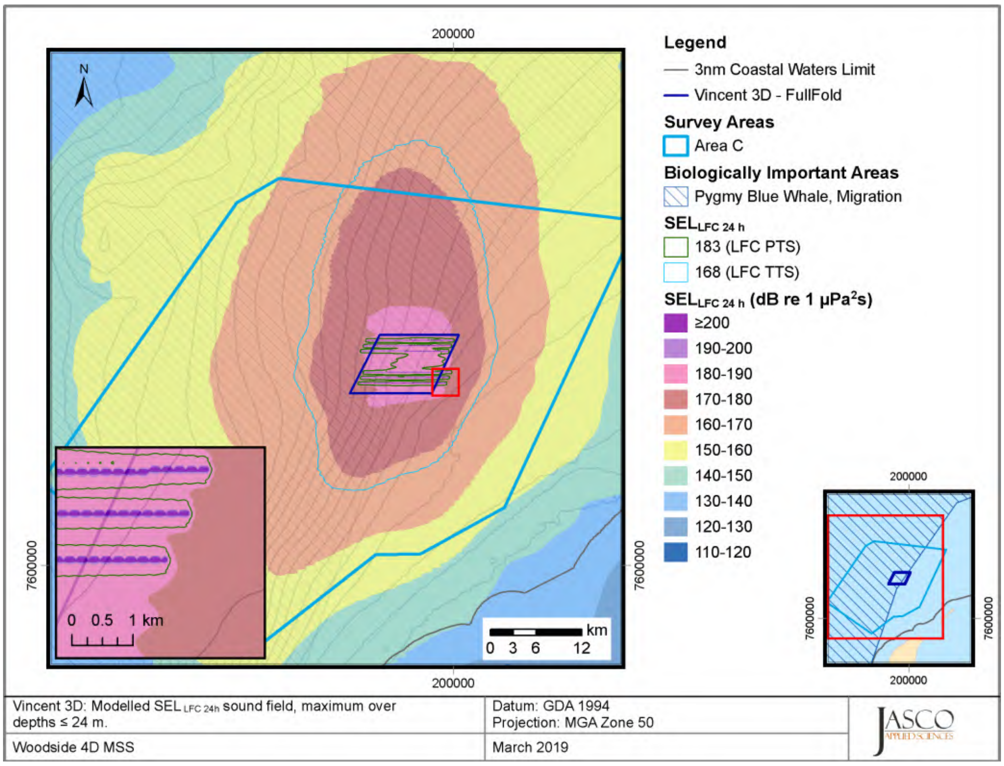

Figure 108. *Vincent 4-D Survey:* Sound level contour map showing low-frequency weighted maximum-over-depth for depths ≤24 m SEL_{24h} results for pygmy blue whales.

6. Discussion

6.1. Overview and Source Levels

This modelling study predicted underwater sound levels associated with six planned seismic surveys with the Woodside 4-D North-West-Shelf seismic campaign. The underwater sound field was modelled for a 3510 in^3 seismic source and a 2560 in^3 seismic source (Appendix B). An analysis of seasonal sound speed profiles was conducted for each survey (Appendix D.3.2) to determine which month with in the proposed acquisition periods was the most conducive to sound propagation (Table 7). The modelling also accounted for site-specific bathymetric variations (Appendix D.3.1) and local geoacoustic properties (Appendix D.3.3).

Most acoustic energy from the seismic sources is output at lower frequencies, in the tens to hundreds of hertz. Simulation results indicated that there was little difference between the two considered sources in terms of the peak source pressure level, the broadband SEL source levels were slightly higher for the 3150 in^3 by approximately 1 dB. Both arrays have a pronounced broadside directivity for 1/3-octave-bands between approximately 100 Hz to about 250 Hz (Appendix B.2), which leads to a noticeable axial bulge in the modelled acoustic footprints.

The overall broadband (10–25000 Hz) unweighted per-pulse SEL source level of the 3150 in^3 array operating at 6 m depth was 224.5 dB 1 μPa^{2}m^{2}s in the broadside direction and 223.5 dB 1 μPa^{2}m^{2}s in the endfire direction. For comparison, the overall broadband (10–25000 Hz) unweighted per-pulse SEL source level of the 2560 in^3 array operating at 5 m depth was 223.7 dB 1 μPa^{2}m^{2}s in the broadside direction and 222.9 dB 1 μPa^{2}m^{2}s in the endfire direction. Additional results are presented in Tables 14 and 15 for each respective array.

6.2. Per-Pulse Sound Fields

The per-pulse modelling sites encompassed water depths from 76 to 910 m across three different geological areas and water column profiles. At all single impulse sites for all three Survey Areas, the distances to identified isopleths were greater in the broadside direction than in the endfire direction, a difference apparent in all footprint maps in Sections 5.2.1.3, 5.2.2.2, and 5.2.3.3. The array directionality and frequency content coupled with the bathymetry had a considerable effect on propagation at longer distances, with generally larger lobes of sound energy extending into the deeper waters at all modelling sites. The vertical slice plots (Sections 5.2.1.4, 5.2.2.3, and 5.2.3.4) assist in demonstrating the influence of the bathymetry, source location and sound speed profile on the sound field. Furthermore, sources located in deeper water have a lower “cut-off frequency (f_c)” than sources in shallower water. The cut-off frequency is a single number that describes how much acoustic energy can propagate with minimal loss between then sea-surface and seafloor interfaces. For a given acoustic signal, frequencies below f_c are subject to higher loss compared to frequencies above the f_c (Jensen et al. 2011). For sources in waters greater than 150 m deep (Sites 4–10, 13, 15–23), the cut off frequency was approximately 10 Hz, and for these sources a large amount of low-frequency energy can propagate in the water column compared to sources in shallow water below 150 m (Sites 1–3, 11–12, and 14).

The sound speed profiles (Figures D-10 to D-12) were primarily downwards refracting apart from a moderate surface duct for Sites 15–23. All profiles had a minimum sound speed at approximately 1000 m that forms the sound channel axis and is indicative of deep ocean profiles. For source locations above the continental shelf break and continental slope significant amounts energy reflected from the seabed can be trapped in the deep sound channel and propagate for large distances within the ocean interior (Figure 56). This phenomenon resulted in large ranges to all isopleths in the offshore directions, furthermore the largest ranges occur when the broadside azimuth of the array points in the offshore direction. Furthermore, this is one of the reasons the distance to the marine mammal behavioural disturbance threshold of 160 dB re 1 μPa SPL (NMFS 2014) for pygmy blue whales for depths ≤ 24 m is typically less than the distance for other depth ranges (≤ 129 m, ≤ 506 m, and full-water column) (Tables 18, 26, and 32).

The shallow surface duct (≤50 m deep) in the profiles shown in Figures D-11 and D-12 is not deep enough to trap energy below approximately 550 Hz (Equation 1.36 in Jensen et al. (2011)). The surface duct therefore can only trap the higher frequencies of the array that contribute less to the broadband source level than lower frequencies (Figures B-1 and B-2). However, when trapped, high frequencies can propagate with little loss and can produce higher levels near the sea-surface than scenarios where no surface duct is present.

As the region surrounding each Survey Area is large and includes a number of physical environments, seabed sediments have been assumed to be composed of silty and fines sands ranging to thick layers of pelagic mud and ooze as described in Appendix D.3.3. The contrasts in the geoacoustic parameters between the modelling sites are minor, with the layer thickness and gradients in wave-speed being the biggest comparable differences in the profiles. From the results presented in this study given the specific geoacoustics for the considered regions, the geoacoustic profiles for different modelling sites have a less pronounced influence on the sound field than has been observed in other modelling studies in northwestern Australia with different geology. Variations in sound levels at different azimuths and ranges for this study are therefore more strongly influenced by the directionality of the airgun arrays and interaction with the bathymetry and sound speed profile.

The distances to PK based potential injury criteria (Sections 3.2 and 3.3) for fish and benthic invertebrates at the seafloor decrease with increasing depth.

6.3. Multiple Pulse Sound Fields

The accumulated SEL over 24 hours of seismic operation was modelled considering representative scenarios with realistic acquisition patterns for each of the six surveys within the Woodside 4-D North-West-Shelf seismic campaign. The model predicted the accumulation of sound energy, considering the change in location and the azimuth of the source at each pulse point, which were used to assess possible injury in marine mammals and the SEL_{24h} based fish and marine mammal criteria. The results were presented as maps of the accumulated exposure levels and tabulated values of ranges to threshold levels and exposure areas for the given effects criteria (Section 5.3).

The footprints of the accumulated SEL for each survey (Figures 85–106) show noticeable differences in shape in the SEL_{24h} contours, further Survey Area specific discussion is provided in the sub-sections below.

Considering the NMFS (2018) SEL_{24h} threshold criteria, exceedance ranges have been predicted for low-frequency, mid-frequency, and high-frequency cetacean PTS and TTS thresholds over the full water column. The threshold levels for PTS and TTS in mid-frequency cetaceans were not reached considering SEL_{24h} for any of the survey areas as shown in Section 5.3.

For pygmy blue whales, the accumulated sound fields within the upper 24, 129 and 506 m of the water column (explained in Section 2.1) were considered in relation to the low-frequency cetacean NMFS (2018) SEL_{24h} criteria for PTS and TTS. For all surveys, the distances to the associated thresholds either remained the same as full water column results or decreased. Any decrease in range is due differences in levels throughout the water column due to propagation effects, as discussed in Section 6.2.

Potential impacts on fish were assessed for accumulated SEL in addition to PK as per the Popper et al. (2014) criteria. For the all surveys the potential for mortal injury in any fish overlaps the range for recoverable injury in any fish. The similarity in these R_{max} ranges is a result of the small footprint of associated sound levels for all Survey Areas, with the distances to thresholds for potential injury being near the modelled survey lines and limited to numerical precision in resolving small changes in level over small distances.

6.3.1. Survey Area A

In Area A, considering the NMFS (2018) SEL_{24h} criteria, low- and high-frequency cetaceans are predicted to experience PTS. The maximum distance to PTS and TTS thresholds is predicted to occur for the Harmony 4-D survey. The species specific maximum distance to PTS and TTS for pygmy blue whales decreases with decreasing with depth limit.

The footprints and range maxima for all accumulated SEL thresholds within Area A are substantially influenced by the locations of the source near the shelf break and slope. As discussed above, for a survey line which transitions from shallow to deep water, more low frequency energy is transmitted into the water column, where it can be trapped in the deep-water sound channel and propagate with minimal loss. This effect is manifested in the large extent for isopleths and R_{max} distances to thresholds in the offshore direction shown Figures 85–90. Furthermore, as levels generally decay away from the source the rate of decay decreases with range, propagation of this nature can further reduce the decay rate and allow lower levels to persist to longer ranges.

6.3.2. Survey Area B

In Area B, considering the NMFS (2018) SEL_{24h} criteria, low- and high-frequency cetaceans are predicted to experience PTS. The footprints and range maxima for all accumulated SEL thresholds within Area B is influenced by the consistent water depth with the surrounding area of the survey. The species specific maximum distance to PTS and TTS for pygmy blue whales decreases with decreasing with depth limit. Water depths on average 900 m allow the large amount of low frequency energy to propagate within the water column, which can result in levels propagating to significant distances away from the source by being continually refracted within the deep sound channel. Furthermore, the presence of a surface duct, during the autumn months when this survey may be conducted, has the potential to trap levels at high frequencies which would otherwise dissipate more rapidly in range due to spreading and seabed loss.

6.3.3. Survey Area C

In Area C, considering the NMFS (2018) SEL_{24h} criteria, low- and high-frequency cetaceans are predicted to experience PTS. The maximum distance to PTS and TTS thresholds is predicted to occur for the Cimatti 4-D survey. Similar to survey Area A, the maximum distance to PTS and TTS for pygmy blue whales decreases with decreasing with threshold depth limit.

The footprints and range maxima for all accumulated SEL thresholds within Area C are influenced by similar mechanisms discussed above in Area A and Area B. However, PTS ranges are slightly larger than those in survey Area A due to the smaller survey areas and more closely spaced survey lines considered is a given 24 h scenario, which results in more energy accumulating at a given range.

There is no discernible difference between the extent of isopleths due to airgun array differences for surveys conducted in Area C with different airgun arrays but in similar scenarios (i.e., 3150 in^3 vs 2560 in^3). Despite the power spectrums for the two arrays being slightly different (Figures B-1 and B-2), the broadband source levels only differ by about 1 dB as discussed in Section 6.1, and any differences are not greater than those caused by site specific bathymetry.

6.4. Summary

The findings of the study pertaining each of the metrics and criteria for various marine species of interest are summarised below with references to the result location.

Marine mammal injury and behaviour

- The distances in each Survey Area to where the NMFS (2014) marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL) could be exceeded are summarised in Table 56.
- The results for the criteria applied for marine mammal Permanent Threshold Shift (PTS), NMFS (2018), consider both metrics within the criteria (PK and SEL_{24h}). The longest distance associated with either metric is required to be applied. Table 57 summarises the maximum distances for

PTS, along with the relevant metric and the location of the results within this report. For mid-frequency cetaceans, because the arrays are not a point source (approximately 14 × 12 m and 16 × 9 m), the actual ranges from the edge of airgun arrays are small.

- The 24-h SEL is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The corresponding SEL_{24h} radii for low-frequency cetaceans were larger than those for peak pressure criteria, but they represent an unlikely worst-case scenario. More realistically, marine mammals (and fish) would not stay in the same location or at the same range for 24 hours. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with injury (either PTS or TTS) if it remained in that range for 24 hours.

Table 56. Distances to marine mammal behavioural response criterion of 160 dB re 1 µPa (SPL), Tables 17, 18, 25, 26, 31 and 32.

Fauna and water column section	Distance (km)				
	Survey Area A		Survey Area B	Survey Area C	
	Min	Max	Single Site	Min	Max
All cetaceans, Maximum-over-depth	2.3	8.5	6.8	4	6.5
Pygmy blue whales, depth ≤ 24 m	2.1	7.9	6.8	3.1	6.1
Pygmy blue whales, depth ≤ 129 m	2.3	7.9	6.8	3.1	6.5
Pygmy blue whales, depth ≤ 506 m	2.3	8.5	6.8	3.2	6.5

Table 57. Summary of maximum marine mammal PTS onset distances for 24-h SEL modelled scenarios (PK values from Tables 19, 27 and 33 and SEL_{24h} values from Tables 38, 41, 44, 47, 50 and 53.

Relevant hearing group	Metric associated with longest distance to PTS onset	R_{max} (km)					
		Pluto	*Harmony*	*Scarborough*	*Laverda*	*Cimatii*	*Vincent*
Low-frequency cetaceans†	SEL_{24h}	0.86	1.1	5.96	0.7	2.14	2.07
Mid-frequency cetaceans	PK	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
High-frequency cetaceans	PK	0.22	0.22	0.19	0.19	0.19	0.19

† The model does not account for shutdowns.

Table 58. Summary of maximum PTS onset distances for Pygmy blue whale 24-h SEL modelled scenarios from Tables 39 42 45 48 51 and 54.

Species	Depth limit (m)	R_{max} (km)					
		Pluto	*Harmony*	*Scarborough*	*Laverda*	*Cimatii*	*Vincent*
Pygmy blue whales, Low-frequency cetacean weighted†	506	0.86	1.1	5.95	0.44	1.35	2.03
	129	0.40	0.50	5.93	0.35	0.58	2.0
	24	0.22	0.24	4.50	0.2	0.25	1.38

† The model does not account for shutdowns.

Turtles

- The PK turtle injury criteria of 232 dB re 1 µPa for PTS and 226 dB re 1 µPa for TTS from Finneran et al. (2017) was not exceeded at a distance greater than 20 m from the centre of the array. Because the arrays are not a point source (approximately 14 × 12 m and 16 × 9 m), the actual ranges from the edge of airgun arrays are small.
- The distances in each Survey Area to where the NMFS criterion (NSF 2011a) for behavioural effects in turtles of 166 dB re 1 µPa (SPL) and the 175 dB re 1 µPa (SPL) Moein et al. (1995) criterion could be exceeded are summarised in Table 59.

Table 59. Distances to turtle behavioural response criteria for maximum over depth range of ≤ 250 m, Tables 18, 26, and 32.

SPL (L_p; dB re 1 µPa)	Distance (km)				
	Survey Area A		Survey Area B	Survey Area C	
	Min	Max	Single Site	Min	Max
175#	0.72	1	0.74	0.6	0.8
166†	1.4	2.9	1.5	1.3	3.3

† Threshold for turtle behavioural response to impulsive noise (NSF 2011b).
# Threshold for turtle behavioural response to impulsive noise (Moein et al. 1995).

Fish, fish eggs, and fish larvae

- The modelling study assessed the ranges for quantitative criteria based on Popper et al. (2014) and considered both PK and SEL_{24h} metrics associated with mortality and potential mortal injury and impairment in the following groups:
  - Fish without a swim bladder (also appropriate for sharks in the absence of other information)
  - Fish with a swim bladder that do not use it for hearing
  - Fish that use their swim bladders for hearing
  - Fish eggs and fish larvae
- Table 60 summarises the distances to injury criteria for fish, fish eggs, and fish larvae along with the relevant metric and the location of the information within this report.

Table 60. Summary of maximum fish, fish eggs, and larvae injury and TTS onset distances for single impulse and 24 h SEL modelled scenarios (PK values from Tables 19, 22, 27, 33 and 36 and SEL_{24h} values from Tables 40, 43 46, 49, 52, and 55).

Relevant hearing group	Injury criteria	Water column				Seafloor		
		Metric associated with longest distance to injury criteria	R_{max} (km)			Metric associated with longest distance to injury criteria	R_{max} (km)	
			Area A	Area B	Area C		Area A	Area C
Fish: No swim bladder	Injury	PK	0.06	0.05	0.06	PK	0.06	-
	TTS‡	SEL_{24h}	2.54	14.0	5.16	SEL_{24h}	2.38	2.78
Fish: Swim bladder not involved in hearing Swim bladder involved in hearing	Injury	PK	0.11	0.11	0.11	PK	0.13	0.05
	TTS‡	SEL_{24h}	2.54	14.0	5.16	SEL_{24h}	2.38	2.78
Fish eggs, and larvae	Injury	PK	0.11	0.11	0.11	PK	0.13	0.05

Crustaceans and Bivalves, Sponges and Coral, and Plankton

To assist with assessing the potential effects on these receptors, the following have been determined:

- Crustaceans: The sound level of 202 dB re 1 µPa PK-PK from Payne et al. (2008) was considered; it was reached at ranges between 375 and 415 m depending on the modelled site within Area A (Table 23) and at 424 m within Area C (Table 37).
- Sponges and coral: The PK sound level at the seafloor directly underneath the seismic source was estimated at all modelling sites considered for seafloor fish receptors, and compared to the sound level of 226 dB re 1 µPa PK for sponges and corals (Heyward et al. 2018); it was found that the level was not reached at any of the five considered sites (Tables 22 and 36).
- To assist with the assessment of potential effects on plankton, the distances to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017b) were estimated as summarised in Table 61.

Table 61. The distance to the sound level of 178 dB re 1 µPa PK-PK from McCauley et al. (2017a) relevant to plankton was estimated within each Survey Area through full-waveform modelling using FWRAM

PK-PK ($L_{pk\text{-}pk}$; dB re 1 µPa)	Distance (km)				
	Survey Area A		Survey Area B	Survey Area C	
	Min	Max	Single Site	Min	Max
178	2.26	9.91	9.57	6.25	9.04

Divers

To assess the potential human health effects of underwater sound levels the following been considered in this modelling study:

- As part of a precautionary approach for seismic impulses, a broadband level of 145 dB re 1 µPa (SPL) suggested by Fothergill et al. (2001) and Parvin (2005) has been adopted as a human health assessment threshold for recreational divers and swimmers.
- The R_{max} ranges reported herein are highly dependent on the directionality of the seismic source and acoustic propagation effects. The R_{max} range to the threshold of 145 dB re 1 µPa (SPL) is consistently orientated in the offshore direction for the considered modelling sites and scenarios.

- For shallow water source locations, the threshold ranges in the inshore direction are less than the reported R_{max} ranges, additional ranges other than the R_{max} may be estimated from the provided SPL maps.

Marine Protected Areas

Predicted received levels (SPL) at the nearest boundary of marine protected areas have been predicted to vary from 101 to 161 dB re 1 µPa (SPL). The closest marine protected areas to the three survey acquisition areas have been determined to be:

- Montebello Islands Marine Park (Western Australia),
- Gascoyne Marine Park (Commonwealth of Australia),
- Ningaloo Marine Park (Western Australia),
- Murion Islands Marine Management Areas (Western Australia).
- The maximum received level at the boundary of any considered marine protected area has been predicated to occur at the boundary of the Gascoyne Marine Park, produced by activities in acquisition Area C, however, this level is predicted to occurs deep waters (>900 m). Levels received at the boundary of marine protected areas in shallow water (<200 m) have been predicted to range from 101 to 122 dB re 1 µPa (SPL) for the considered receiver locations.

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Appendix A. Acoustic Metrics

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially impulsive noise such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life. We provide specific definitions of relevant metrics used in the accompanying report. Where possible we follow the ANSI and ISO standard definitions and symbols for sound metrics, but these standards are not always consistent.

The zero-to-peak sound pressure level (PK; L_{pk}; $L_{p,pk}$; dB re 1 µPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,pk} = 20\log_{10}\left[\frac{\max\left(\left|p(t)\right|\right)}{p_0}\right] \tag{A-1}$$

PK is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of a noise event, it is generally a poor indicator of perceived loudness.

The peak-to-peak sound pressure level (PK-PK; $L_{pk\text{-}pk}$; $L_{p,pk\text{-}pk}$; dB re 1 µPa) is the difference between the maximum and minimum instantaneous sound pressure levels in a stated frequency band attained by an impulsive sound, $p(t)$:

$$L_{p,pk-pk} = 10\log_{10}\left\{\frac{\left[\max\left(p(t)\right) - \min\left(p(t)\right)\right]^2}{p_0^2}\right\} \tag{A-2}$$

The sound pressure level (SPL; L_p; dB re 1 µPa) is the rms pressure level in a stated frequency band over a specified time window (T, s) containing the acoustic event of interest. It is important to note that SPL always refers to a rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right) \tag{A-3}$$

The SPL represents a nominal effective continuous sound over the duration of an acoustic event, such as the emission of one acoustic pulse, a marine mammal vocalization, the passage of a vessel, or over a fixed duration. Because the window length, T, is the divisor, events with similar sound exposure level (SEL) but more spread out in time have a lower SPL. A fixed window length of 0.125 s (critical duration defined by Tougaard et al. (2015)) is used in this study for impulsive sounds.

The sound exposure level (SEL; L_E; $L_{E,p}$; dB re 1 µPa^2·s) is a measure related to the acoustic energy contained in one or more acoustic events (N). The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)dt \Big/ T_0 p_0^2\right) \tag{A-4}$$

where T_0 is a reference time interval of 1 s. The SEL continues to increase with time when non-zero pressure signals are present. It therefore can be construed as a dose-type measurement, so the integration time used must be carefully considered in terms of relevance for impact to the exposed recipients.

SEL can be calculated over periods with multiple acoustic events or over a fixed duration. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the *N* individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right). \quad \text{(A-5)}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,LFC,24h}$; Appendix A.3). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should else be specified.

A.2. Marine Mammal Impact Criteria

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury and disturbance. The following sections summarize the recent development of thresholds; however, this field remains an active research topic.

A.2.1. Injury

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.3). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 µPa^2·s. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 µPa^2·s.

As of 2017, an optimal approach is not apparent. There is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018; only the PK criteria defined in NMFS (2018) are applied in this report.

A.3. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

A.3.1. Marine mammal frequency weighting functions

In 2015, a U.S. Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a\left[1+(f/f_{hi})^2\right]^b}\right)\right] \quad \text{(A-6)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2016, NMFS 2018). Table A-1 lists the frequency-weighting parameters for each hearing group; Figure A-1 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018).

Hearing group	a	b	f_{lo} (Hz)	f_{hi} (kHz)	K (dB)
Low-frequency cetaceans (baleen whales)	1.0	2	200	19,000	0.13
Mid-frequency cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
High-frequency cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36

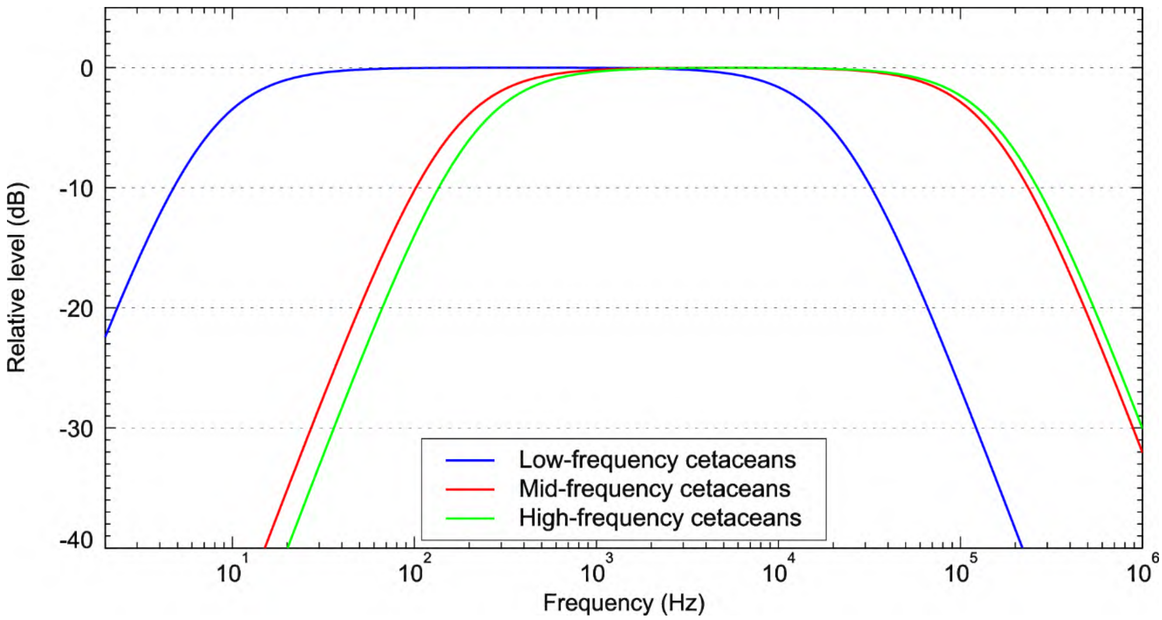

Figure A-1. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by NMFS (2018).

Appendix B. Acoustic Source Model

B.1. Airgun Array Source Model

The source levels and directivity of the seismic source were predicted with JASCO's Airgun Array Source Model (AASM). AASM includes low- and high-frequency modules for predicting different components of the seismic source spectrum. The low-frequency module is based on the physics of oscillation and radiation of airgun bubbles, as originally described by Ziolkowski (1970), that solves the set of parallel differential equations that govern bubble oscillations. Physical effects accounted for in the simulation include pressure interactions between airguns, port throttling, bubble damping, and generator-injector (GI) gun behaviour discussed by Dragoset (1984), Laws et al. (1990), and Landro (1992). A global optimisation algorithm tunes free parameters in the model to a large library of airgun source signatures.

While airgun signatures are highly repeatable at the low frequencies, which are used for seismic imaging, their sound emissions have a large random component at higher frequencies that cannot be predicted using a deterministic model. Therefore, AASM uses a stochastic simulation to predict the high-frequency (800−25,000 Hz) sound emissions of individual airguns, using a data-driven multiple-regression model. The multiple-regression model is based on a statistical analysis of a large collection of high quality seismic source signature data recently obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation to simulate the random component of the high-frequency spectrum of each airgun in an array. The mean high-frequency spectra from the stochastic model augment the low-frequency signatures from the physical model, allowing AASM to predict airgun source levels at frequencies up to 25,000 Hz.

AASM produces a set of "notional" signatures for each array element based on:

- Array layout
- Volume, tow depth, and firing pressure of each airgun
- Interactions between different airguns in the array

These notional signatures are the pressure waveforms of the individual airguns at a standard reference distance of 1 m; they account for the interactions with the other airguns in the array. The signatures are summed with the appropriate phase delays to obtain the far-field source signature of the entire array in all directions. This far-field array signature is filtered into 1/3-octave-bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered a directional point source in the far field.

A seismic array consists of many sources and the point source assumption is invalid in the near field where the array elements add incoherently. The maximum extent of the near field of an array (R_{nf}) is:

$$R_{\mathrm{nf}} < \frac{l^2}{4\lambda} \tag{B-1}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002, §5.2.4). For example, a seismic source length of l = 21 m yields a near-field range of 147 m at 2 kHz and 7 m at 100 Hz. Beyond this R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modelling.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the inter-airgun separation distances, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and the effective directivity is less.

B.2. Array Source Levels and Directivity

Figures B-1 and B-2 show the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction), and vertical overpressure signature and corresponding power spectrum levels for the 3150 and 2650 in^3 arrays (Appendix D.4).

Horizontal 1/3-octave-band source levels are shown as a function of band centre frequency and azimuth (Figures B-3 and B-4); directivity in the sound field is most noticeable at mid-frequencies as described in the model detail in Appendix B.1.

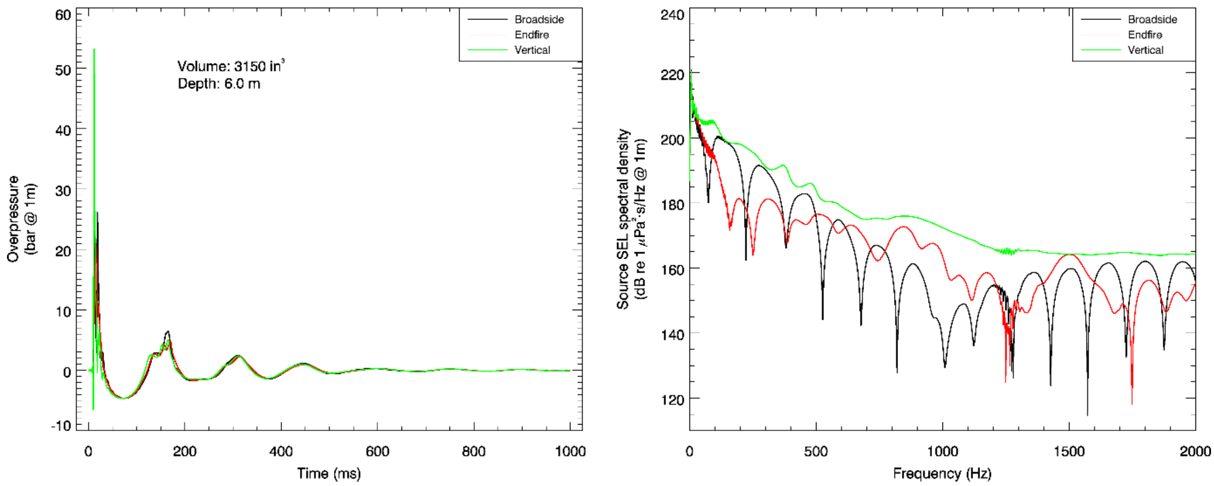

Figure B-1. 3150 in^3 array: Predicted source level details at a 6 m towed depth. (Left) the overpressure signature and (right) the power spectrum for in-plane broadside, endfire, and vertical directions.

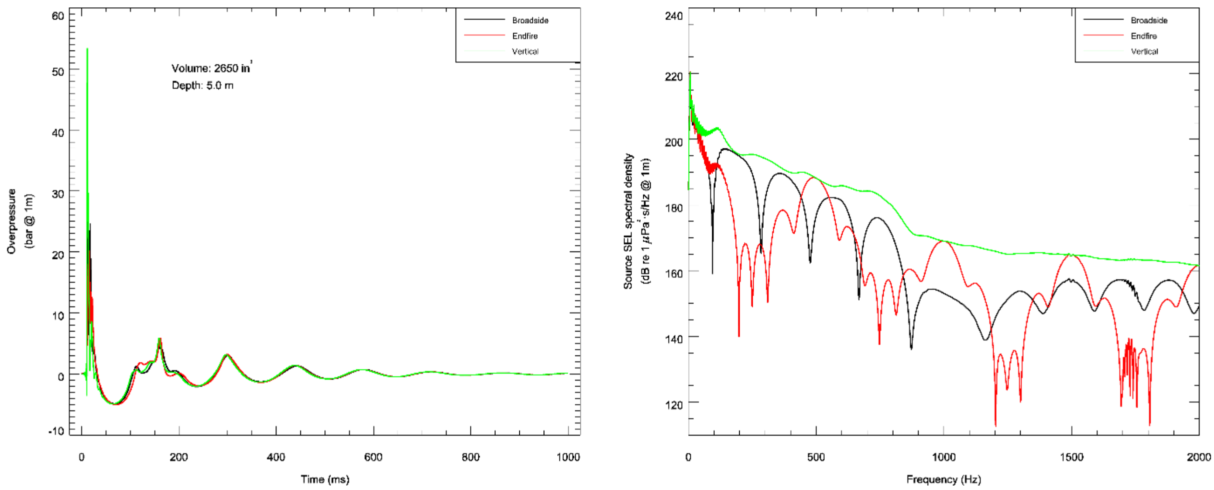

Figure B-2. 2650 in^3 array: Predicted source level details at a 5 m towed depth. (Left) the overpressure signature and (right) the power spectrum for in-plane broadside, endfire, and vertical directions.

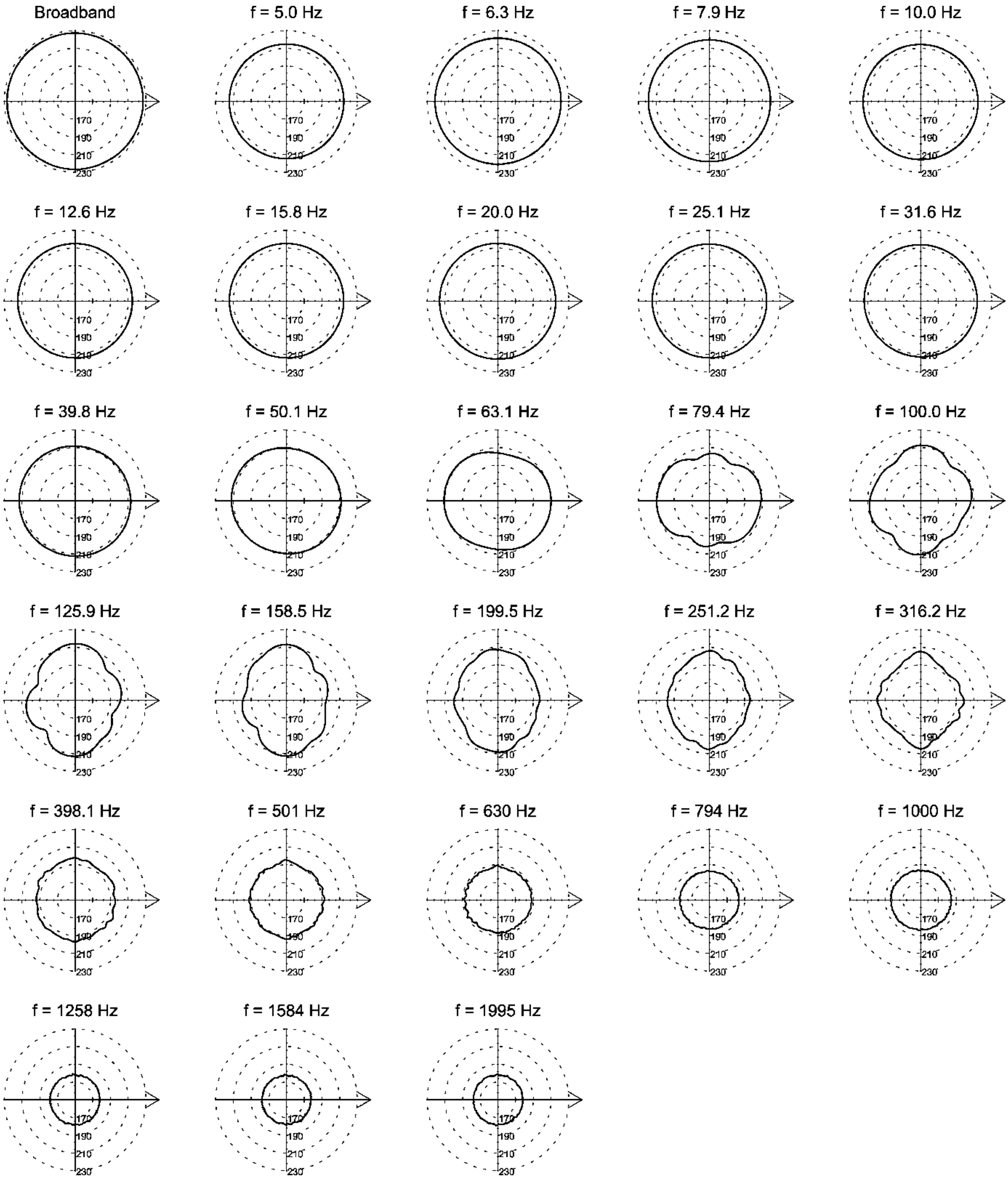

Figure B-3. 3150 in^3 array: Directionality of the predicted horizontal source levels , 10 Hz to 2 kHz. Source levels (in dB re 1 µPa^2·s m^2) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the plots. Tow direction is to the right. Tow depth is 6 m (see Figure B-1).

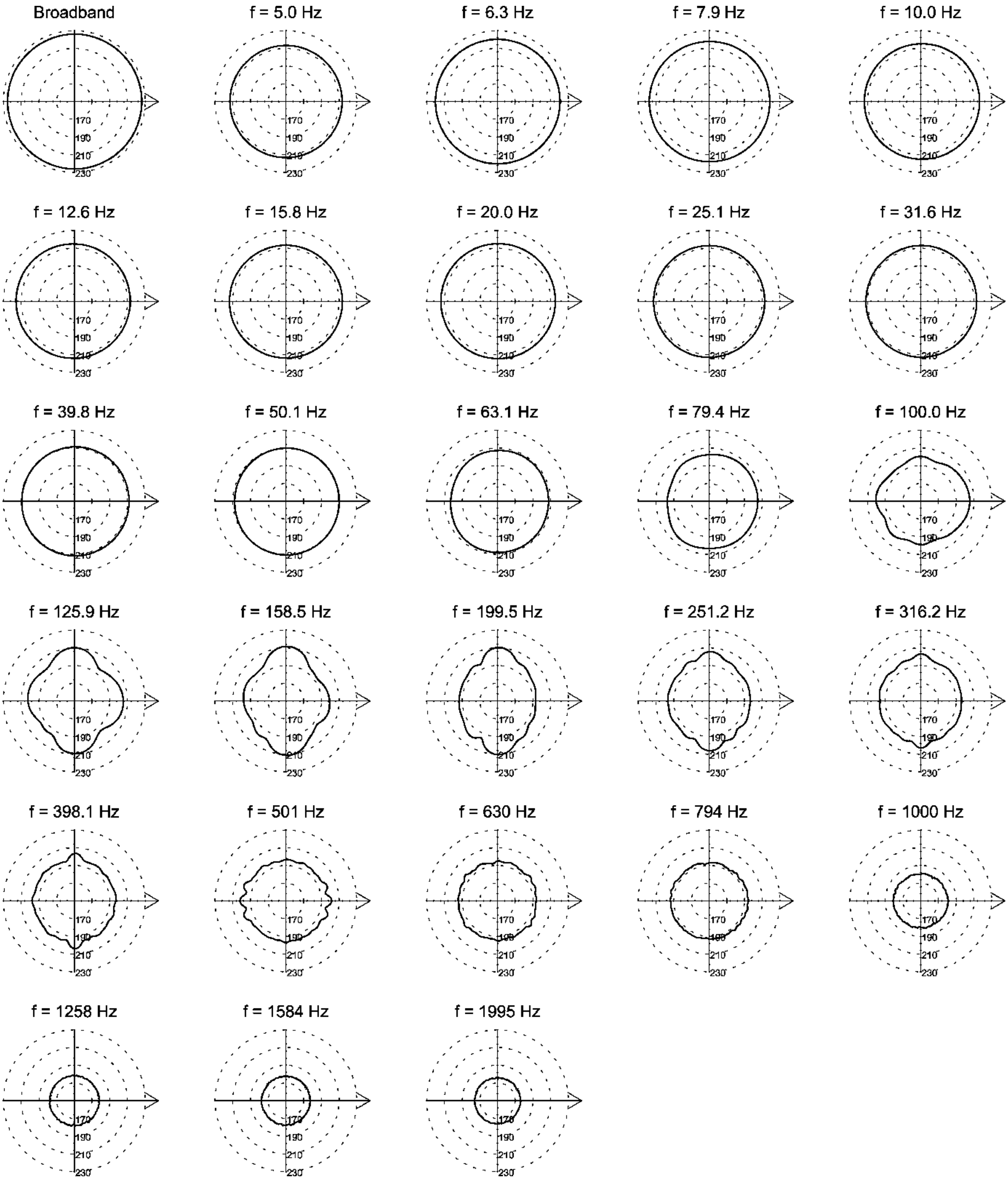

Figure B-4. 2650 in^3 array: Directionality of the predicted horizontal source levels, 10 Hz to 2 kHz. Source levels (in dB re 1 µPa^2·s m^2) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the plots. Tow direction is to the right. Tow depth is 5 m (see Figure B-2).

Appendix C. Sound Propagation Models

C.1. MONM-BELLHOP

Long-range sound fields were computed using JASCO's Marine Operations Noise Model (MONM). Compared to VSTACK, MONM less accurately predicts steep-angle propagation for environments with higher shear speed but is well suited for effective longer-range estimation. This model computes sound propagation at frequencies of 10 Hz to 1.25 kHz via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). MONM computes sound propagation at frequencies > 1.25 kHz via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

This version of MONM accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water in addition to acoustic attenuation due to reflection at the medium boundaries and internal layers (Fisher and Simmons 1977). The former type of sound attenuation is significant for frequencies higher than 5 kHz and cannot be neglected without noticeably affecting the model results.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding N = 360°/$\Delta\theta$ number of planes (Figure C-1).

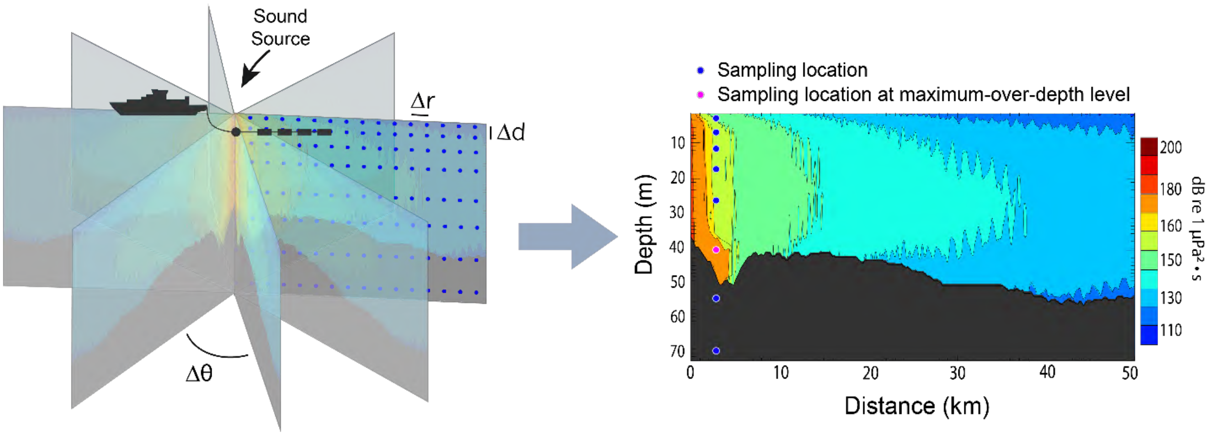

Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, starting at 10 Hz, are modelled to include most of the acoustic energy emitted by the source. At each centre frequency, the transmission loss is modelled within each of the N vertical planes as a function of depth and range from the source. The 1/3-octave-band received per-pulse SEL are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received per-pulse SEL are then computed by summing the received 1/3-octave-band levels.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest in terms of the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by marine mammals. The received per-pulse SEL at a surface sampling location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SEL are presented as colour contours around the source.

An inherent variability in measured sound levels is caused by temporal variability in the environment and the variability in the signature of repeated acoustic impulses (sample sound source verification results is presented in Figure C-2). While MONM's predictions correspond to the averaged received levels, cautionary estimates of the threshold radii are obtained by shifting the best fit line (solid line, Figure C-2) upward so that the trend line encompasses 90% of all the data (dashed line, Figure C-2).

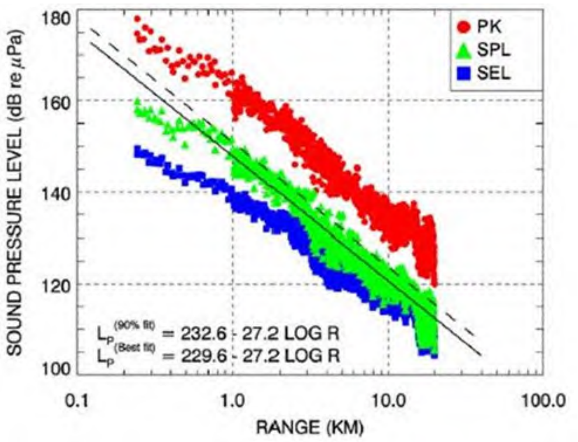

Figure C-2. PK and SPL and per-pulse SEL versus range from a 20 in^3 seismic source. Solid line is the least squares best fit to SPL. Dashed line is the best fit line increased by 3.0 dB to exceed 90% of all SPL values (90th percentile fit) (Ireland et al. 2009, Figure 10).

C.2. Full Waveform Range-dependent Acoustic Model: FWRAM

For impulsive sounds from the seismic source, time-domain representations of the pressure waves generated in the water are required to calculate SPL and PK. Furthermore, the seismic source must be represented as a distributed source to accurately characterise vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seafloor geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modelled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Besides providing direct calculations of the PK and SPL, the synthetic waveforms from FWRAM can also be used to convert the SEL values from MONM to SPL.

C.3. Wavenumber Integration Model

Sound pressure levels near the seismic source were modelled using JASCO's VSTACK wavenumber integration model. VSTACK computes synthetic pressure waveforms versus depth and range for arbitrarily layered, range-independent acoustic environments using the wavenumber integration approach to solve the exact (range-independent) acoustic wave equation. This model is valid over the full angular range of the wave equation and can fully account for the elasto-acoustic properties of the sub-bottom. Wavenumber integration methods are extensively used in the field of underwater acoustics and seismology where they are often referred to as reflectivity methods or discrete wavenumber methods. VSTACK computes sound propagation in arbitrarily stratified water and seabed layers by decomposing the outgoing field into a continuum of outward-propagating plane cylindrical waves. Seabed reflectivity in the model is dependent on the seabed layer properties: compressional and shear wave speeds, attenuation coefficients, and layer densities. The output of the model can be post-processed to yield estimates of the SEL, SPL, and PK.

VSTACK accurately predicts steep-angle propagation in the proximity of the source, but it is computationally slow at predicting sound pressures at large distances due to the need for smaller wavenumber steps with increasing distance. Additionally, VSTACK assumes range-invariant bathymetry with a horizontally stratified medium (i.e., a range-independent environment) which is azimuthally symmetric about the source. VSTACK is thus best suited to modelling the sound field near the source.

Appendix D. Methods and Parameters

This section describes the specifications of the seismic source that was used at all sites and the environmental parameters used in the propagation models.

D.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure D-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure D-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure D-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

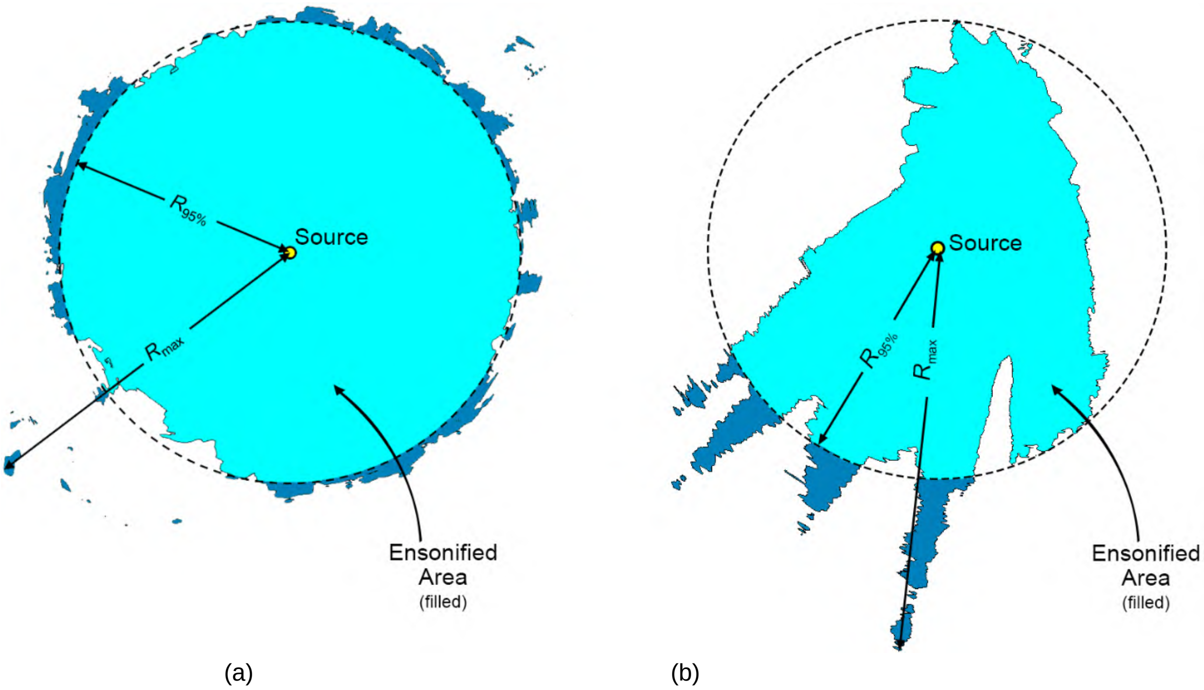

Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

D.2. Estimating SPL from Modelled SEL Results

The per-pulse SEL of sound pulses is an energy-like metric related to the dose of sound received over a pulse's entire duration. The pulse SPL on the other hand, is related to its intensity over a specified time interval. Seismic pulses typically lengthen in duration as they propagate away from their source, due to seafloor and surface reflections, and other waveguide dispersion effects. The changes in pulse length, and therefore the time window considered, affect the numeric relationship between SPL and SEL. This study has applied a fixed window duration to calculate SPL (T_{fix} = 125 ms; see Appendix A.1), as implemented in Martin et al. (2017b). Full-waveform modelling was used to estimate SPL, but this type of modelling is computationally intensive, and can be prohibitively time consuming when run at high spatial resolution over large areas.

For the current study, FWRAM (Appendix C.2) was used to model synthetic seismic pulses over the frequency range 10–1000 Hz. This was performed along all broadside and endfire radials at eight sites. FWRAM uses Fourier synthesis to recreate the signal in the time domain so that both the SEL and SPL from the source can be calculated. The differences between the SEL and SPL were extracted for all ranges and depths that corresponded to those generated from the high spatial-resolution results from MONM. A 125 ms fixed time window positioned to maximize the SPL over the pulse duration was applied. The resulting SEL-to-SPL offsets were averaged in 0.5 km range bins along each modelled radial and depth, and the 90th percentile was selected at each range to generate a generalised range-dependent conversion function for each site. The range- dependent conversion function was averaged between the two sites and applied to predicted per-pulse SEL results from MONM to model SPL values. Figures D-2 to D-9 shows the conversion offsets for each site; the spatial variation is caused by changes in the received airgun pulse as it propagates from the source.

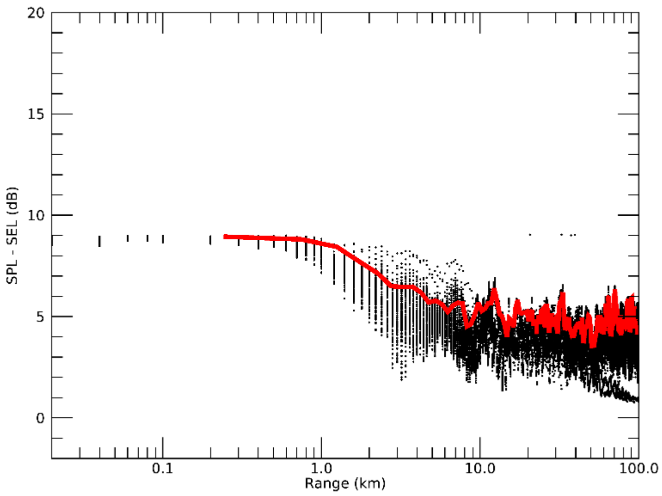

Figure D-2. Slices for the 3150 in^3 array at Site 1: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

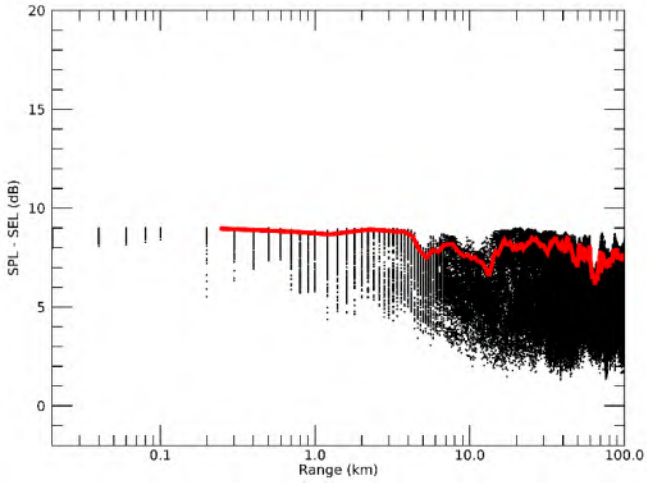

Figure D-3. Slices for the 3150 in^3 array at Site 7: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

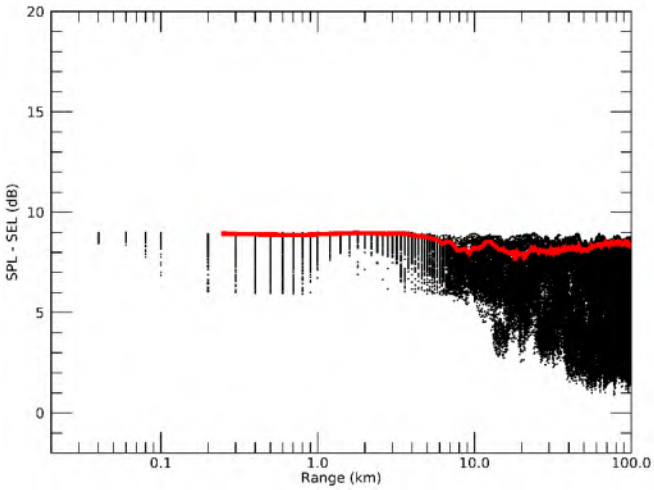

Figure D-4. Slices for the 3150 in^3 array at Site 9: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

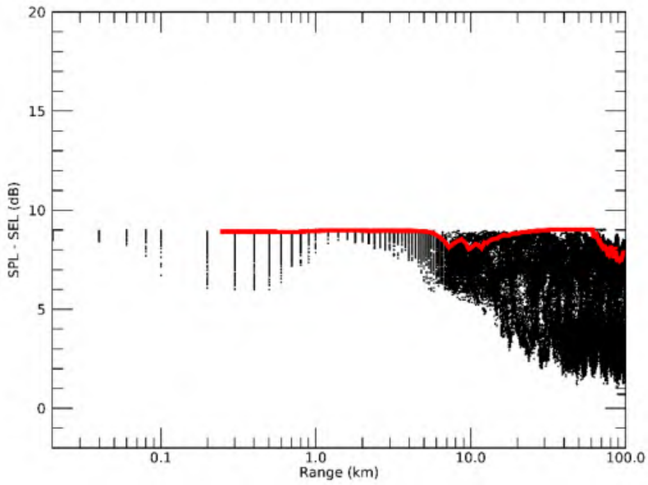

Figure D-5. Slices for the 3150 in^3 array at Site 13: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

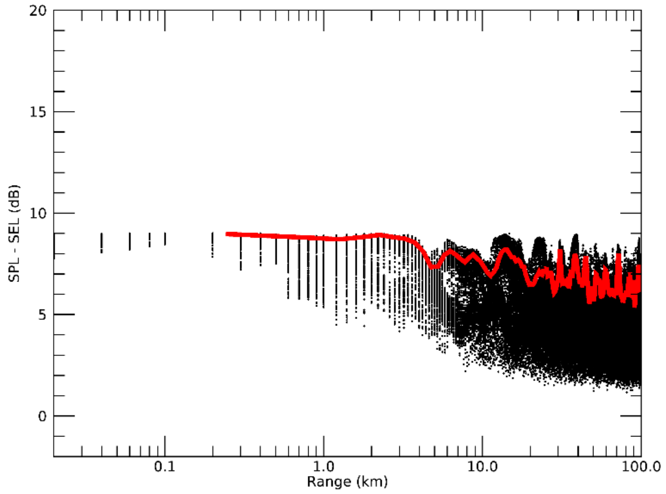

Figure D-6. Slices for the 3150 in^3 array at Site 15: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

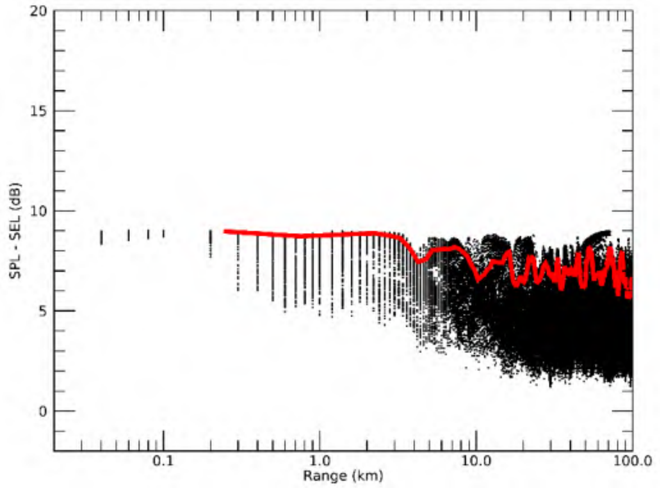

Figure D-7. Slices for the 2560 in^3 array at Site 16: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

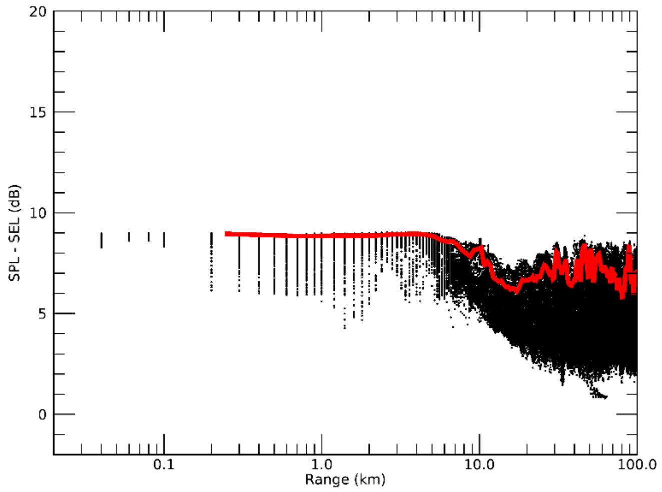

Figure D-8. Slices for the 3150 in^3 array at Site 19: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

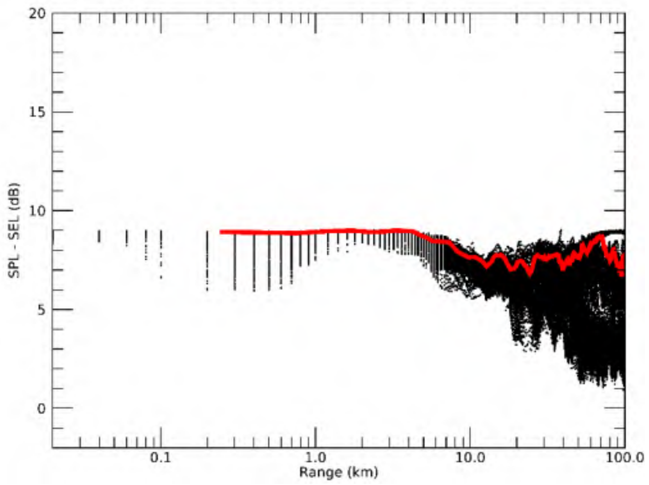

Figure D-9. Slices for the 3510 in^3 array at Site 21: Range-and-depth-dependent conversion offsets for converting SEL to SPL for seismic pulses. Black lines are the modelled differences between SEL and SPL across different radials and receiver depths; the solid red line is the 90th percentile of the modelled differences at each range.

D.3. Environmental Parameters

D.3.1. Bathymetry

Water depths throughout the modelled area were extracted from the Australian Bathymetry and Topography Grid, a 9 arc-second grid rendered for Australian waters (Whiteway 2009). Bathymetry data were extracted and re-gridded onto a Map Grid of Australia (MGA) coordinate projection (Zone 50) with a regular grid spacing of 100 × 100 km centred on each modelling site location.

D.3.2. Sound speed profile

The sound speed profiles for the modelled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Three areas were defined based on survey grouping: Pluto and Harmony survey area; Scarborough survey area; and Laverda, Cimatti, and Vincent survey area (Figure D-10 to Figure D-12). In each area mean monthly sound speed profiles were derived from the GDEM profiles within a 200 km box radius representative of that area. The proposed operational months were considered for the surveys within each area and the most conservative sound speed profile, i.e., the sound speed profile between these months most favourable to long-range propagation, was chosen. For the Scarborough survey area, and the Laverda, Cimatti, and Vincent survey area the May sound speed profile was chosen. In both cases the profile displayed a prominent surface duct in comparison to the profiles for other operational months. For the Pluto and Harmony survey area, there were no distinguishing features affecting propagation in the sound speed profiles so the profile for December was selected as the mid-point of the proposed operational time period.

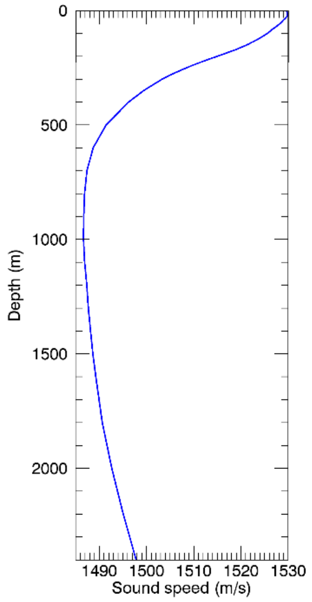

Figure D-10. The final sound speed profile (December) used for the modelling of sites in the Pluto and Harmony survey areas. Profiles are calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

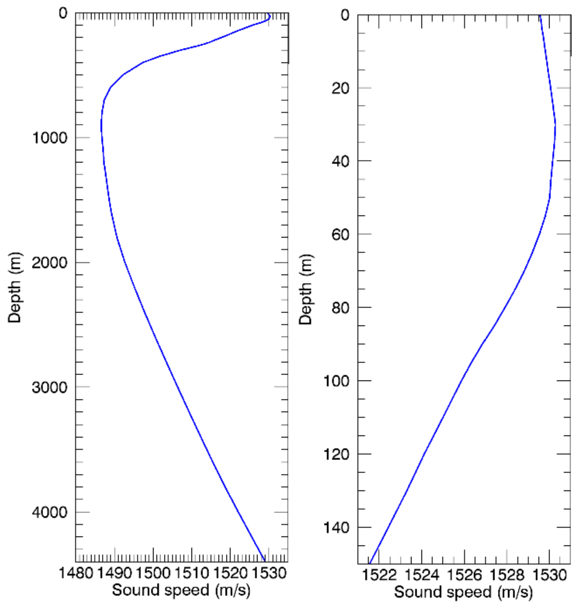

Figure D-11. The final sound speed profile (May) used for the modelling of sites in the Scarborough survey area.The profile for the entire water column is shown on the left and the surface duct on the right. Profiles are calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

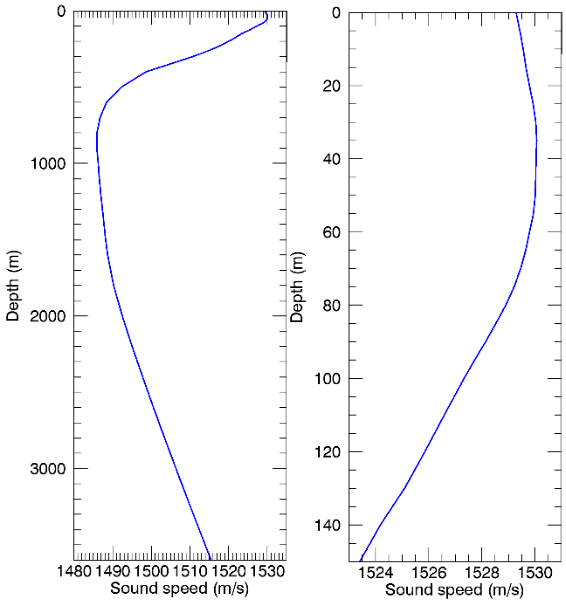

Figure D-12. The final sound speed profile (May) used for the modelling of sites in the Laverda, Cimatti, and Vincent survey areas.The profile for the entire water column is shown on the left and the surface duct on the right. Profiles are calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

D.3.3. Geoacoustics

Acoustic propagation loss modelling requires the geoacoustic properties of the seabed and sub-bottom to be as representative of the modelling area as possible. The study area is located in the Northern Carnarvon Basin. Three geoacoustic profiles were compiled for the modelling areas defined by the water depth at each modelling site and based on available data for the depositional environment and lithology for the region. Because the modelled area is large and geoacoustic information is limited, simplified geoacoustic profiles were constructed to represent the major features of the sediment column at the modelled sites.

D.3.3.1. Shallow water modelling sites

For modelling sites in shallow water (<200 m), relevant data was extracted from the Marine Sediments (MARS) Database (Heap 2009) within the modelling area, and using available shallow core information the surficial sediment was determined to be appropriately represented as fine sand. Additionally, deeper core samples (Gallagher et al. 2017a) indicate the presence of increasingly cemented packstone layers with depth below this surface sediment layer. Based on this layer information and generic properties for carbonate sediments and calcarenite from Hamilton (1980) and Duncan et al. (2013), the geoacoustic profile in Table D-1 was derived.

Table D-1. Shallow water sites: Estimated geoacoustic profile. Within each depth range, each parameter varies linearly within the stated range. For modelling using MONM-BELLHOP and FWRAM, only the surficial S-wave properties are considered. The compressional wave is the primary wave and the shear wave is the secondary wave.

Depth below seafloor (m)	Material	Density (g/cm3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–10	Fine sand	1.94–1.96	1531–1548	0.77	300.0–366.4	3.65–4.54
10–20		1.96–1.98	1548–1565	0.77	366.4–404.3	4.54–5.05
20–50		1.98–2.03	1565–1616	0.77	404.3–461.8	5.05–5.82
50–250	Slightly to semi-cemented sand/calcarenite	1.90	2100	0.12	550	0.25
250–600	Semi-cemented sand/calcarenite	1.90	2200	0.12	650	0.25
600–850	Well-cemented sand/calcarenite	2.20	2600	0.2	1200	0.4

D.3.3.2. Mid-depth water modelling sites

For mid-depth water sites (200 to ~600 m), information on the surficial sediment was determined from Baker et al. (2008), and core information from Gallagher et al. (2017b) was used to determine the deeper stratigraphy. The geoacoustic profile shown in Table D-2 was subsequently determined from properties for carbonate sediments and calcarenite from Hamilton (1980) and Duncan et al. (2013).

Table D-2. Mid-depth water sites: Estimated geoacoustic profile. Within each depth range, each parameter varies linearly within the stated range. For modelling using MONM-BELLHOP and FWRAM, only the surficial S-wave properties are considered. The compressional wave is the primary wave and the shear wave is the secondary wave.

Depth below seafloor (m)	Material	Density (g/cm³)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–10	Silty Sand	1.70–1.72	1619.0–1636.1	0.59–0.69	200.0–219.4	3.65–3.91
10–50	Increasingly consolidated sand-silt-clay	1.62–1.69	1636.1–1659.7	0.20–0.55	219.4–275.1	3.91–4.66
50–100		1.69–1.76	1659.7–1742.6	0.55–0.96	275.1–313.4	4.66–5.17
100–300		1.76–1.95	1742.6–2055.2	0.96–1.03	313.4–516.3	5.17–7.89
300–850	Semi-cemented sand/calcarenite	1.95–2.20	2100–2600	0.12–0.20	650–1200	0.25–0.40
>850	Well-cemented sand/calcarenite	2.20	2600	0.20	1200	0.40

D.3.3.3. Deep water modelling sites

Deep core samples (Exon and Willcox 1980) show the presence of a thick package of pelagic sediments below the seafloor that is bounded by sedimentary bedrock at a depth of ~2000 m. Table D-3 shows the derived geoacoustic profile that was based on geologic information and descriptions from core samples, generic properties for carbonate sediments and calcarenite from Hamilton (1980) and Duncan et al. (2013).

Table D-3. Deep water sites: Estimated geoacoustic profile. Within each depth range, each parameter varies linearly within the stated range. For modelling using MONM-BELLHOP and FWRAM, only the surficial S-wave properties are considered. The compressional wave is the primary wave and the shear wave is the secondary wave.

Depth below seafloor (m)	Material	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–30	Foraminifera/nannofossil ooze, calcisiltit	1.52–1.56	1560–1600	0.12–0.13	250	3.65
30–100		1.56–1.65	1600–1700	0.13–0.15		
200–2000	Calcarenite/calcisiltit	1.90–2.20	2100–2600	0.25–0.52		
>2000	Sedimentary bedrock	2.54	3500	0.11		

D.4. Seismic Sources

The layouts of the seismic sources considered in Appendix B are provided in Figures D-13 to D-14.

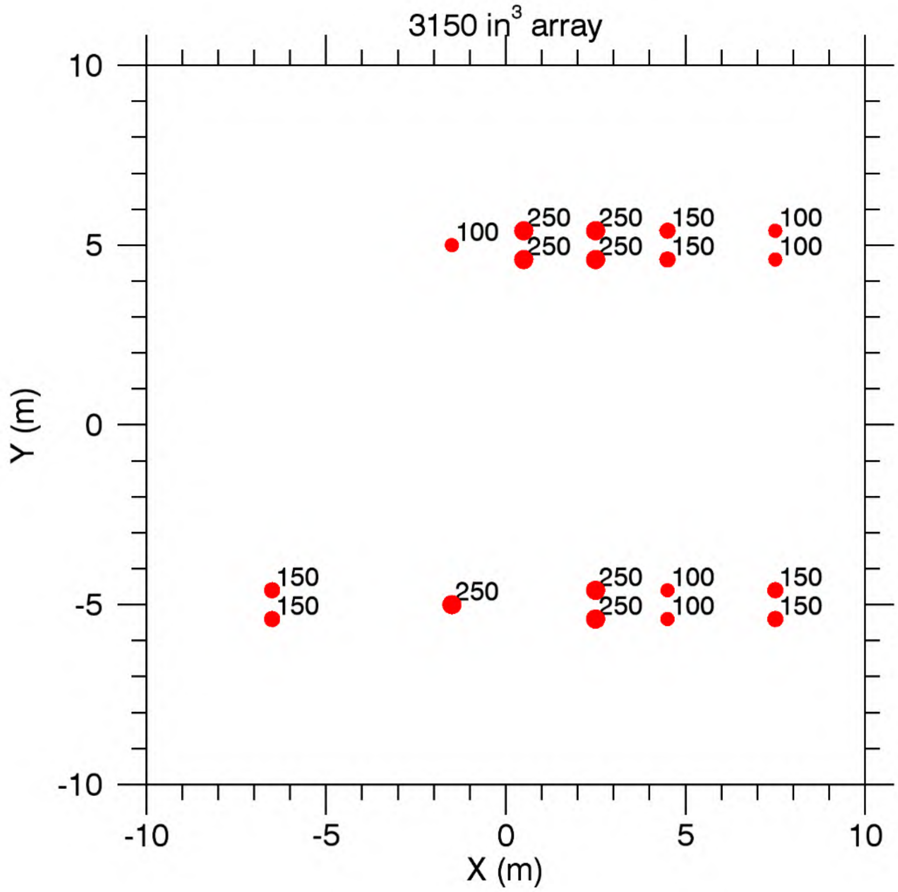

Figure D-13. Layout of the modelled 3150 in^3 seismic source array. Tow depth is 6 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table D-4.

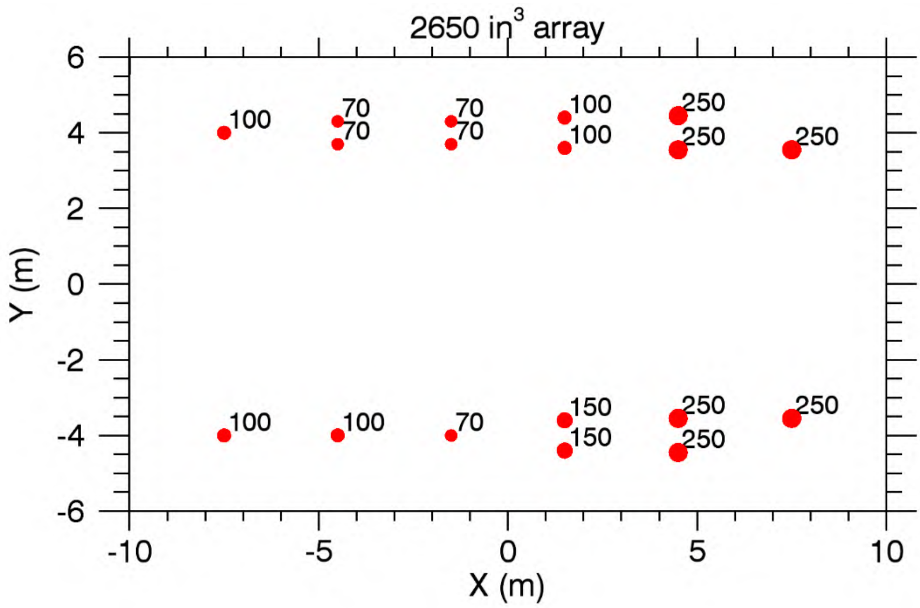

Figure D-14. Layout of the modelled 2650 in^3 seismic source array. Tow depth is 5 m. The labels indicate the firing volume (in cubic inches) for each airgun. Also see Table D-5.

Table D-4. Layout of the modelled 3150 in^3 seismic source array. Tow depth is 6 m. Firing pressure for all guns is 2000 psi. Also see Figure D-13.

Gun	x (m)	y (m)	z (m)	Volume (in^3)	Gun	x (m)	y (m)	z (m)	Volume (in^3)
1	7.5	−5.4	6	150	10	7.5	4.6	6	100
2	7.5	−4.6	6	150	11	7.5	5.4	6	100
3	4.5	−5.4	6	100	12	4.5	4.6	6	150
4	4.5	−4.6	6	100	13	4.5	5.4	6	150
5	2.5	−5.4	6	250	14	2.5	4.6	6	250
6	2.5	−4.6	6	250	15	2.5	5.4	6	250
7	−1.5	−5	6	250	16	0.5	4.6	6	250
8	−6.5	−5.4	6	150	17	0.5	5.4	6	250
9	−6.5	−4.6	6	150	18	−1.5	5	6	100

Table D-5. Layout of the modelled 2650 in^3 seismic source array. Tow depth is 5 m. Firing pressure for all guns is 2000 psi. Also see Figure D-14.

Gun	x (m)	y (m)	z (m)	Volume (in^3)	Gun	x (m)	y (m)	z (m)	Volume (in^3)
1	7.5	−3.55	5	250	10	4.5	3.55	5	250
2	4.5	−4.45	5	250	11	4.5	4.45	5	250
3	4.5	−3.55	5	250	12	1.5	3.6	5	100
4	1.5	−4.4	5	150	13	1.5	4.4	5	100
5	1.5	−3.6	5	150	14	−1.5	3.7	5	70
6	−1.5	−4	5	70	15	−1.5	4.3	5	70
7	−4.5	−4	5	100	16	−4.5	3.7	5	70
8	−7.5	−4	5	100	17	−4.5	4.3	5	70
9	7.5	3.55	5	250	18	−7.5	4	5	100

D.5. Model Validation Information

Predictions from JASCO's Airgun Array Source Model (AASM) and propagation models (MONM, FWRAM and VSTACK) have been validated against experimental data from a number of underwater acoustic measurement programs conducted by JASCO globally, including the United States and Canadian Artic, Canadian and southern United States waters, Greenland, Russia and Australia (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Matthews and MacGillivray 2013, Martin et al. 2015, Racca et al. 2015, Martin et al. 2017a, Martin et al. 2017b, Warner et al. 2017, MacGillivray 2018, McPherson et al. 2018, McPherson and Martin 2018).

In addition, JASCO has conducted measurement programs associated with a significant number of anthropogenic activities which have included internal validation of the modelling (including McCrodan et al. 2011, Austin and Warner 2012, McPherson and Warner 2012, Austin and Bailey 2013, Austin et al. 2013, Zykov and MacDonnell 2013, Austin 2014, Austin et al. 2015, Austin and Li 2016, Martin and Popper 2016) .

Appendix E. Additional Results

E.1. SEL Contour Maps

E.1.1. Area A

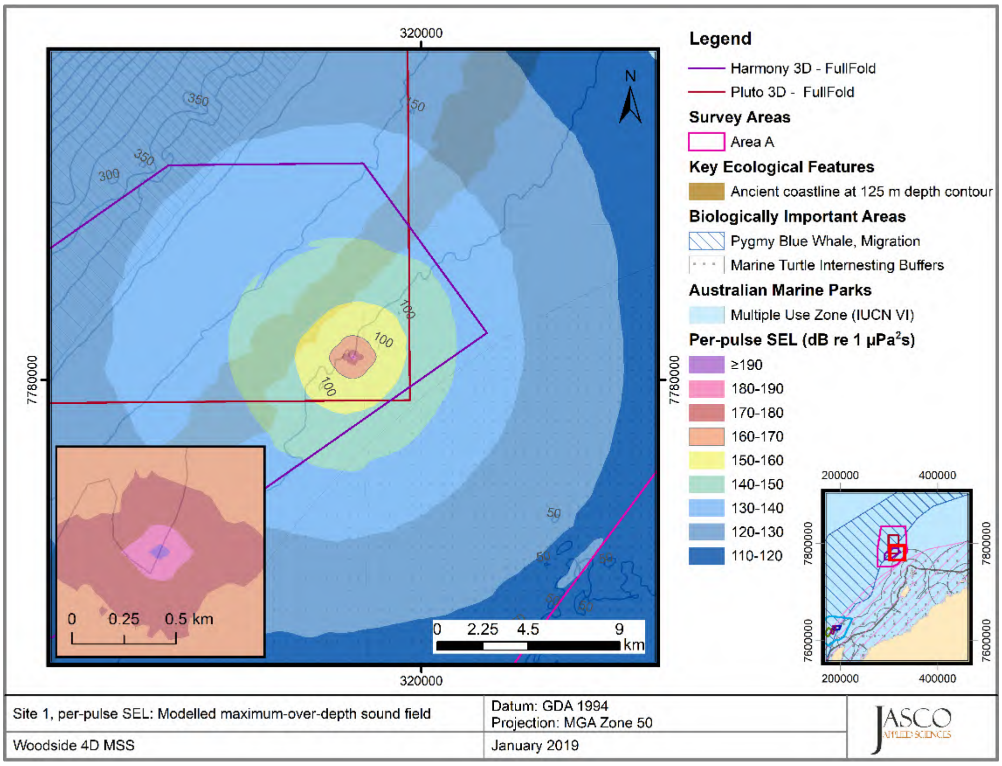

Figure E-1. *Site 1, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

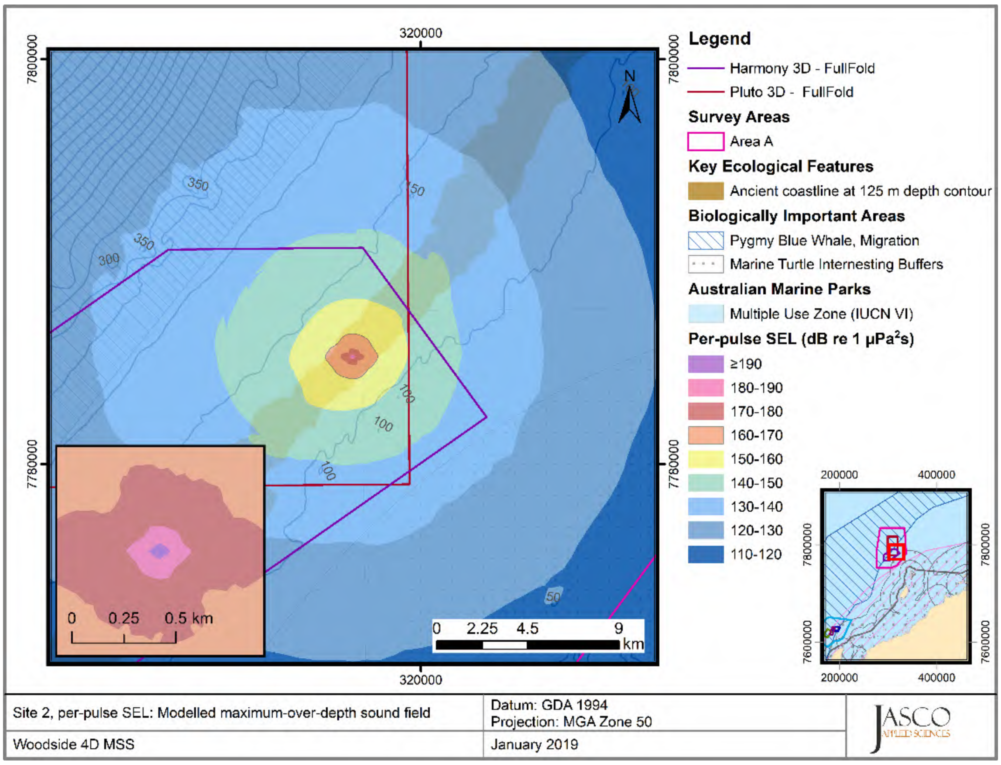

Figure E-2. *Site 2, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

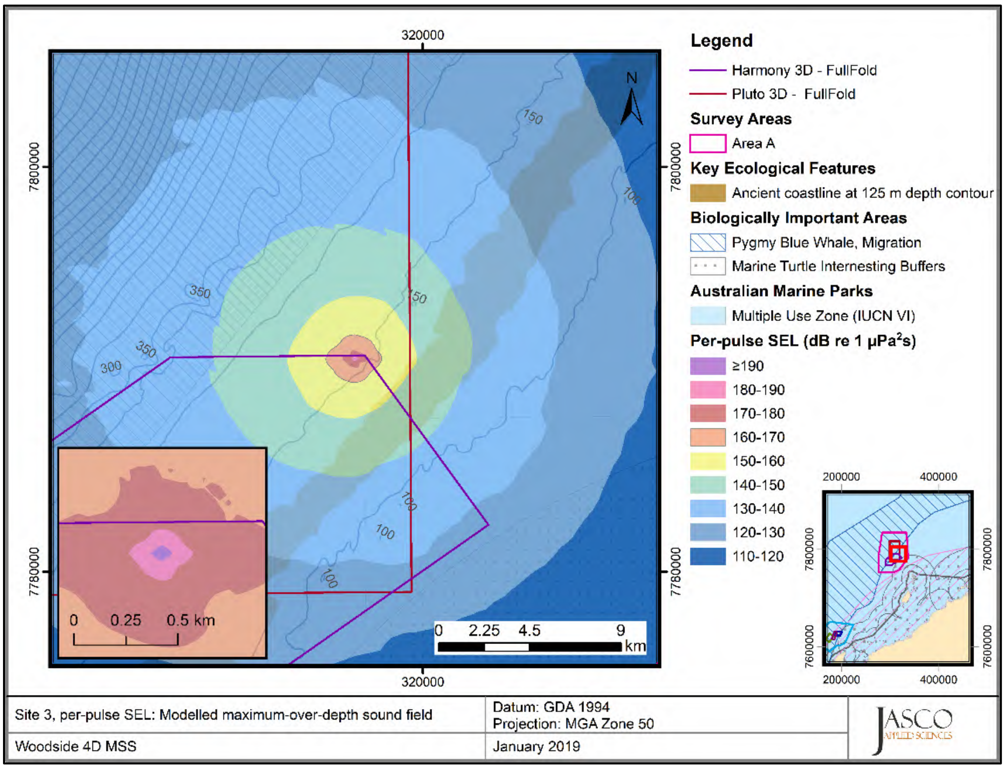

Figure E-3. *Site 3, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

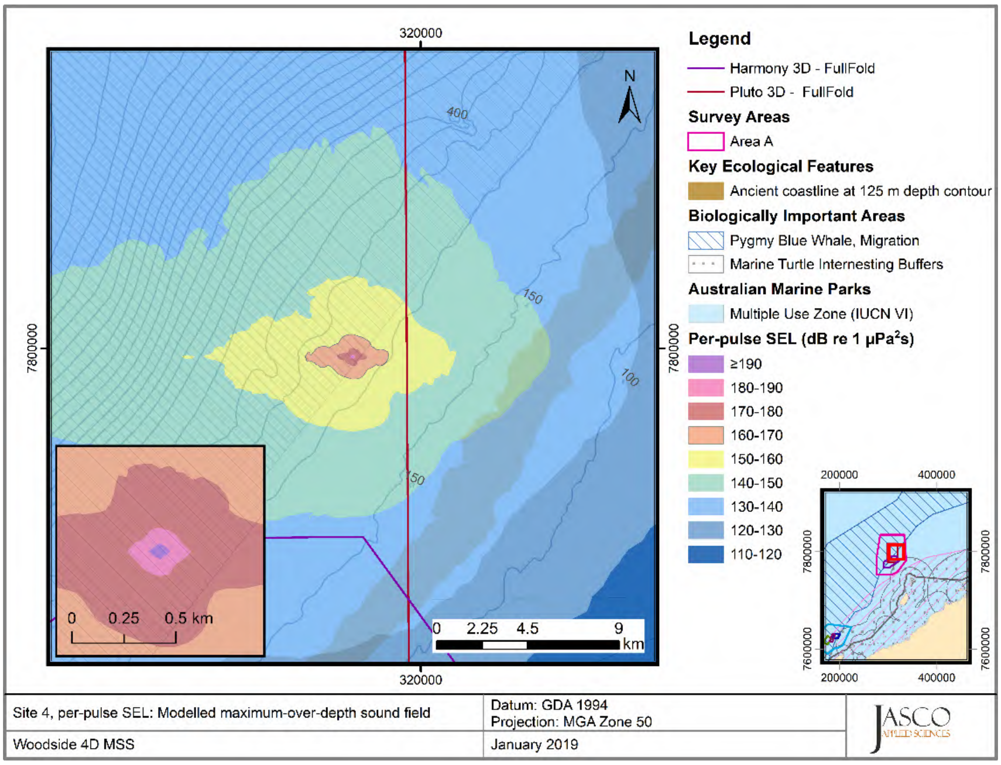

Figure E-4. *Site 4, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

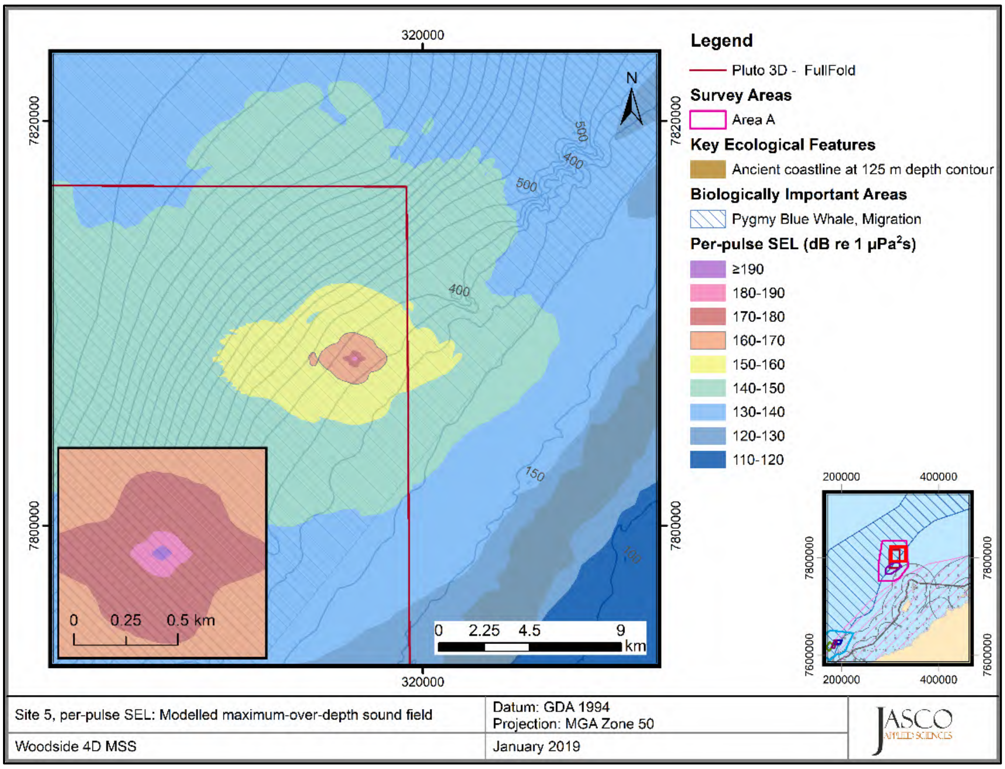

Figure E-5. *Site 5, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

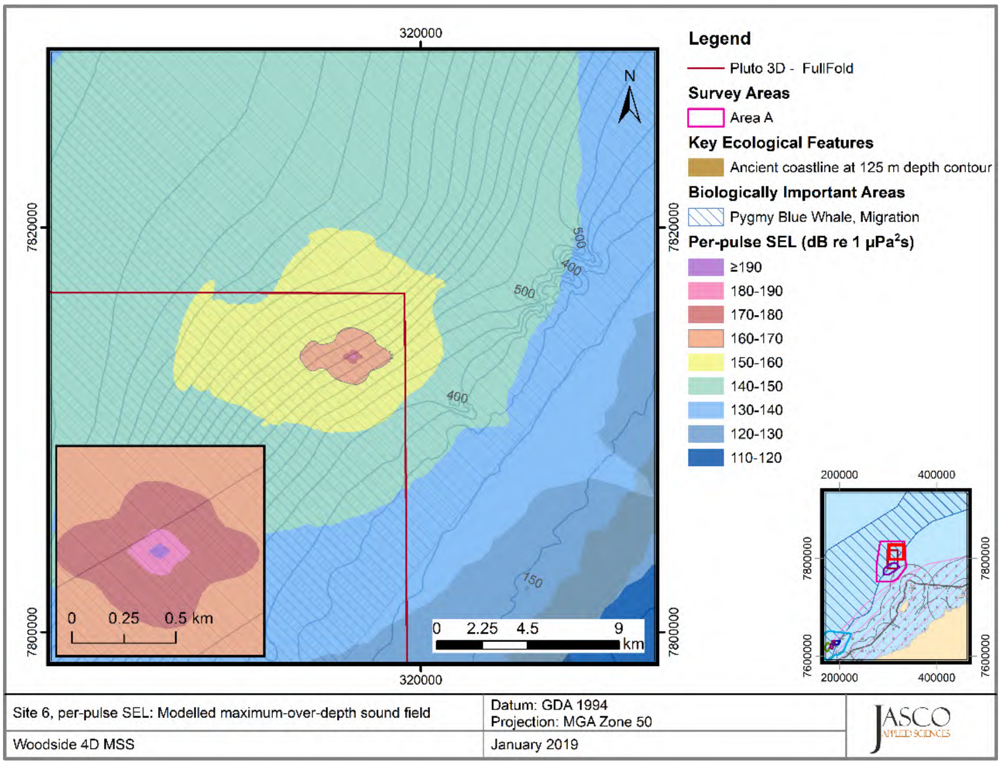

Figure E-6. *Site 6, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

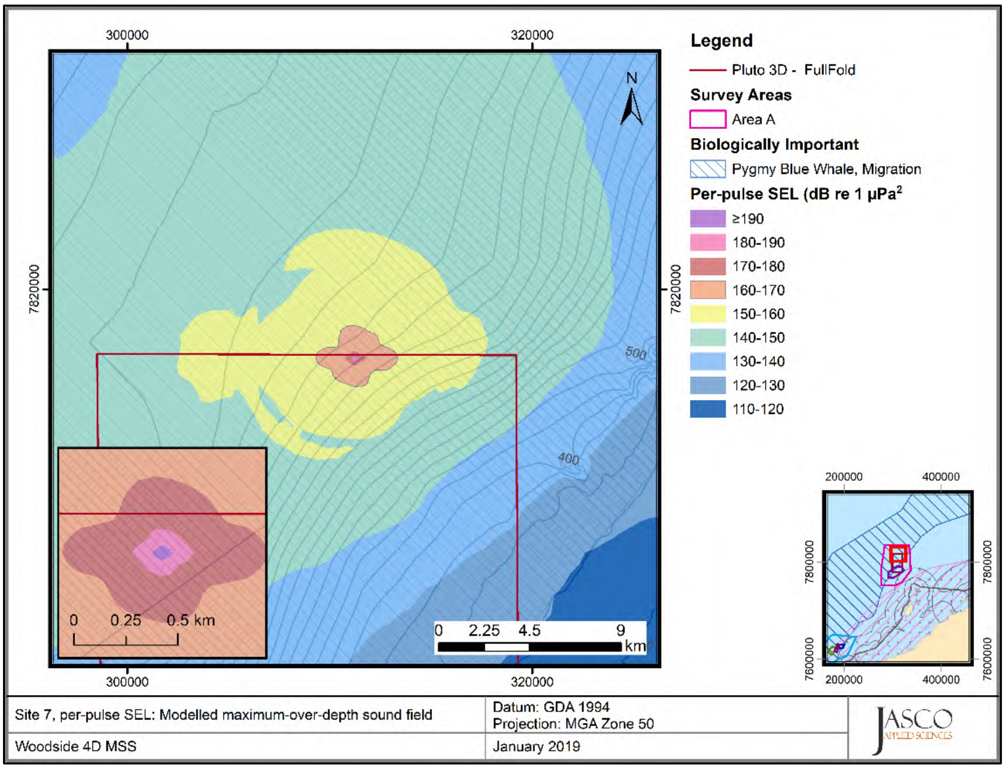

Figure E-7. *Site 7, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

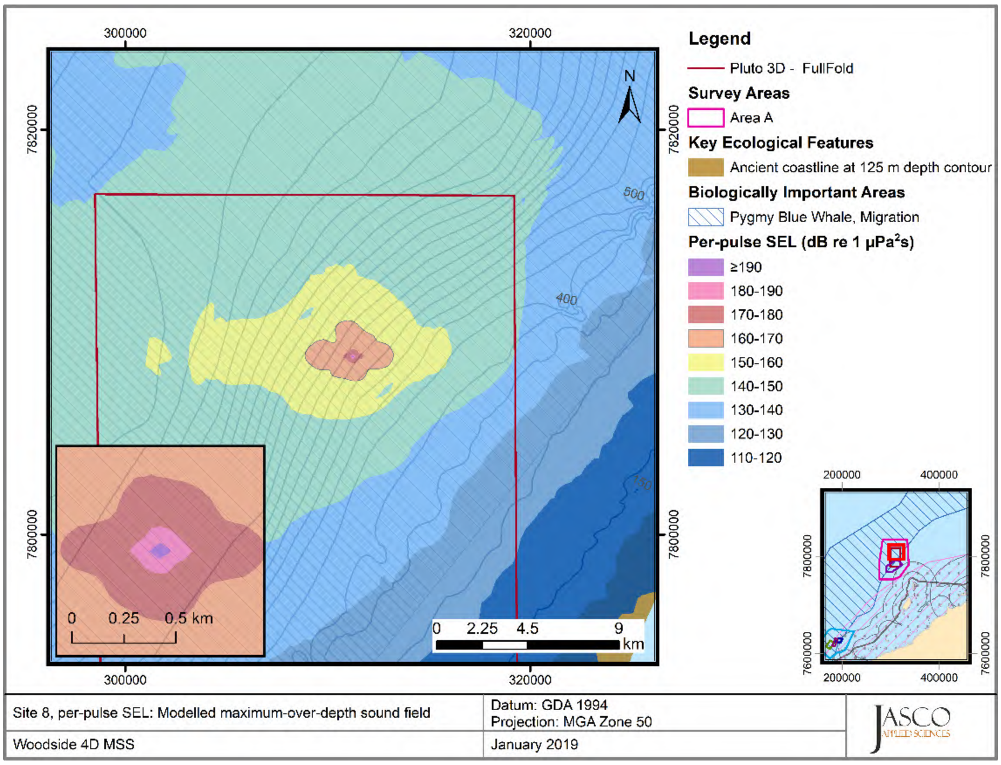

Figure E-8. *Site 8, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

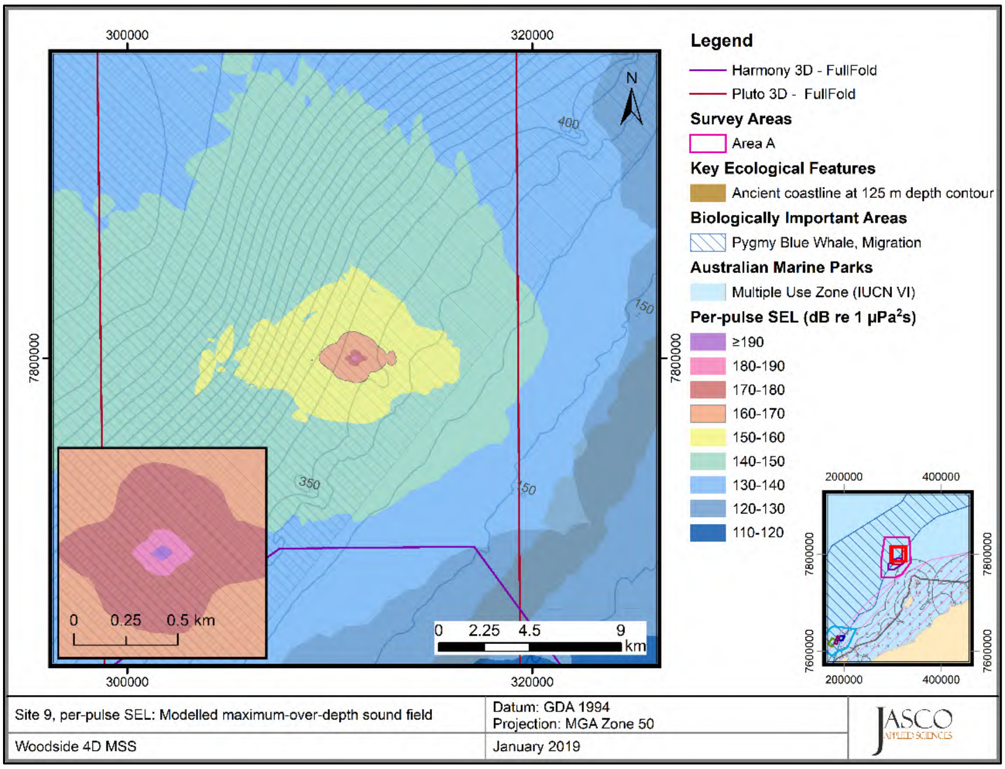

Figure E-9. *Site 9, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

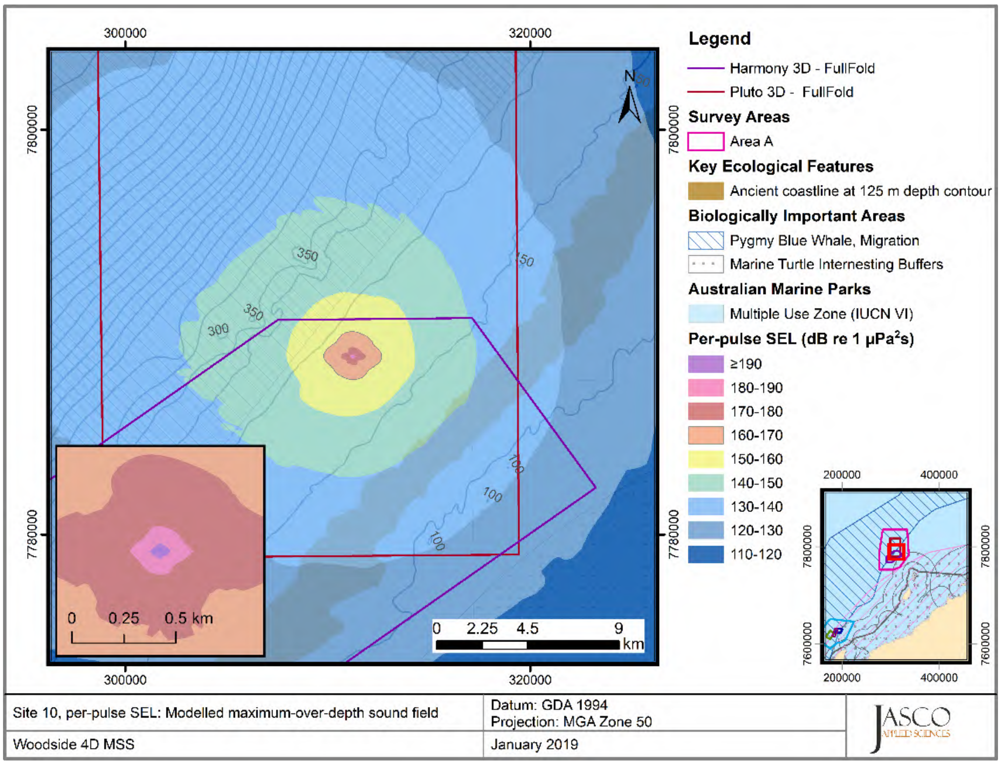

Figure E-10. *Site 10, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

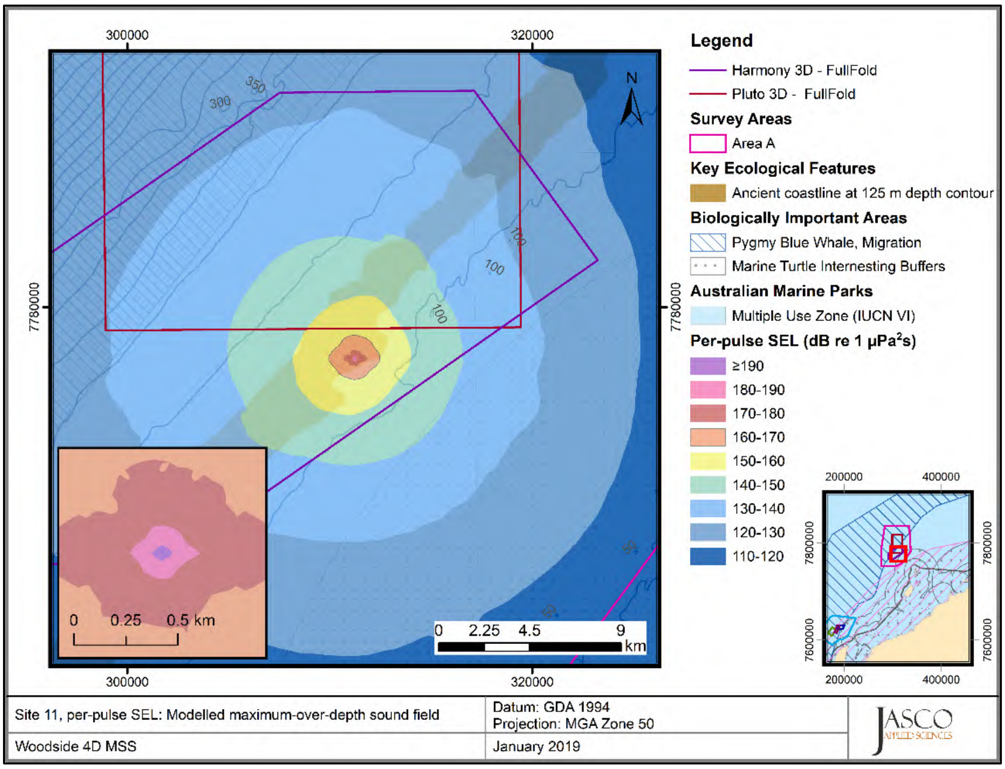

Figure E-11. *Site 11, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

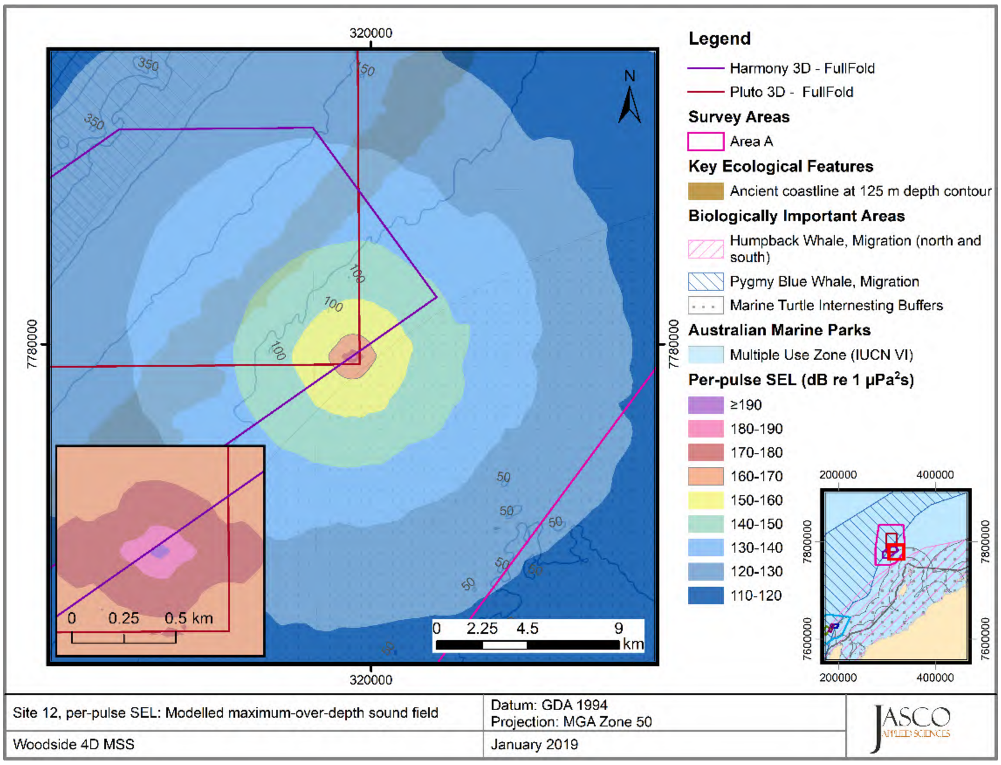

Figure E-12. *Site 12, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

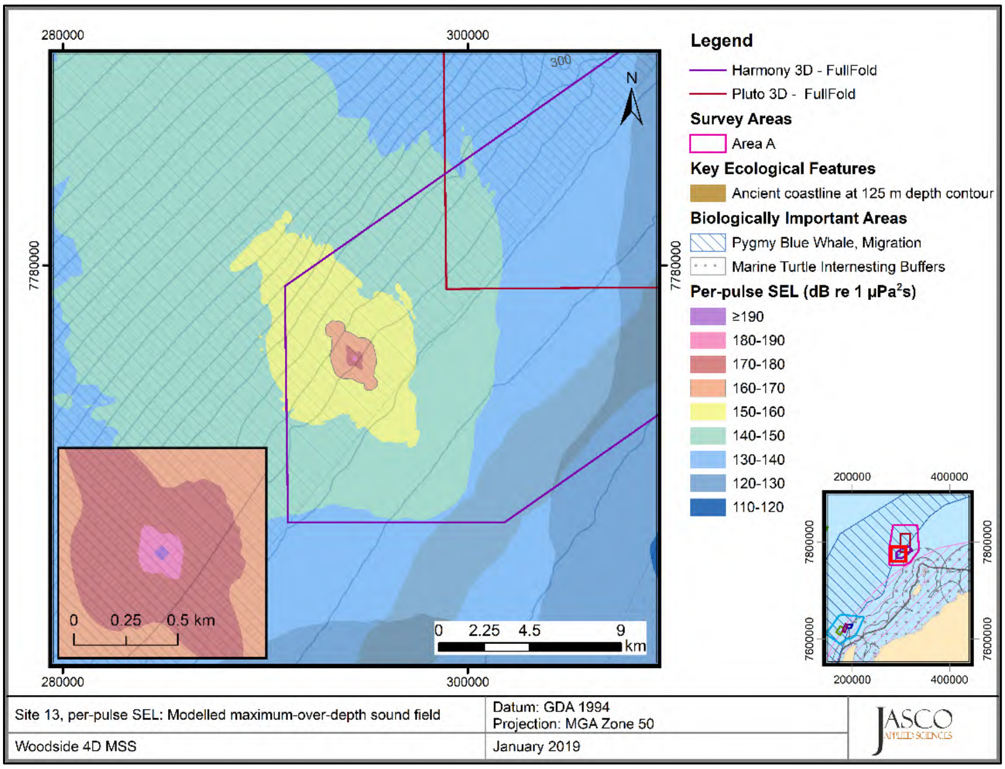

Figure E-13. *Site 13, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

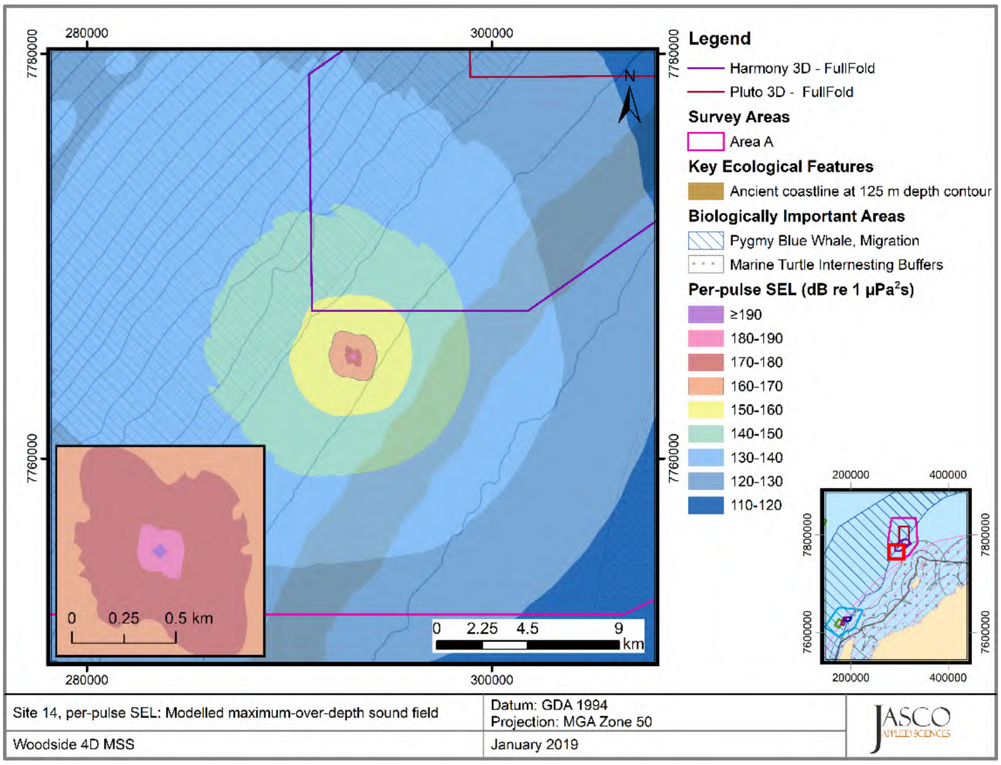

Figure E-14. *Site 14, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

E.1.2. Area B

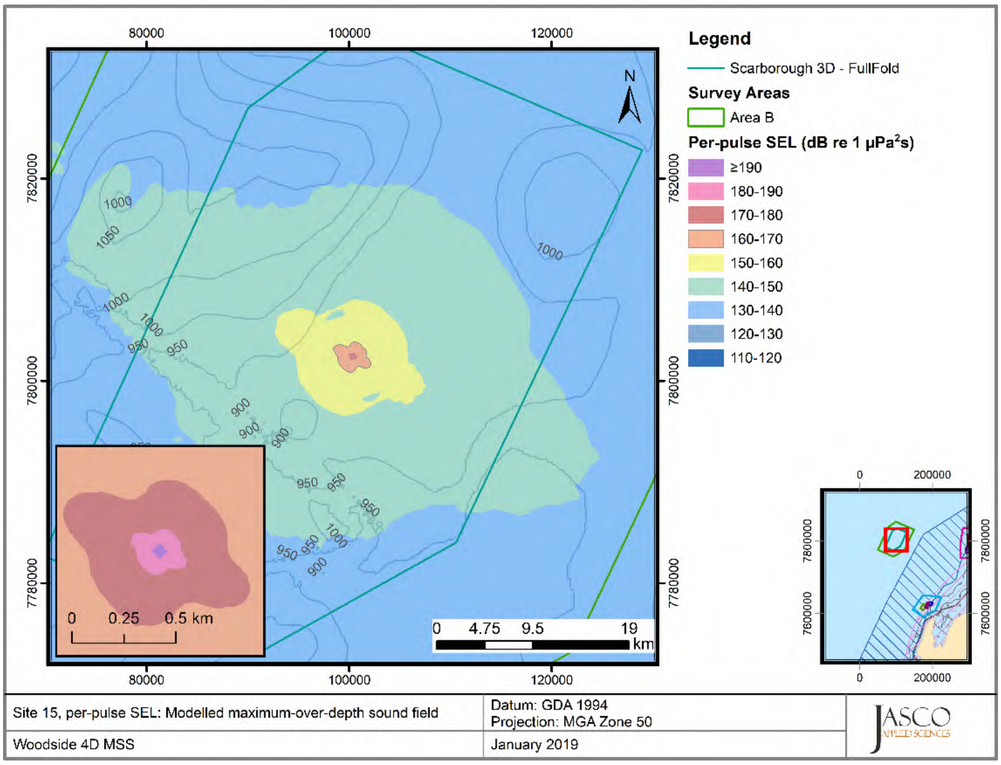

Figure E-15. *Site 15, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

E.1.3. Area C

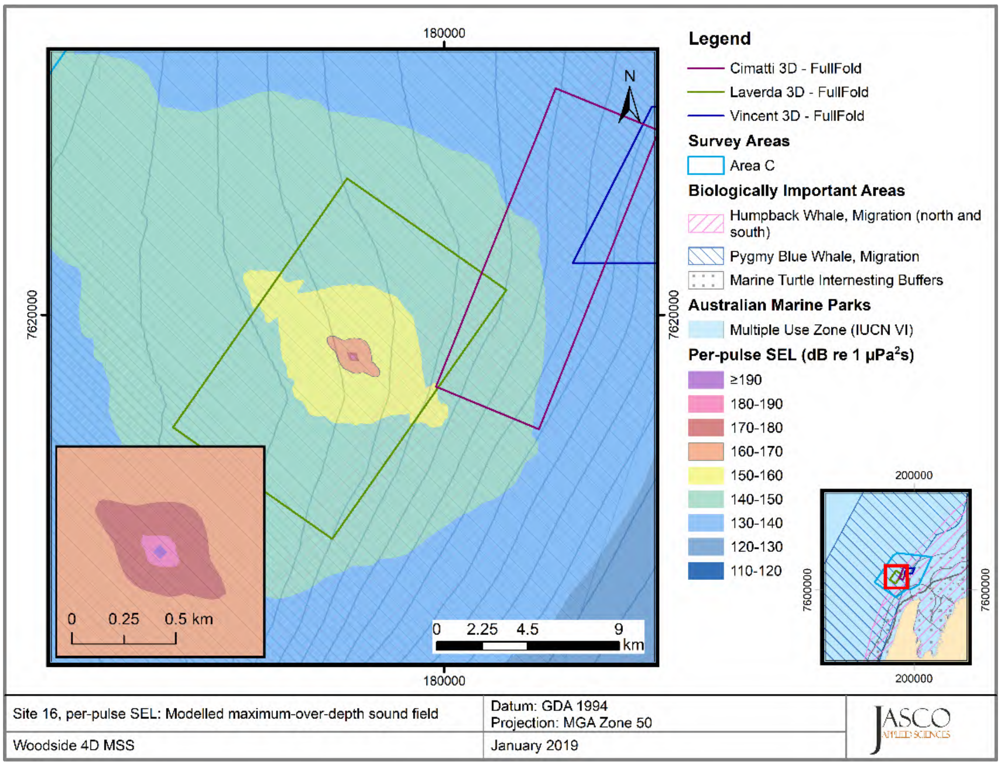

Figure E-16. *Site 16, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

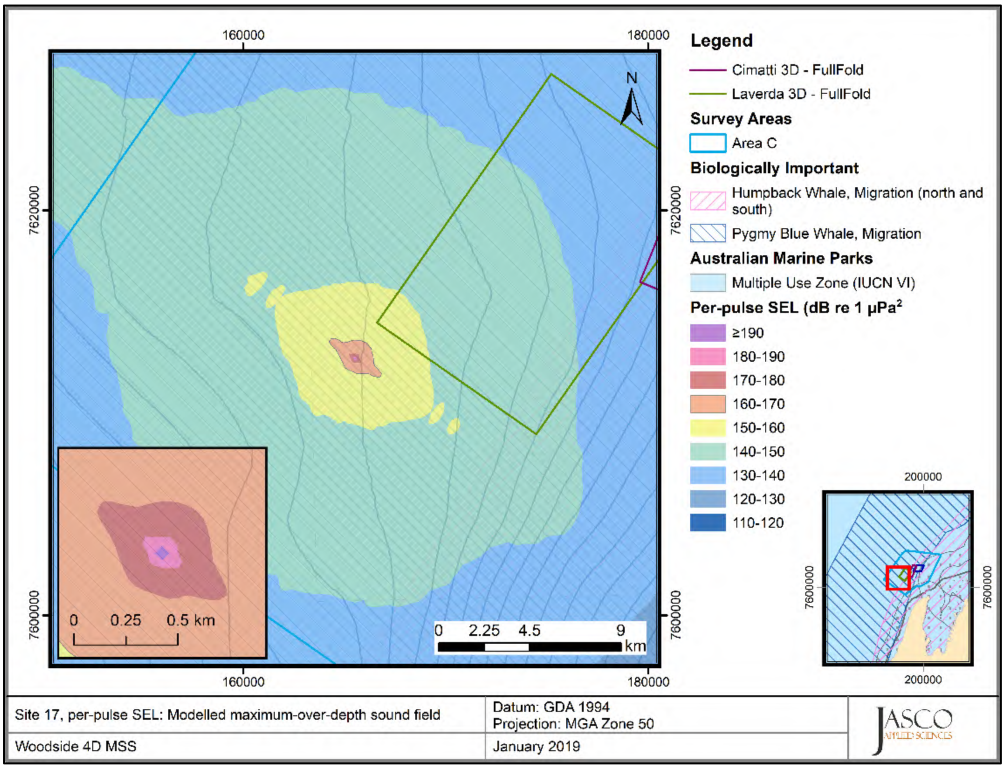

Figure E-17. *Site 17, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

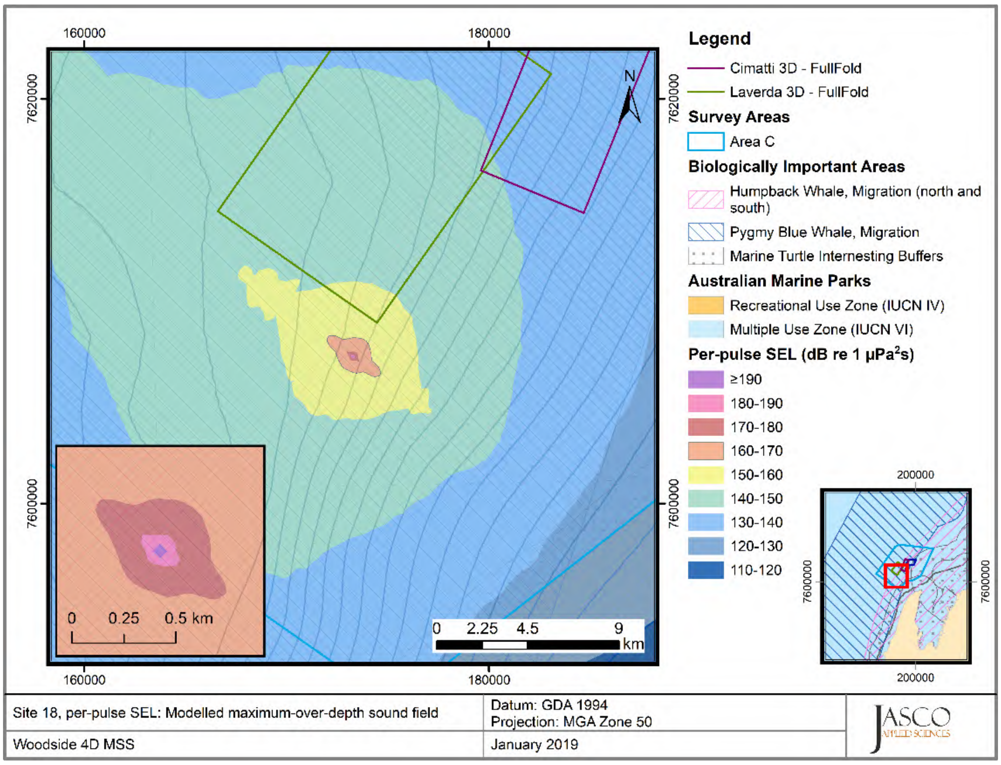

Figure E-18. *Site 18, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

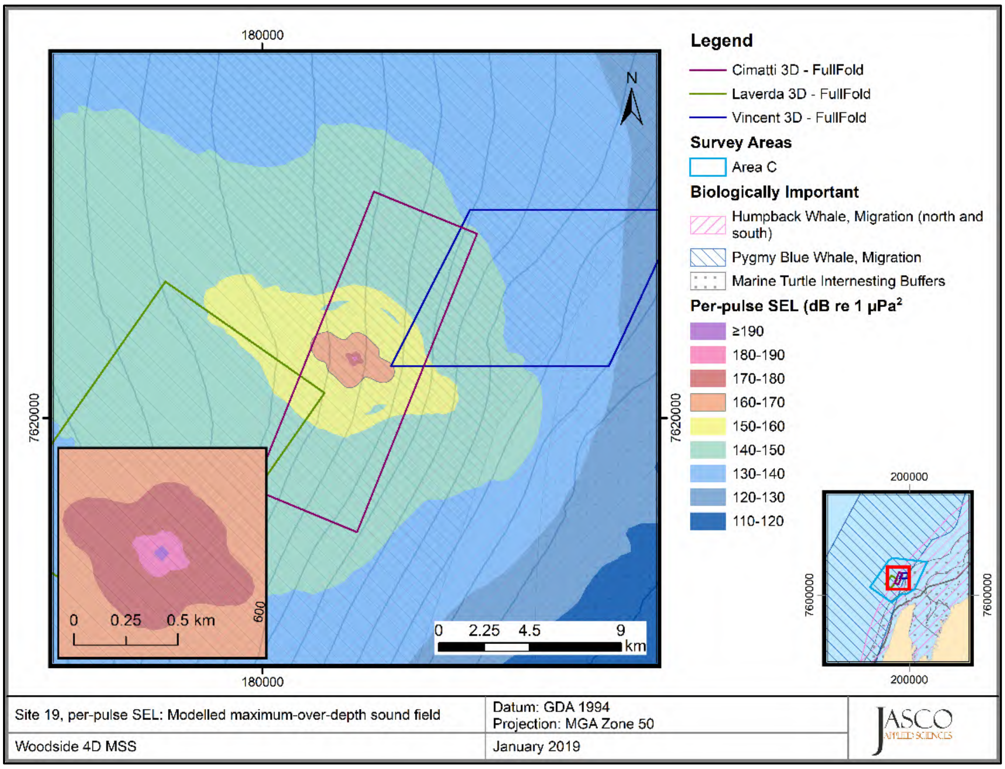

Figure E-19. *Site 19, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

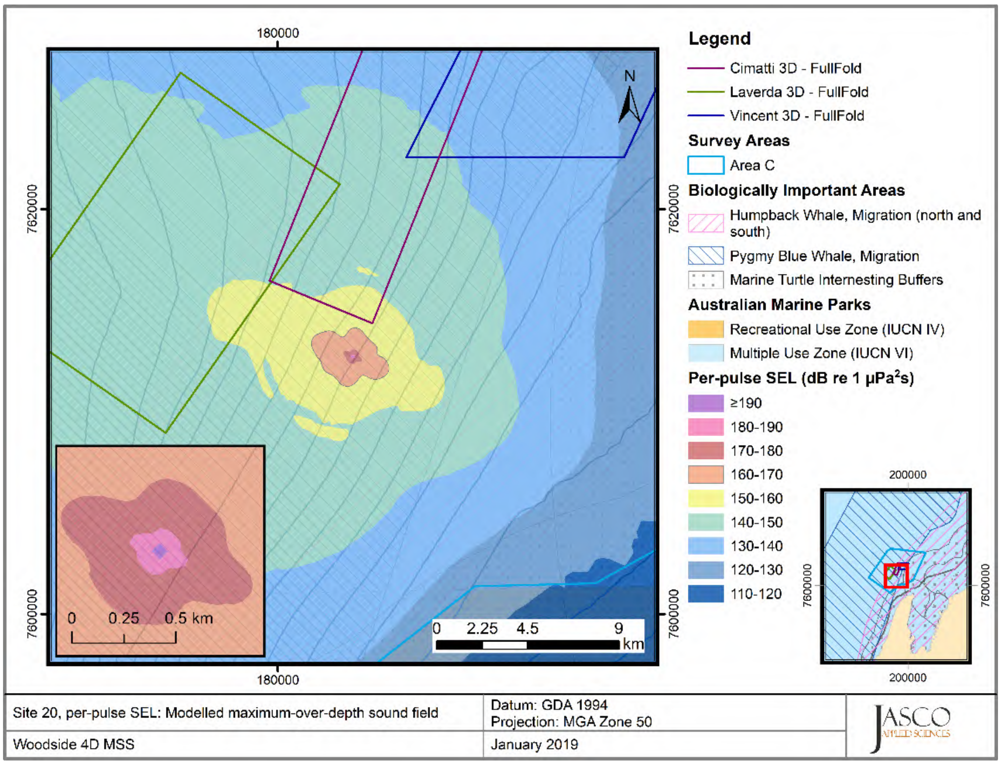

Figure E-20. *Site 20, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

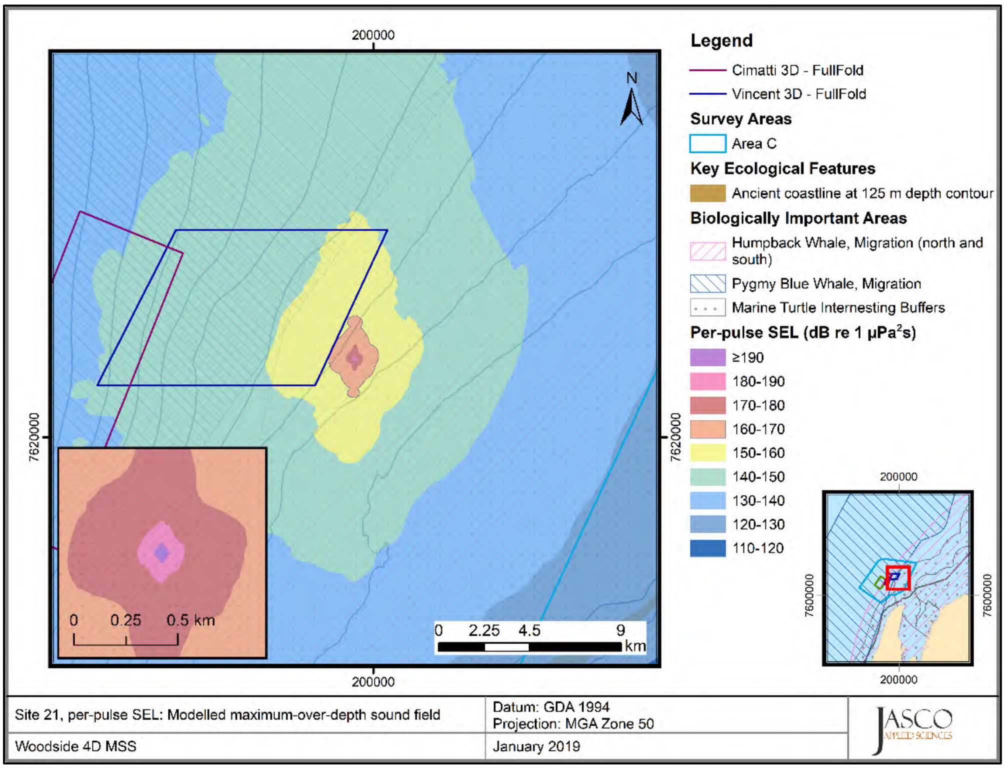

Figure E-21. *Site 21, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

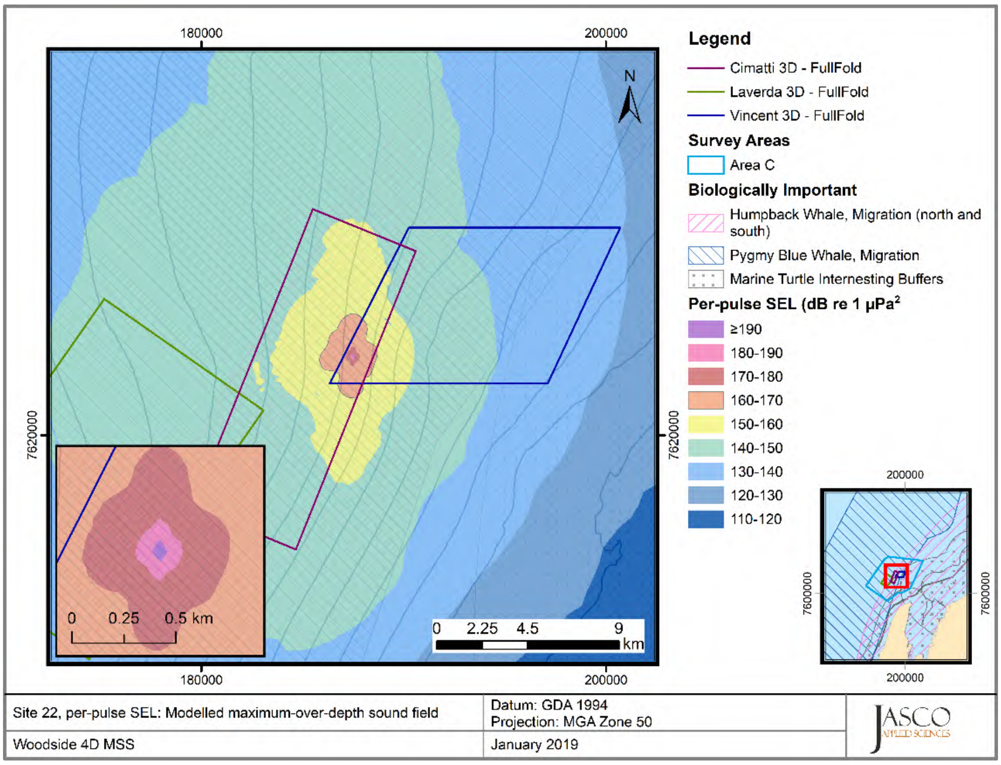

Figure E-22. *Site 22, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

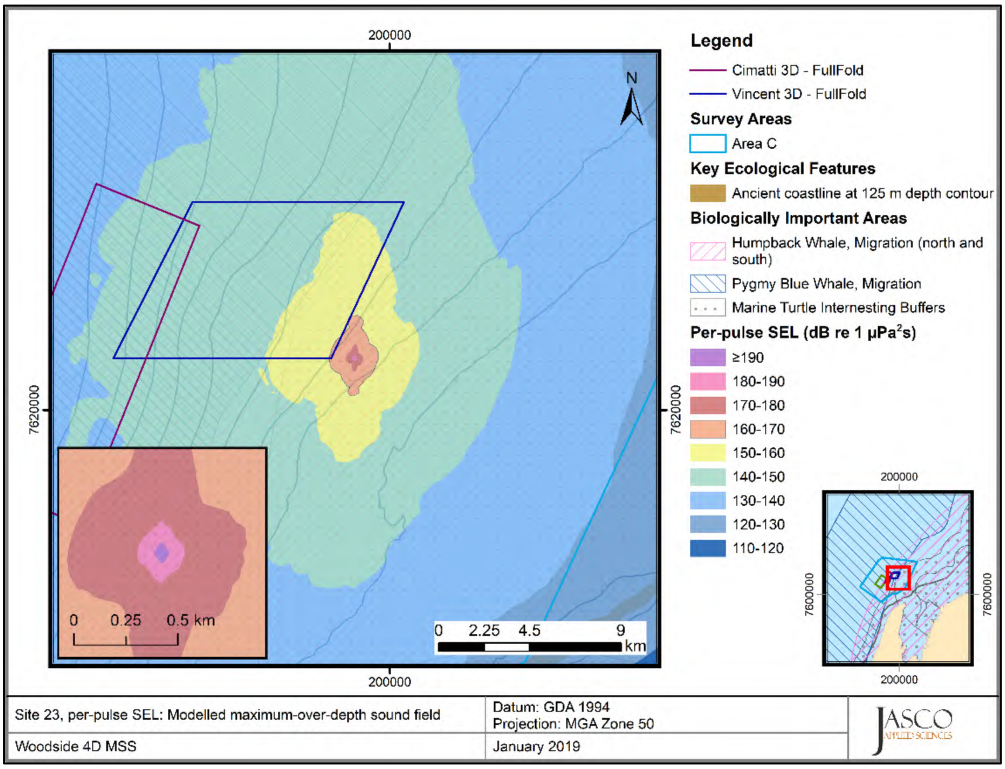

Figure E-23. *Site 23, per-pulse SEL:* Sound level contour map showing unweighted maximum-over-depth.

E.2. Vertical Slice Plots

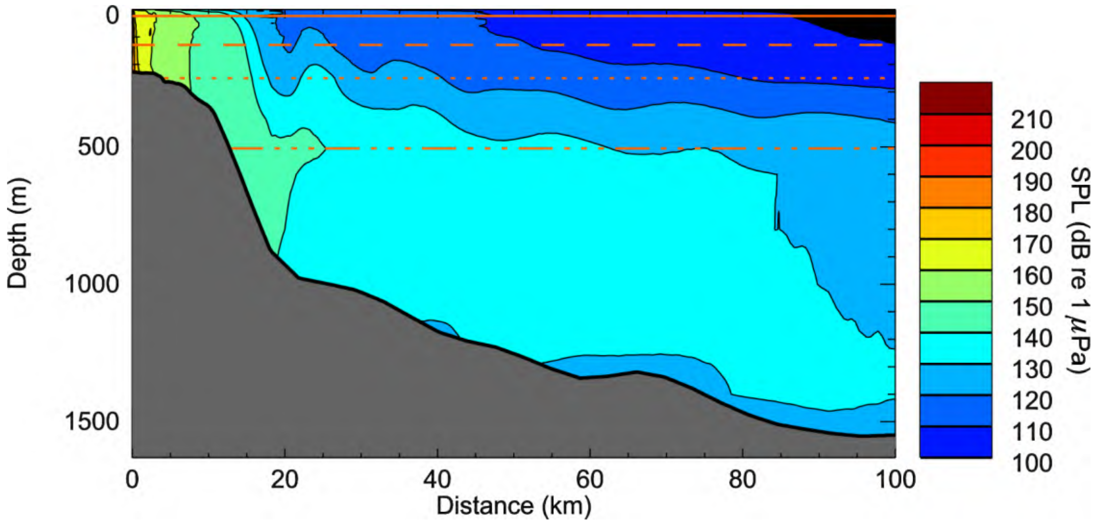

Figure E-24. *Site 4*: Long-range vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown out to a maximum range of 100 km along at an azimuth of 0° (endfire direction), with the pygmy blue whale (24, 129 and 506 m) and turtle (250 m) depth limits shown.

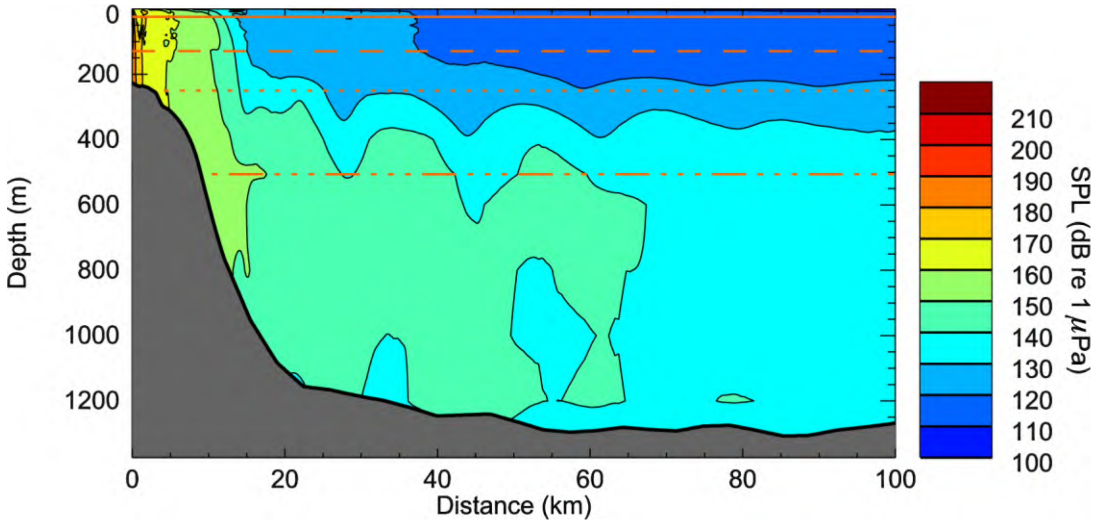

Figure E-25. *Site 4*: Long-range vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown out to a maximum range of 100 km along at an azimuth of 270° (broadside direction), with the pygmy blue whale (24, 129 and 506 m) and turtle (250 m) depth limits shown.

Woodside 4-D Marine Seismic Survey

Pygmy Blue Whale Exposure Modelling

Submitted to:

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Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

EXECUTIVE SUMMARY 4
1. INTRODUCTION 5
2. MODELLING SCENARIOS FOR EXPOSURE MODELLING 7
3. NOISE EFFECT CRITERIA 13
4. METHODS 14
 4.1. Acoustic Modelling 14
  4.1.1. Acoustic Source Model 14
  4.1.2. Sound Propagation Models 14
  4.1.3. Parameter Overview 14
 4.2. Animal Movement and Exposure Modelling 15
  4.2.1. Methodology 15
  4.2.2. Animal behaviour 16
  4.2.3. Density estimates 17
5. RESULTS 20
6. DISCUSSION 22
LITERATURE CITED 25
APPENDIX A. ACOUSTIC METRICS A-1
APPENDIX B. ANIMAL MOVEMENT AND EXPOSURE MODELLING B-1

Figures

Figure 1. Overview of the features for the pygmy blue whale exposure modelling for the Woodside 4-D seismic campaign. 6
Figure 2 *Area A*: Animat modelling extent and survey fullfold areas. 7
Figure 3 *Area C*: Animat modelling extent and survey fullfold areas. 8
Figure 4. *Area A, Pluto 4-D Survey*: Representative acquisition lines considered for animat calculations. 10
Figure 5. *Area A, Harmony 4-D Survey*: Representative acquisition lines considered for animat calculations. 10
Figure 6. *Area C, Laverda 4-D Survey*: Representative acquisition lines considered for animat calculations. 11
Figure 7. *Area C, Cimatti 4-D Survey*: Representative acquisition lines considered for animat calculations. 11
Figure 8. *Area C, Vincent 4-D Survey*: Representative acquisition lines considered for animat calculations. 12
Figure 9. Cartoon of animats in a moving sound field. 15
Figure 10. Stacked histograms showing migrating pygmy blue whale exposures for an example 24 h period above and below the TTS SEL_{24h} threshold at Laverda (upper panel) and Pluto (lower panel). The 95th percentile range in each case is denoted by a dashed line. 23
Figure 11. *Site 16, Laverda*: Vertical slice of the predicted SPL for the 2650 in^3 array. 23
Figure 12. *Site 5, Pluto*: Vertical slice of the predicted SPL for the 3150 in^3 array. 24

Figure A-1. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by NMFS (2018). A-4

Tables

Table 1. Surveys within the Woodside 4-D North-West-Shelf seismic campaign considered for animat modelling. 5
Table 2. Location details for the standalone single impulse sites. 9
Table 3. Details for each exposure Scenario for each survey. 9
Table 4. Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine mammals. 13
Table 5. Exposure modelling scenarios and associated areas of interest for the simulation. 16
Table 6. Population growth estimates based on 4.3% per annum. 18
Table 7. Density calculations 19
Table 8. *Area A*: Summary of animat simulation results for migratory pygmy blue whales. 20
Table 9. *Area C*: Summary of animat simulation results for migratory and foraging pygmy blue whales. 21

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018). A-3
Table B-1. *Foraging pygmy blue whales*: Data values and references input in JASMINE to create diving behaviour B-3
Table B-2. *Migrating pygmy blue whales*: Data values and references input in JASMINE to create diving behaviour B-4

Executive Summary

JASCO Applied Sciences performed an acoustic exposure analysis study for pygmy blue whales for five of the six planned 4-D Marine Seismic Surveys (MSS) within two Survey Areas for the Woodside 4-D North-West-Shelf seismic campaign. Previously, acoustic modelling was conducted for these surveys to determine ranges to acoustic exposure thresholds representing the best available science for potential injury and behavioural disruption of marine fauna including marine mammals, turtles and fish (McPherson et al. 2019).

The aim of this study was to employ animal movement (animat) modelling simulations in conjunction with these previously computed three-dimensional sound fields to predict the number of individual animals that could be impacted above threshold criteria for injury and behavioural disturbance. To achieve this, the JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to integrate the sound fields with species-typical behaviour. JASMINE results provide an estimate of the probability of sound exposure, which can be compared to acoustic thresholds and then scaled to estimate the number of animals expected to receive sound levels that may cause injury or behavioural disruption.

The behaviour of pygmy blue whales was modelled without migration bias, i.e. the animats were resident in the animat modelling area over the entire modelling period. The two migratory behaviours (migratory dives and exploratory dives) were modelled at an even probability of occurrence. Both of these approaches were chosen to present conservative results due to the limited data available.

Simulations were run for a representative period of 7 days, then scaled down to 24 h for easier comparison with ranges to acoustic exposure thresholds. Animat modelling focussed on migrating and foraging pygmy blue whales in Biologically Important Areas (BIAs) in the vicinity of the seismic surveys. Using the distribution of ranges of animats exposed above threshold, the 95th percentile range was computed for comparison with previous range to threshold estimates.

The total number of animats exposed above threshold criteria were scaled to adjust for the local real-world pygmy blue whale density relative to the seeded density, assuming a population growth of 4.3% per year. Additional scaling was done to correct for the proportion of the total simulation area that intersected with the relevant BIA, and also to correct for excluded simulation areas in the cases where the BIA and survey areas did not intersect.

The BIA for foraging pygmy blue whales did not directly intersect any of the acquisition areas for any of the five surveys, and was only within the maximum range of propagation modelling for the surveys in Area C (Laverda, Cimatti, and Vincent). In those cases, animats nearer than the closest point of approach to the surveys were excluded from final counts. This resulted in low exposure estimates for foraging pygmy blue whales for all of the Area C surveys.

The results of the animat analysis predicted that the number of individual pygmy blue whales potentially exposed to sound levels above the NMFS (2018) permanent threshold shift (PTS) criteria was very low for migrating pygmy blue whales (0.08–0.09), and occurred within 95th percentile ranges of 0.7–2.14 km. No PTS exposures were predicted for foraging whales. Exposures above NMFS (2018) temporary threshold shift (TTS) criteria were predicted to occur for both migratory and foraging whales, with the 95th percentile ranges greatest for the Laverda survey. For this survey (Laverda), a maximum of 5.49 and 0.64 individual exposures to migratory and foraging whales respectively were predicted. Exposures above the NMFS (2014) behavioural threshold are expected to occur for migratory whales for all surveys, with number of individual exposures ranging from 1.97–3.23. The three Area C surveys are not predicted to result in exposures exceeding the behavioural threshold in foraging pygmy blue whales.

The estimated 95th percentile ranges for all scenarios were lower than comparable ranges to threshold reported in McPherson et al. (2019). This was expected since previous modelling efforts did not incorporate both moving sources and moving receivers, but rather assumed that, as per the NMFS (2018) criteria, SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours considering that an animal is consistently exposed to such noise levels at a fixed position.

1. Introduction

JASCO Applied Sciences (JASCO) performed an acoustic exposure analysis study for pygmy blue whales (*Balaenoptera musculus brevicauda*) for five of the six planned 4-D Marine Seismic Surveys (MSS) within two Survey Areas (A and C) for the Woodside 4-D North-West-Shelf seismic campaign (Figure 1 and Table 1).

This report describes the modelled predictions of sound levels that individual pygmy blue whales may receive during operations of these surveys. Sound exposure distribution estimates are determined by moving large numbers of simulated animals (animats) through a modelled time-evolving sound field, computed using specialised sound source and sound propagation models. This approach provides the most realistic prediction of the maximum expected root-mean-square sound pressure level (SPL, L_p) and peak pressure level (PK, L_{pk}), and the temporal accumulation of sound exposure level (SEL, L_E) that are now considered the most relevant sound metrics for impact assessment. The most recent science in the peer-reviewed literature regarding sound propagation and animal movement modelling was used.

Sound level exposure estimates were calculated by comparing pre-determined exposure threshold criteria with computed sound fields generated by the sound source associated with the seismic operation, which were then sampled using computational models of animal movement. A detailed sound modelling study has been conducted for each individual survey within the two survey areas (McPherson et al. 2019); the results have been used in this acoustic exposure analysis.

Table 1. Surveys within the Woodside 4-D North-West-Shelf seismic campaign considered for animat modelling.

Survey area	Survey name	Survey period
A	Pluto 4-D	November to February (spring/summer)
	Harmony 4-D	
C	Laverda 4-D	January to May (summer/autumn)
	Cimatti 4-D	
	Vincent 4-D	

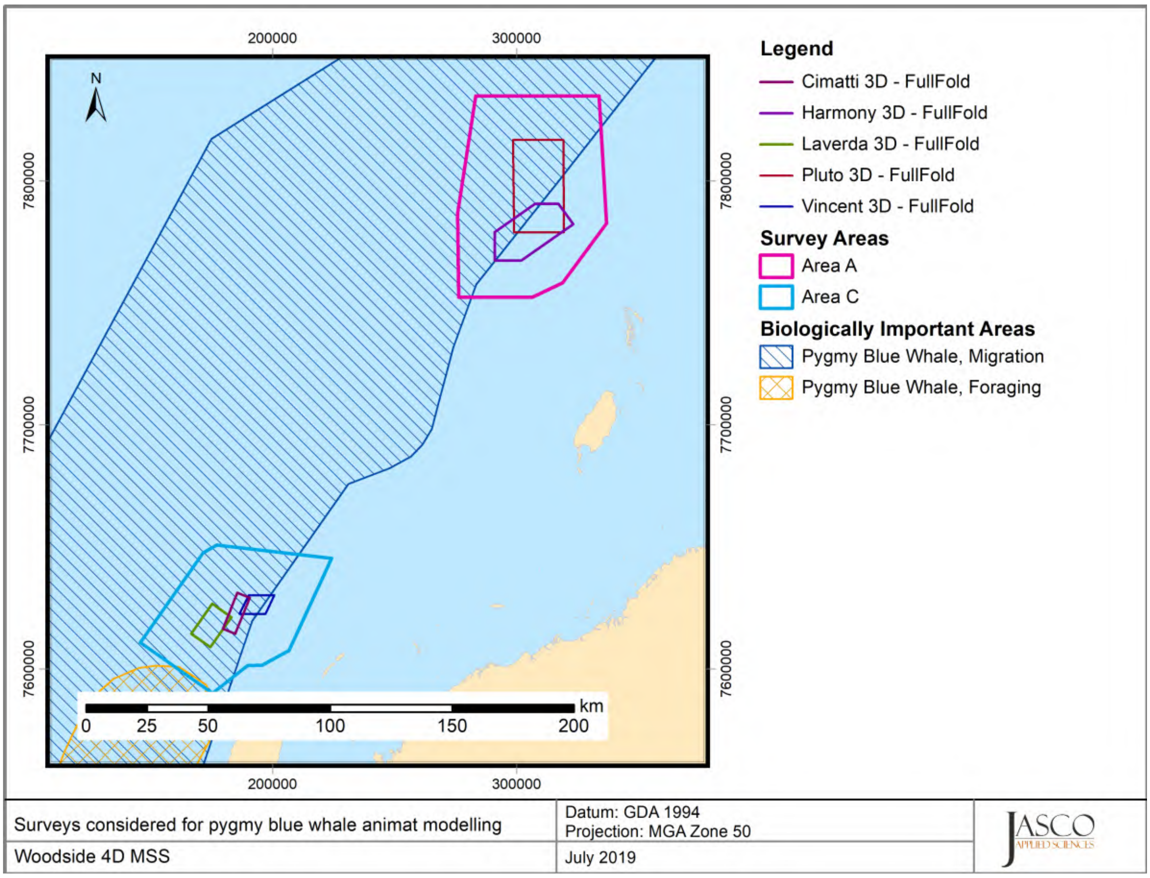

Figure 1. Overview of the features for the pygmy blue whale exposure modelling for the Woodside 4-D seismic campaign.

2. Modelling Scenarios for Exposure Modelling

For the five planned 4-D MSSs within the two considered Survey Areas, source and propagation modelling were conducted to generate 3D sound fields which are used in conjunction with animal movement modelling (McPherson et al. 2019). Exposure modelling scenarios considered a total of seven days of survey track lines for each survey to obtain statistically robust exposure estimates. The animal movement modelling simulation area was designed to extend to approximately 50 km beyond propagation modelling extents to allow for simulated animals to leave and enter the ensonified area. Each of the survey areas and individual fullfold acquisition areas are shown in Figure 2 and Figure 3, along with the animat seeding regions for Area A and Area C.

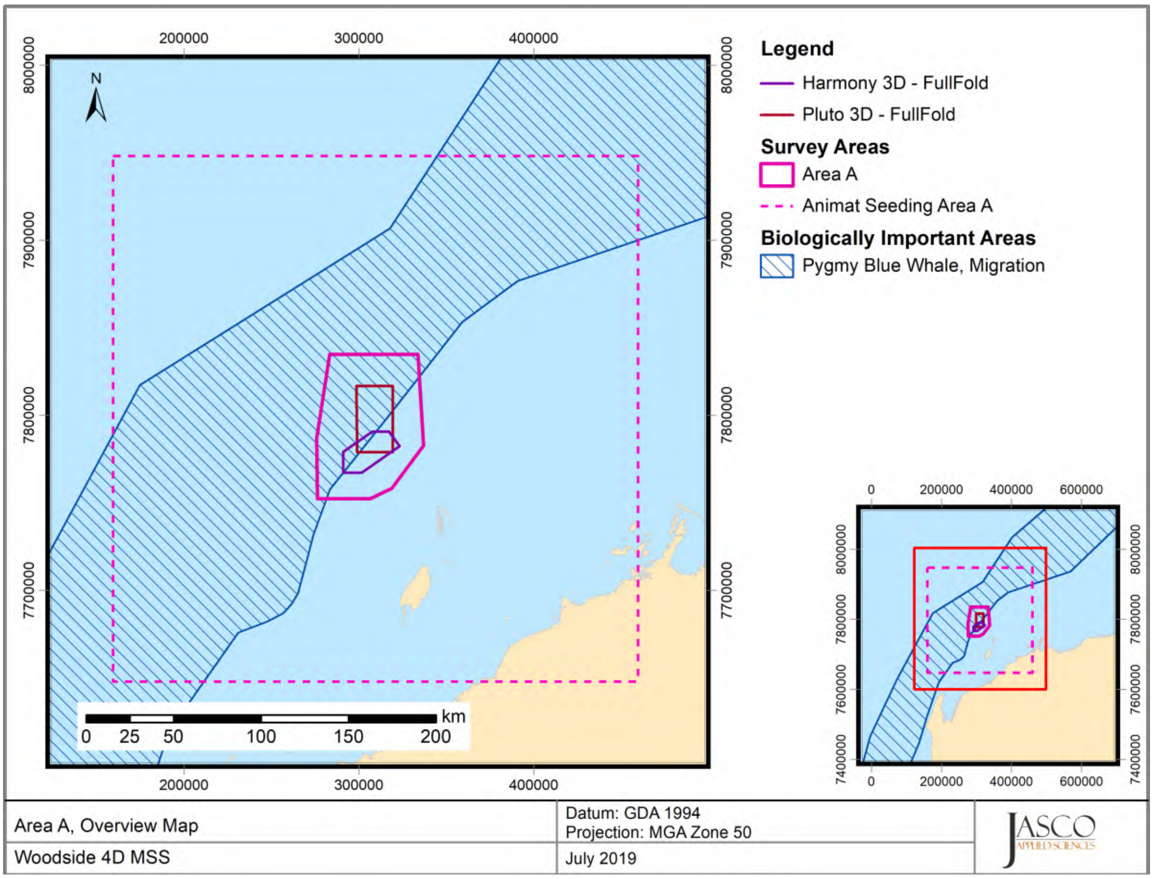

Figure 2 *Area A*: Animat modelling extent and survey fullfold areas.

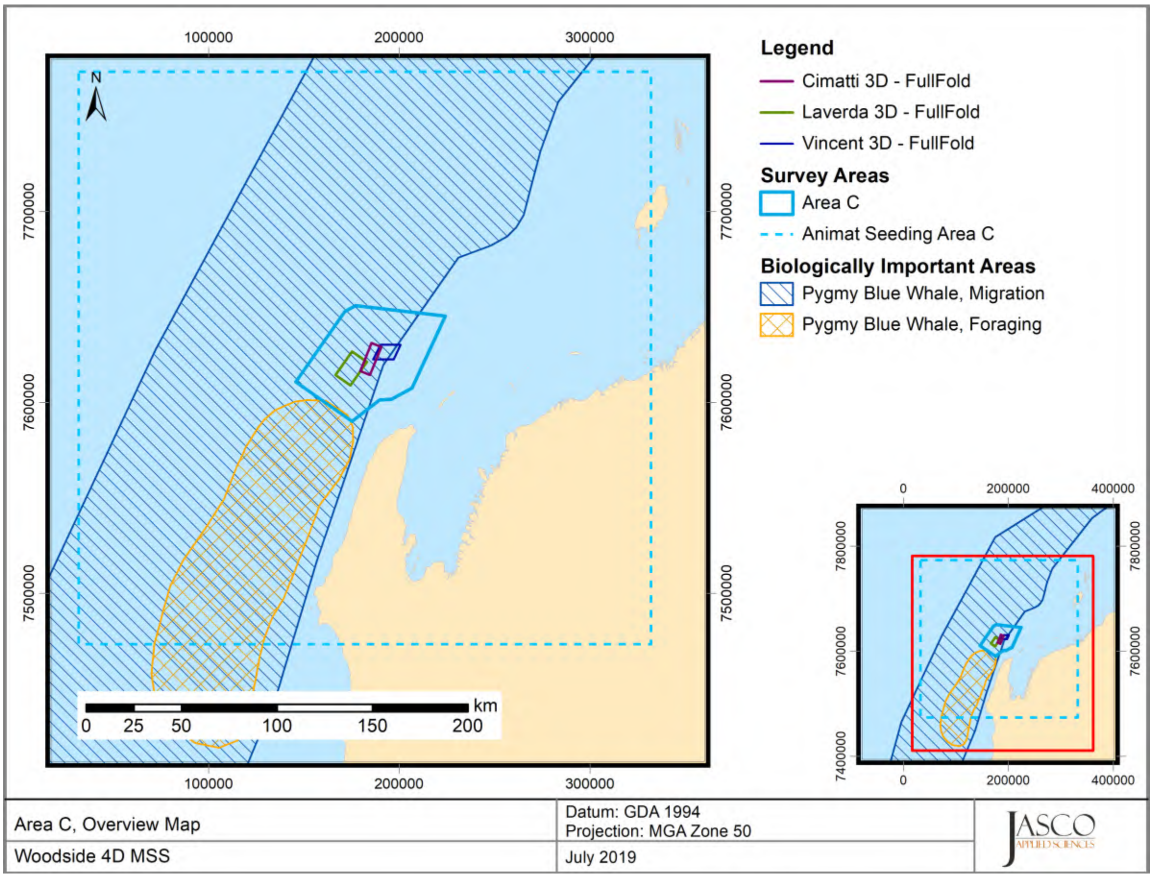

Figure 3 *Area C*: Animat modelling extent and survey fullfold areas.

Table 2 provides the locations of all modelling sites and modelling lines. The acquisition lines for each exposure scenario for each survey are shown in Figures 4 – 8 along with the survey boundaries. Because the Pluto and Harmony 4-D MSS operational areas overlap, Sites 1 and 3 were used for both surveys, accounting for the different tow directions for each survey (Table 2, Figures 4 and 5).

The modelling assumed that the seismic vessel will sail along the survey lines at ~4.5 knots, with an impulse interval of either 12.5 or 18.75 m depending on the survey. The survey details of each exposure scenario are detailed in Table 3. The exposure scenarios were designed considering acquisition lines from previous 3-D or 4-D surveys.

Table 2. Location details for the standalone single impulse sites.

Survey area	Survey/SEL24h scenario	Site	Location		MGA (GDA94), Zone 50		Water depth (m)	Tow directions (°)
			Latitude (S)	Longitude (E)	*X* (m)	*Y* (m)		
A	Pluto	1	20° 03' 28.803"	115° 14' 48.366"	316648.0	7781138	100	0 and 180
		2	20° 01' 12.835"	115° 14' 49.858"	316647.5	7785319	125	0 and 180
		3	19° 58' 23.066"	115° 14' 51.754"	316648.0	7790540	154	0 and 180
		4	19° 53' 28.478"	115° 14' 54.970"	316647.1	7799600	226	0 and 180
		5	19° 48' 46.866"	115° 14' 58.066"	316647.3	7808260	328	0 and 180
		6	19° 45' 52.523"	115° 14' 59.981"	316647.6	7813622	593	0 and 180
		7	19° 44' 14.457"	115° 11' 55.600"	311248.0	7816581	959	0 and 180
		8	19° 48' 27.754"	115° 11' 52.732"	311247.4	7808791	573	0 and 180
		9	19° 53' 13.914"	115° 11' 49.489"	311247.1	7799991	326	0 and 180
		10	19° 59' 17.906"	115° 11' 45.360"	311247.2	7788797	177	0 and 180
		11	20° 05' 26.472"	115° 11' 41.173"	311247.9	7777462	121	0 and 180
		12	20° 04' 26.392"	115° 16' 12.381"	319107.6	7779393	76	0 and 180
	Harmony	1	20° 03' 28.803"	115° 14' 48.366"	316648.0	7781138	100	56 and 235
		3	19° 58' 23.066"	115° 14' 51.754"	316648.0	7790540	154	56 and 235
		13	20° 06' 26.920"	115° 02' 01.393"	294425.8	7775412	257	56 and 235
		14	20° 12' 03.476"	115° 01' 12.961"	293142.1	7765045	159	56 and 235
C	Laverda	16	21° 30' 43.518"	113° 52' 04.642"	175494.6	7617922	788	36 and 215
		17	21° 33' 27.010"	113° 46' 14.540"	165515.2	7612684	903	36 and 215
		18	21° 36' 28.030"	113° 50' 40.310"	173280.6	7607269	769	36 and 215
	Cimatti	19	21° 28' 06.488"	113° 57' 23.154"	184573.7	7622936	615	23 and 203
		20	21° 33' 37.780"	113° 56' 46.620"	183720.7	7612720	505	23 and 203
	Vincent	21	21° 27' 44.083"	114° 05' 47.480"	199088.9	7623902	283	91 and 271
		22	21° 27' 37.263"	113° 59' 05.174"	187495.3	7623892	535	91 and 271
		23	21° 28' 27.670"	114° 05' 18.630"	198282.8	7622545	275	91 and 271

Table 3. Details for each exposure Scenario for each survey.

Survey area	Survey name	Array size (in³)	Source configuration	Impulse interval (m)	Number of survey lines	Average time per line (h)	Number of impulses
A	Pluto 4-D	3150	Dual	18.75	25	5.0	115038
	Harmony 4-D				27	3.9	94422
C	Laverda 4-D	2650		12.5	51	2.1	146071
	Cimatti 4-D	3150			37	2.2	91696
	Vincent 4-D				30	1.4	95552

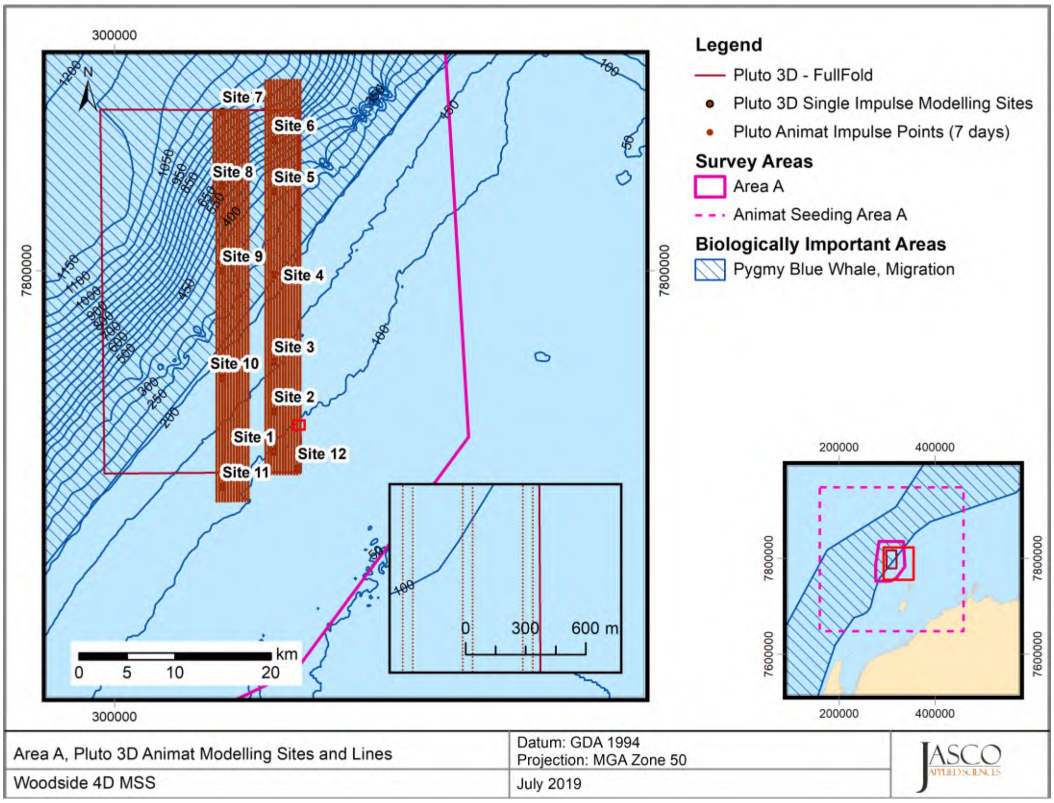

Figure 4. *Area A, Pluto 4-D Survey*: Representative acquisition lines considered for animat calculations.

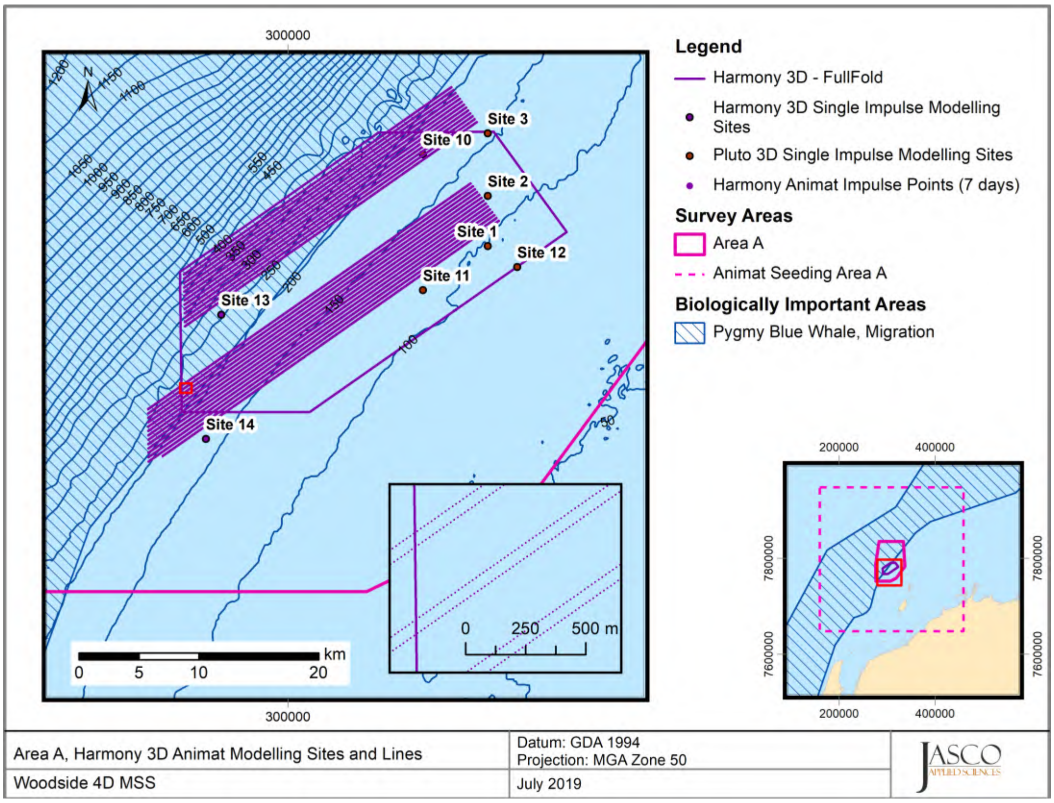

Figure 5. *Area A, Harmony 4-D Survey*: Representative acquisition lines considered for animat calculations.

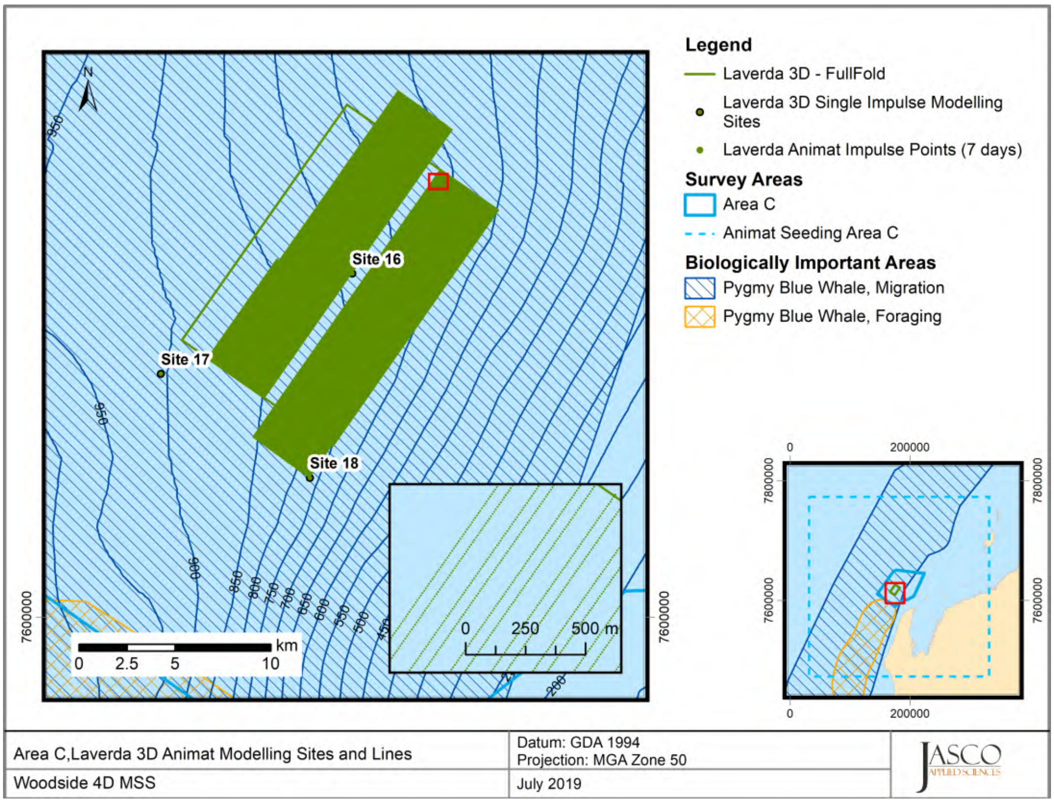

Figure 6. *Area C, Laverda 4-D Survey*: Representative acquisition lines considered for animat calculations.

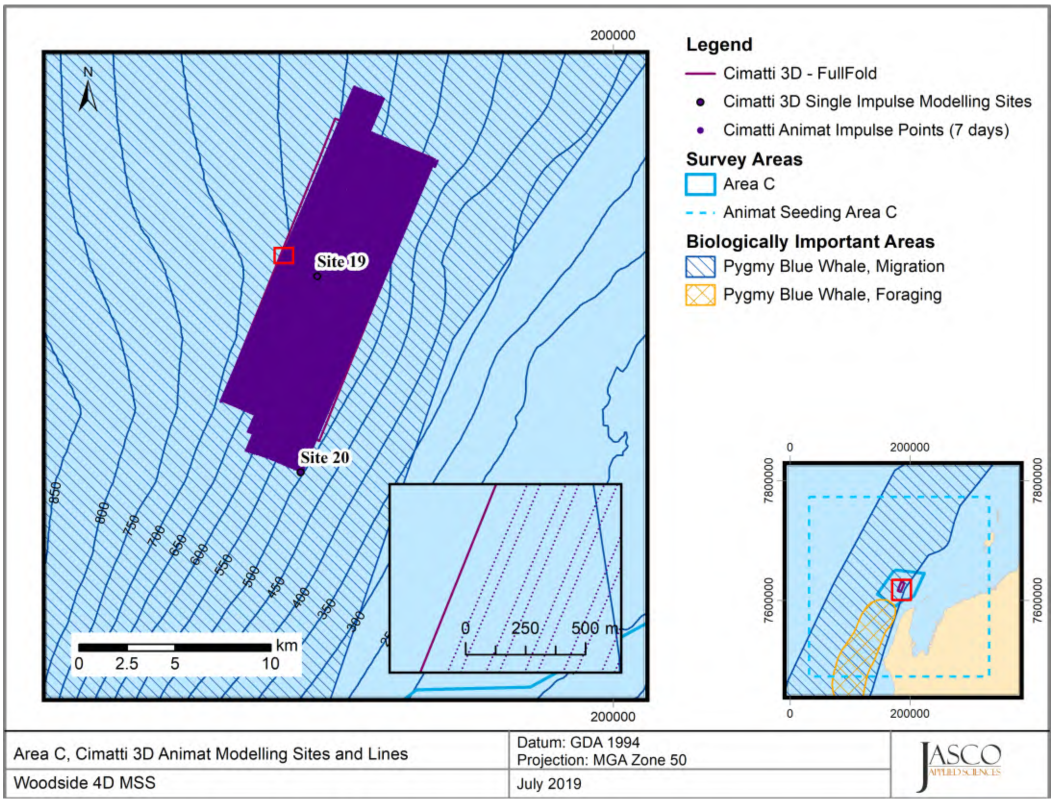

Figure 7. *Area C, Cimatti 4-D Survey*: Representative acquisition lines considered for animat calculations.

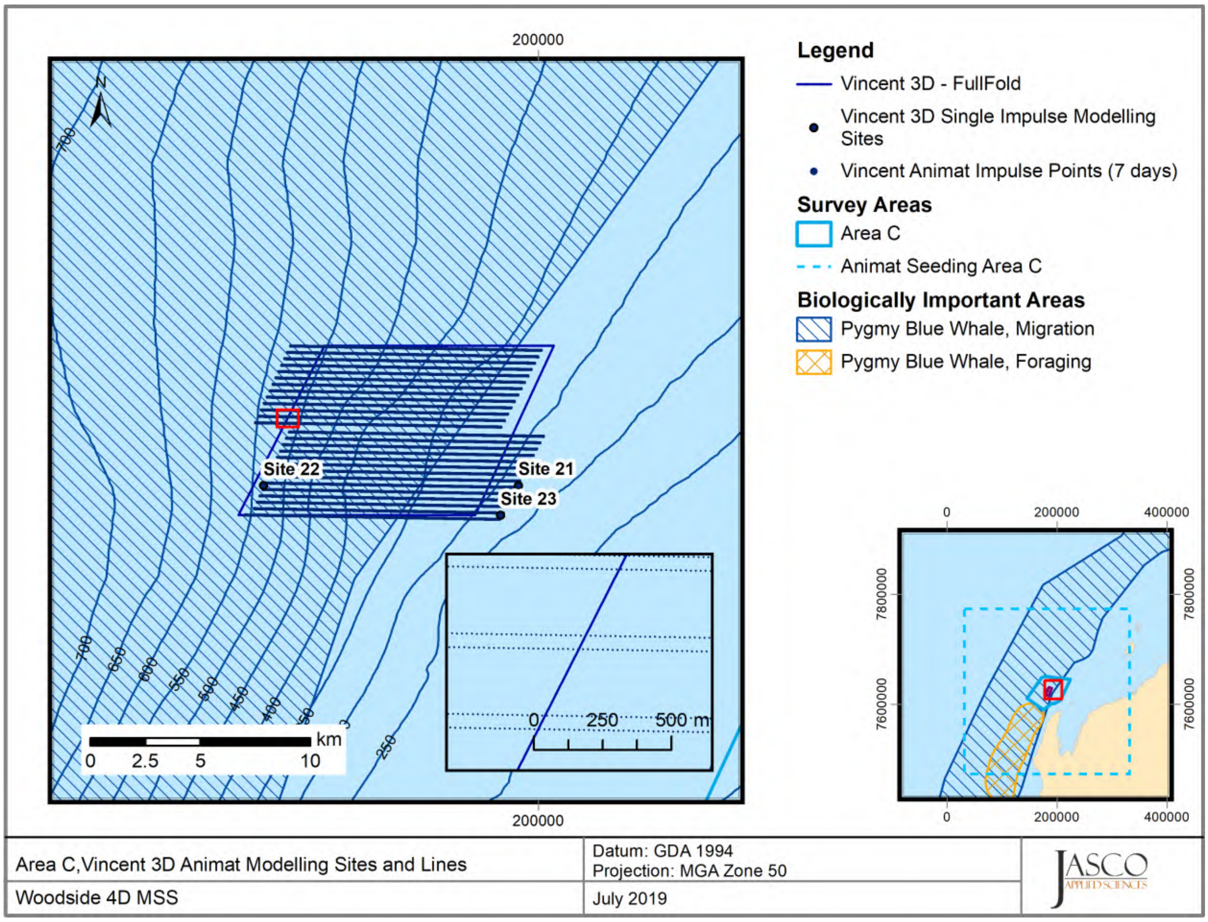

Figure 8. *Area C, Vincent 4-D Survey*: Representative acquisition lines considered for animat calculations.

3. Noise Effect Criteria

The noise effect criteria which were considered for pygmy blue whales in the acoustic modelling (McPherson et al. 2019) are summarised in this section to provide context for exposure modelling results.

The sound level metrics of PK, SPL, and SEL, were considered, and the acoustic metrics in this report reflect the updated ISO standard for acoustic terminology, ISO/DIS 18405.2:2017 (2017), more detail is provided in Appendix A.

The noise criteria considered are those suggested by the best available science:

1. Peak pressure levels (PK; L_{pk}) and frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from the U.S. National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for the onset of Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) in marine mammals (Table 4).
2. Marine mammal behavioural threshold based on the current interim U.S. National Marine Fisheries Service (NMFS) (2014) of 160 dB re 1 µPa SPL (L_p) for impulsive sound sources (Table 4).

Table 4. Unweighted SPL, SEL_{24h}, and PK thresholds for acoustic effects on marine mammals.

Hearing group	NMFS (2014)	NMFS (2018)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213
Mid-frequency cetaceans		185	230	170	224
High-frequency cetaceans		155	202	140	196

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_p denotes sound pressure level period and has a reference value of 1 µPa.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa²s.
Subscripts indicate the designated marine mammal auditory weighting.

4. Methods

4.1. Acoustic Modelling

A summary of the acoustic modelling presented in McPherson et al. (2019) is included to provide context for the acoustic exposure assessment.

4.1.1. Acoustic Source Model

The pressure signatures of the individual airguns and the composite 1/3-octave-band point-source equivalent directional levels (i.e., source levels) of two seismic sources (3150 and 2650 in^3) were modelled with JASCO's Airgun Array Source Model (AASM).

AASM considers:

- Array layout.
- Volume, tow depth, and firing pressure of each airgun.
- Interactions between different airguns in the array.

The array was modelled over AASM's full frequency range, up to 25 kHz.

4.1.2. Sound Propagation Models

Two sound propagation models were used to predict the acoustic field around the seismic source:

- Combined range-dependent parabolic equation and Gaussian beam acoustic ray-trace model (MONM-BELLHOP, 10 Hz to 25 kHz).
- Full Waveform Range-dependent Acoustic Model (FWRAM, 5 Hz to 1000 Hz).

The models were used in combination to characterise the acoustic fields in terms of SEL, SPL, PK, and PK-PK. MONM-BELLHOP was used to calculate 3D SEL fields as a function of range and depth relative to the source. The 3D SPL fields were computed by applying an SEL to SPL conversion factor to the SEL sound fields. The conversion factor was obtained using FWRAM, which is substantially more computationally expensive than MONM-BELLHOP, but retains the full phase and amplitude information needed to estimate SPL or PK. Since ranges to relevant PTS and TTS PK thresholds were found to be ≤ 60 m and therefore well within the acoustic near-field of the seismic arrays, acoustic sound fields were not generated for this metric at full azimuthal resolution.

4.1.3. Parameter Overview

The specifications of the seismic sources and the environmental parameters used in the propagation models are described in detail in The following seismic sources were considered:

- A 3150 in^3 seismic source array consisting of two strings towed at a 6 m depth, with a nominal firing pressure of 2000 psi (Pluto, Harmony, Cimatti, and Vincent surveys).
- A 2650 in^3 seismic source array consisting of two strings towed at a 5 m depth, with a nominal firing pressure of 2000 psi (Laverda survey).

Two sound speed profiles were considered in the modelling with the surveys grouped by geographical location, Survey Area A, and C. The profiles were extracted based on the seasonal period that would provide the greatest propagation during the proposed timeframe of the survey. Geological profiles consistent with associated water depths were also used.

4.2. Animal Movement and Exposure Modelling

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the exposure of animats (virtual marine mammals) to sound arising from the seismic surveys. Sound exposure models like JASMINE integrate the predicted sound field with biologically meaningful movement rules for each marine mammal species (here: pygmy blue whales) that result in an exposure history for each animat in the model. Inside JASMINE, the sound source, which can be stationary or moving (Figure 9), mimics the proposed seismic survey patterns. As shown in Figure 9, animats are programmed to behave like the marine animals that may be present in the area. The parameters used for forecasting realistic behaviours (e.g., diving, foraging, aversion, surface times) are determined and interpreted from marine mammal studies (e.g., tagging studies) where available, or reasonably extrapolated from related species. An individual animat's sound exposure levels are summed over a specified duration, such as 24 hours or the entire simulation, to determine its total received energy, and then compared to the threshold criteria (for detailed information on JASMINE see Appendix B).

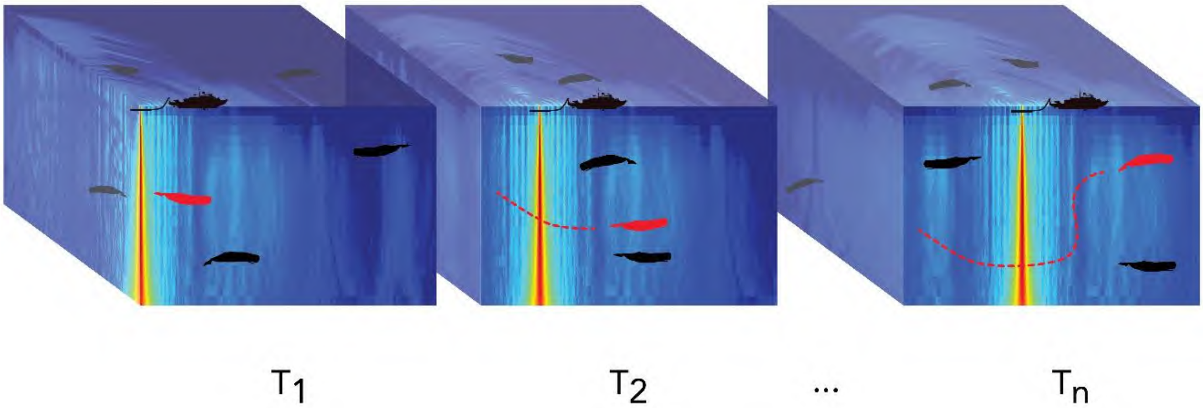

Figure 9. Cartoon of animats in a moving sound field. Example animat (red) shown moving with each time step (T_x). The acoustic exposure of each animat is determined by where it is in the sound field, and its exposure history is accumulated as the simulation steps through time.

4.2.1. Methodology

The exposure criteria for impulsive sounds (described in Section 3) were used to determine the number of animats exceeding thresholds. Model simulations were run with animat densities of 0.5 animats/km^2. To evaluate potential injury (PTS), TTS, and behavioural disturbance, exposure results were obtained for each survey using detailed behavioural information for pygmy blue whales described in Section 4.2.2 and summarised in Appendix B. Simulations were run for a representative period of 7 days, then scaled down to 24 h for easier comparison with previously modelled results (McPherson et al. 2019).

Pygmy blue whales are found in specific biologically important areas (BIAs) depending on behavioural mode (e.g. migrating or foraging). Figures 2 and 3 show the Department of Environment and Energy (DEE) BIAs for migrating and foraging pygmy blue whales in relation to each of the five seismic surveys. This map also shows the extents of the animat simulation area. For the final calculations, BIA areas are clipped to the extents of the simulation. To account for the difference between the animat simulation area and the BIAs, the final exposure estimates are scaled by the ratio of the clipped BIA area relative to the simulation area.

In some cases, the survey track lines do not intersect the BIAs. Without adjustment, this would result in animats occurring at much closer ranges than would be expected based on the BIA extents. To correct for this, animats exposed at ranges less than the closest point of approach *r* between the survey and the BIA were not included in the final count. This effectively reduces the animat simulation area by an area including a buffer of width r around the seismic survey. Therefore, the final area-based scaling S_A is

$$S_A = \frac{BIA_{clipped}}{(A_{full} - A_{buffer})}, \quad (1)$$

where $BIA_{clipped}$ is the BIA clipped to the full animat simulation area A_{full}, and A_{buffer} is the seismic survey area plus a buffer of width *r*. A summary of the BIA areas and the various inputs to exposure scaling for each of the animat modelling scenarios can be found in Table 5.

The total number of animats exposed above behavioural and auditory impact threshold criteria were scaled using the seeded density D_S and the real-world density D_R, where available. The scaling factor S_D is therefore

$$S_D = \frac{D_R}{D_S}, \quad (2)$$

The distribution of ranges of exposed animats was used to estimate the 95th percentile ranges at which the animats were exposed above threshold. Within the 95th percentile range, there are generally some proportion of animats that did not exceed threshold criteria.

Since the PK sound fields showed that TTS and PTS PK ranges to thresholds were small (<60m), animat exposures for those criteria were estimated by counting the number of animats within threshold ranges estimated from propagation modelling, rather than counting exposures above threshold using full 3D sound fields (see Section 4.1.2 for more details). For this reason, estimates of 95th percentile ranges were not calculated.

Table 5. Exposure modelling scenarios and associated areas of interest for the simulation.

Animat Scenario	Location	A_{full} (km^2)	R_{min} (km)	A_{buffer} (km^2)	Adjusted A_{full} (km^2)	$BIA_{clipped}$ (km^2)	Area-based scaling, S_A
Pygmy blue whale foraging	Cimatti	90000.0	21.4	2574.5	87425.5	6964.2	0.08
	Laverda	90000.0	11.8	1172.6	88827.4	6964.2	0.08
	Vincent	90000.0	31.7	4563.2	85436.8	6964.2	0.08
Pygmy blue whale migrating	Cimatti	90000.0	0.0	0.0	90000.0	39848.0	0.44
	Laverda	90000.0	0.0	0.0	90000.0	39848.0	0.44
	Vincent	90000.0	0.0	0.0	90000.0	39848.0	0.44
	Pluto	90000.0	0.0	0.0	90000.0	36650.0	0.41
	Harmony	90000.0	0.0	0.0	90000.0	36650.0	0.41

4.2.2. Animal behaviour

Two behavioural profiles were considered for pygmy blue whales, foraging and migration. The research summarised in this section was used to inform the species behavioural definition (Appendix B-3). Detailed, fine-scale diving behaviour of a migrating pygmy blue whale was derived from Owen et al. (2016) who equipped an individual with a multi-sensor tag off the west coast of Australia. The study identified areas of high residence using the horizontal movement data; the analysis of the dive data showed that the depth of migratory dives was highly consistent over time and unrelated to local bathymetry. Blue whales (*Balaenoptera musculus*) are known to primarily migrate and feed in the first few hundred metres of the water column (Croll et al. 2001, Goldbogen et al. 2011), with the deepest dive being reported from a pygmy blue whale being 506 m (Owen et al. 2016). Dives were identified as migratory, feeding, or exploratory behaviour. The mean depth of migratory dives (82% of all dives) was 14 m ± 4 m, and the whale spent 94% of observed time and completed 99% of observed migratory dives at water depths of less than 24 m. A total of 21 feeding dives were identified during the duration of the tag deployment (one week) with a mean maximum depth of 129 ± 183 m (range 13–505 m). The mean maximum depth of exploratory dives (107 ± 81 m, range 23–320 m) was similar to the mean maximum depth of feeding dives (129 m) and did not appear to be related to seafloor depth.

The behaviour of pygmy blue whales was modelled without migration bias, i.e. the animats were resident in the animat modelling area over the entire modelling period. In reality, pygmy blue whales can be expected to transit through the area in less than half a day (based on McCauley and Jenner 2010); accordingly, the approach used is conservative as it results in higher exposure levels and higher number of animals exposed to levels exceeding the criteria thresholds.

The two migratory behaviours (migratory dives and exploratory dives) were modelled at an even probability of occurrence (i.e. probability for transitioning from one behaviour to another was 0.5 for both) while dive data published by Owen et al. (2016) suggest a higher likelihood for migratory dives to occur. This approach was chosen in the absence of quantitative information on the true proportion between the two dive behaviours.

4.2.3. Density estimates

The entire region off the northwestern coast of Australia is a poorly studied with regard to the abundance and distribution of pygmy blue whales. As described in McCauley et al. (2018), there are two estimates for the Eastern Indian Ocean pygmy blue whale population size along the coastline of Western Australia (WA), the first calculated in 2004 by McCauley and Jenner (2010) at 662–1559 southbound animals, using passive acoustics, and the second calculated over 2002–2006 by Jenner et al. (2008) of 712–1754. Neither of these estimates account for whales further west in the Indian Ocean, and there is evidence that along the WA coast north of latitude ~ 19° S that the migratory pathway spreads out (Gavrilov et al. 2018), with not all animals following the Australian coastline; therefore it is unknown what proportion of the Eastern Indian Ocean pygmy blue whale population either follow the coast or travel further west (McCauley et al. 2018).

However, while near the coast, the observations in McCauley and Jenner (2010) suggested most pygmy blue whales pass along the shelf edge out to water depths of 1000 m but centred near the 500 m depth contour. The boundaries of the DoEE pygmy blue whale migration BIA are designed to reflect this general migratory pattern. The areas considered in this simulation were greater than the acoustic modelling region to provide a buffer zone around the sound fields to account for the possibility of animats moving into and out of the modelled sound fields.

McCauley et al. (2018) provides an estimate for the annual growth rate of pygmy blue whales at Portland (Victoria) of 4.3% per year. However, as pointed out by the authors, this growth rate applies only to the proportion of the population using the south eastern Australian coast, and as such may not reflect the growth rate of the full population. However, in the absence of other population growth estimates, this estimate has been applied as a conservative estimate to the proportion of the population also using the WA coast, in particular the migratory BIA.

Considering an annual growth rate of 4.3%, the two population estimates provided in McCauley and Jenner (2010) and Jenner et al. (2008) have been considered to determine the potential current population, and thus the possible percentage increase since the estimate was derived, as shown in Table 6.

Table 6. Population growth estimates based on 4.3% per annum.

Source	Year	Minimum estimate	Maximum estimate	Percentage increase
Based on McCauley and Jenner (2010)	2004, Estimated	662	1559	
	2019, Extrapolated	1245	2932	188%
Based on Jenner et al. (2008)	2002-2006, Estimate	712	1724	
	2019, Extrapolated	1231	2980	173%

The acoustic detection data published by McCauley and Jenner (2010) revealed a maximum of three pygmy blue whales on a single day passing through the area during their southward migration (November to late December). McCauley and Jenner (2010) estimated the listening range of this noise logger to be 120 km, which is assumed to be a radius, however, to apply precaution in this assessment the recorder listening area was conservatively calculated using a 60 km radius. Based on an average swimming speed for the southbound pygmy blue whales of five knots (9.26 km/hr), McCauley and Jenner (2010) calculated a transit time through the area of 0.54 days; therefore, the number of animals detected per day equates to an estimated density for vocalising animals in the area of 0.0031207 animals per km^2 for their study. As not all animals are emitting calls during their migration, this density estimate has to be corrected for the percentage of animals calling (‘calling rate’). McCauley and Jenner (2010) proposed that 8.5–20% of the animals present in an area could be vocalising, considering information relating to humpback whales (8.5%, Cato et al. (2001)), and pygmy blue whales (<20%, (McCauley et al. 2001), to take a precautionary approach this study has adopted the lower bound (8.5%), with the resulting density shown in Table 7, which has been used in this assessment. If the vocalisation rate of pygmy blue whales in the Perth Canyon is applied, the resulting density of vocalising animals would be 2.35 times greater, and thus the correction factor for calling animals would be only 5, rather than 11.76.

The maximum number of three pygmy blue whales per day occurred in associated with the population estimate of 662–1559 whales presented in McCauley and Jenner (2010). If the population increases, it is estimated that the number of whales present on any one day would also increase proportionally. Therefore, the population increase estimate of 4.3% per year, and a corresponding Scaling Factor of 188% (Table 6), has been applied in this study, as shown in Table 7. This results in a revised estimate of the maximum number of animals which could be detected within the listening area per day being 5.64, and a real-world density of 0.0690392 animals per km^2.

While the Seeded Density (D_S) for the simulation is only 0.5 animats per km^2, the simulation considers a mobile source active over a representative period of 7 days, scaled down to 24 h, while the whales exhibit no migration bias Therefore, the number of animats potentially exposed is significantly higher than the real world density, but complex to quantify due to the movement of the source and time period scaling.

Table 7. Density calculations

Variable / Factor	Estimate using data from McCauley and Jenner (2010)	Estimate considering 4.3% population growth since 2004
Number of animals in listening area (animals detected per day in listening area)	3	5.64
Recorder listening area (km^2) (McCauley and Jenner 2010)	11309.73	
Density of Vocalising Animals (animals/km^2)	0.0031207	0.0058683
Calling rate based on humpbacks (8.5% of animals present vocalise)	8.5%	
Correction factor for calling animals	11.76	
Real World Density of animals (D_R) (animals/km^2)	0.03671	0.0690392
Seeded Density (D_S) (animats/km^2)	0.5	
Scaling Factor (S_D)	0.0024476	0.0046026
Increase in Scaling Factor considering population growth		188%

5. Results

Summaries of the animat modelling results for migrating and foraging pygmy blue whales, for each of the five seismic survey areas, are provided in Tables 8 and 9.

Table 8. *Area A*: Summary of animat simulation results for migratory pygmy blue whales. The 95th percentile exposure ranges (km), and the number of real-world individuals exposed above threshold (using the estimated densities) are provided. Estimates related to PTS and TTS criteria (NMFS 2018) and behaviour (NMFS 2014) are normalised to 24h from the 7 days of operation simulated to aid comparison to acoustic modelling results. For comparison, maximum distances to threshold from previously completed acoustic modelling are provided.

Threshold		**Maximum distance (km) to threshold from acoustic modelling**	**Migrating Pygmy Blue Whales**	
Threshold description	Sound Level (dB)		Range, P_{95} (km)	Number of individuals
Pluto 4-D MSS				
TTS, PK	213†	0.06	-	0.06
TTS, SEL_{24h}	168‡	59.7	4.95	2.84
PTS, PK	219†	0.03	-	0.04
PTS, SEL_{24h}	183‡	0.86	0.09	0.09
Behavioural response	160#	8.5	4.89	3.23
Harmony 4-D MSS				
TTS, PK	213†	0.05	-	0.06
TTS, SEL_{24h}	168‡	38.8	4.18	1.99
PTS, PK	219†	0.03	-	0.04
PTS, SEL_{24h}	183‡	1.10	0.09	0.08
Behavioural response	160#	6.3	4.17	2.41

† PK (L_{pk}; dB re 1 µPa)
‡ LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)
# SPL (L_p; dB re 1 µPa)
A dash indicates where ranges were not relevant for PK exposures (see Section 4.1.2)

Table 9. *Area C*: Summary of animat simulation results for migratory and foraging pygmy blue whales. The 95th percentile exposure ranges (km), and the number of real-world individuals exposed above threshold (using the estimated densities) are provided. Estimates related to PTS and TTS criteria (NMFS 2018) and behaviour (NMFS 2014) are normalised to 24h from the 7 days of operation simulated to aid comparison to acoustic modelling results. For comparison, maximum distances to threshold from previously completed acoustic modelling are provided.

Threshold		**Maximum distance (km) to threshold from acoustic modelling**	**Migrating Pygmy Blue Whales**		**Foraging Pygmy Blue Whales**	
Threshold description	Sound Level (dB)		Range, P_{95} (km)	Number of individuals	Range, P_{95} (km)	Number of individuals
Laverda 4-D MSS						
TTS, PK	213†	0.06	-	0.06	-	0.00
TTS, SEL_{24h}	168‡	55.3	18.57	5.49	35.49	0.64
PTS, PK	219†	0.03	-	0.04	-	0.00
PTS, SEL_{24h}	183‡	0.70	0.10	0.09	0.00	0.00
Behavioural response	160#	4.2	2.81	1.97	0.00	0.00
Cimatti 4-D MSS						
TTS, PK	213†	0.05	-	0.06	-	0.00
TTS, SEL_{24h}	168‡	47.2	12.40	3.63	29.66	0.08
PTS, PK	219†	0.03	-	0.02	-	0.00
PTS, SEL_{24h}	183‡	2.14	0.09	0.08	0.00	0.00
Behavioural response	160#	6.5	5.19	2.46	0.00	0.00
Vincent 4-D MSS						
TTS, PK	213†	0.05	-	0.06	-	0.00
TTS, SEL_{24h}	168‡	32.4	11.01	3.38	0.00	0.00
PTS, PK	219†	0.03	-	0.04	-	0.00
PTS, SEL_{24h}	183‡	2.07	0.09	0.09	0.00	0.00
Behavioural response	160#	6.2	4.43	2.29	0.00	0.00

† PK (L_{pk}; dB re 1 µPa)
‡ LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)
# SPL (L_p; dB re 1 µPa)
A dash indicates where ranges were not relevant for PK exposures (see Section 4.1.2)

6. Discussion

The estimated sound fields produced by source and propagation models for the five seismic surveys were incorporated into a sound exposure model to estimate the number of animals potentially exposed to levels above the defined thresholds. The range within which 95% of the exposure exceedances occur is also reported.

Animal movement modelling simulation results showed that the number of individuals exposed above PTS or TTS PK or PTS SEL_{24h} thresholds was ≤0.09 for both migrating and foraging pygmy blue whales for all survey scenarios. The number of exposures exceeding TTS SEL_{24h} was slightly higher in all cases, ranging from 0.08–5.49 individuals; The highest number of occurrences was for migrating pygmy blue whales exposed during the Laverda survey with 5.49 individuals above threshold. Foraging pygmy blue whales, which were only exposed to the surveys in Area C, had less exposures above all PTS and TTS thresholds, mainly as a result of the fact that those surveys did not directly intersect the foraging BIA.

For all surveys, there is the potential for behavioural impacts. The number of migrating pygmy blue whale exposures above the 160 dB SPL behavioural threshold ranged from 1.97 for the Laverda survey to 3.23 for the Pluto survey.

All of the estimated 95th percentile ranges computed from the distributions of migrating and foraging pygmy blue whale animats exposed above threshold were lower than the corresponding ranges to threshold estimated from propagation modelling or accumulated SEL_{24h} results presented in McPherson et al. (2019). Previous modelling efforts were inherently more conservative since they did not incorporate the complex interactions of both a moving sound field and moving receivers, but rather assume a static receiver.

While most of the foraging pygmy blue whale 95th percentile ranges were zero, the TTS SEL_{24h} ranges at Laverda and Cimatti were high. These should be interpreted with caution, as the minimum ranges for Cimatti and Laverda were 21.4 km and 11.8 km respectively, which strongly skews the 95th percentile ranges for any of the remaining exposures. In these cases, ranges are not directly comparable with previously modelled ranges to threshold.

Interpretation of the 95th percentile ranges is nuanced and is the result of specific acoustic propagation characteristics as well as the probabilistic nature of the animal movement modelling simulation. As an example, consider a comparison between migrating pygmy blue whale results for the Laverda and Pluto surveys. The maximum range to the TTS, SEL_{24h} threshold estimated using previously reported accumulated SEL_{24h} results was relatively similar for both of these cases: 55.3 km for Laverda and 59.7 km for Pluto. The 95th percentile ranges estimated using animat modelling, however, were quite different from each other: 18.57 km for Laverda and 4.95 km for Pluto. The differences in the distributions of exposures between these two locations is illustrated in Figure 10. Since the average depth of migrating pygmy blue whales is approximately 14 m, these animals are most sensitive to sound levels in the upper tens of meters of the water column. This aligns with findings reported in McPherson et al. (2019) where the TTS ranges to the shallowest depth limit (24m) were substantially larger for the Laverda survey (Figure 11) than for the Pluto survey (Figure 12) (34.6 km and 8.2 km, respectively).

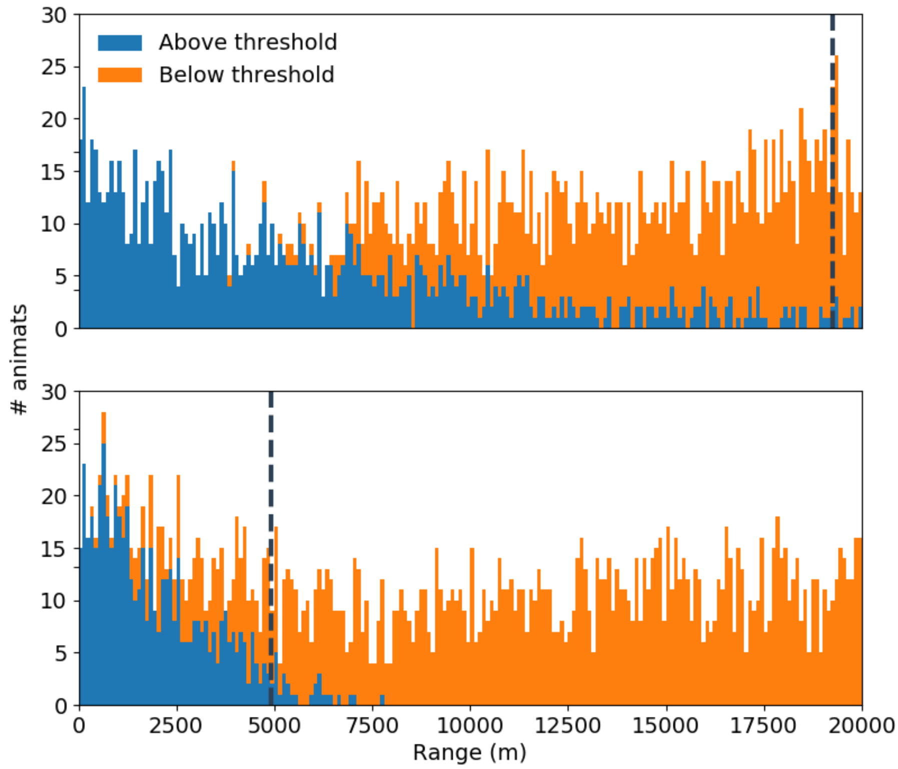

Figure 10. Stacked histograms showing migrating pygmy blue whale exposures for an example 24 h period above and below the TTS SEL_{24h} threshold at Laverda (upper panel) and Pluto (lower panel). The 95th percentile range in each case is denoted by a dashed line.

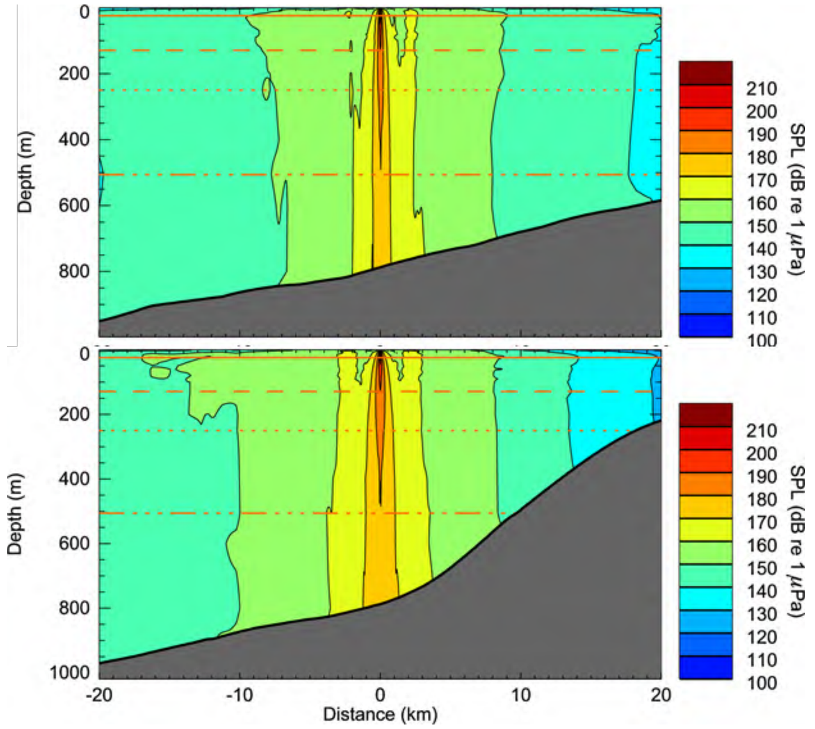

Figure 11. *Site 16, Laverda*: Vertical slice of the predicted SPL for the 2650 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown, Figure 77 in McPherson et al. (2019).

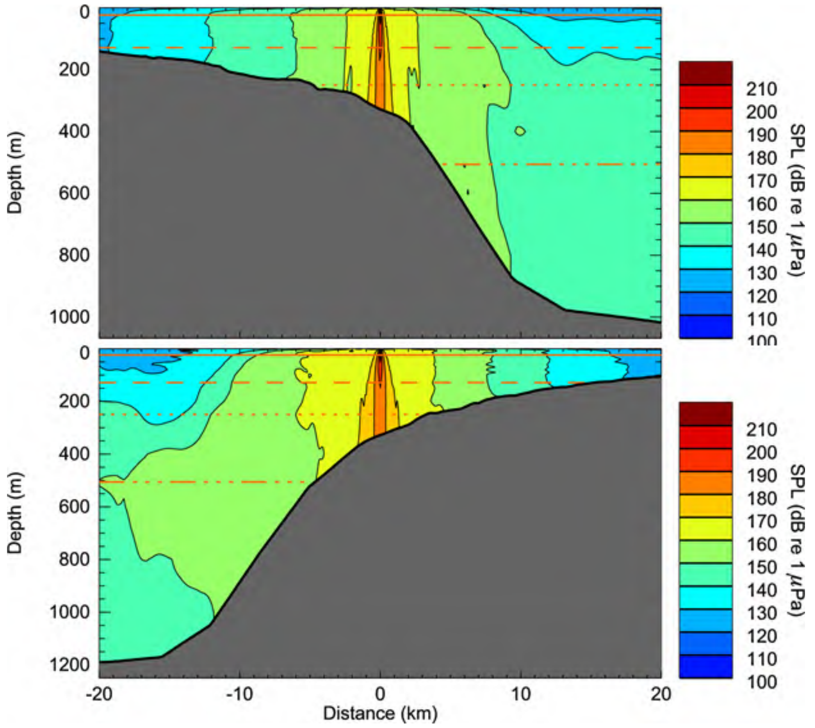

Figure 12. *Site 5, Pluto*: Vertical slice of the predicted SPL for the 3150 in^3 array. Levels are shown along the endfire (top) and broadside (bottom) directions, with the pygmy blue whale (24, 129, and 506 m) and turtle (250 m) depth limits shown, Figure 46 in McPherson et al. (2019).

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Appendix A. Acoustic Metrics

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 µPa. Because the perceived loudness of sound, especially impulsive noise such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life. We provide specific definitions of relevant metrics used in the accompanying report. Where possible we follow the ANSI and ISO standard definitions and symbols for sound metrics, but these standards are not always consistent.

The zero-to-peak sound pressure level (PK; L_{pk}; $L_{p,pk}$; dB re 1 µPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,pk} = 20\log_{10}\left[\frac{\max(|p(t)|)}{p_0}\right] \quad \text{(A-1)}$$

PK is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of a noise event, it is generally a poor indicator of perceived loudness.

The peak-to-peak sound pressure level (PK-PK; $L_{pk\text{-}pk}$; $L_{p,pk\text{-}pk}$; dB re 1 µPa) is the difference between the maximum and minimum instantaneous sound pressure levels in a stated frequency band attained by an impulsive sound, $p(t)$:

$$L_{p,pk-pk} = 10\log_{10}\left\{\frac{[\max(p(t)) - \min(p(t))]^2}{p_0^2}\right\} \quad \text{(A-2)}$$

The sound pressure level (SPL; L_p; dB re 1 µPa) is the rms pressure level in a stated frequency band over a specified time window (T, s) containing the acoustic event of interest. It is important to note that SPL always refers to a rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right) \quad \text{(A-3)}$$

The SPL represents a nominal effective continuous sound over the duration of an acoustic event, such as the emission of one acoustic pulse, a marine mammal vocalization, the passage of a vessel, or over a fixed duration. Because the window length, T, is the divisor, events with similar sound exposure level (SEL) but more spread out in time have a lower SPL. A fixed window length of 0.125 s (critical duration defined by Tougaard et al. (2015)) is used in this study for impulsive sounds.

The sound exposure level (SEL; L_E; $L_{E,p}$; dB re 1 µPa²·s) is a measure related to the acoustic energy contained in one or more acoustic events (N). The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)dt \Big/ T_0 p_0^2\right) \quad \text{(A-4)}$$

where T_0 is a reference time interval of 1 s. The SEL continues to increase with time when non-zero pressure signals are present. It therefore can be construed as a dose-type measurement, so the integration time used must be carefully considered in terms of relevance for impact to the exposed recipients.

SEL can be calculated over periods with multiple acoustic events or over a fixed duration. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the *N* individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right). \quad \text{(A-5)}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of weighted SEL (e.g., $L_{E,LFC,24h}$; Appendix A.3). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should else be specified.

A.2. Marine Mammal Impact Criteria

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury and disturbance. The following sections summarize the recent development of thresholds; however, this field remains an active research topic.

A.2.1. Injury

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.3). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 $\mu Pa^2 \cdot s$. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 $\mu Pa^2 \cdot s$.

As of 2017, an optimal approach is not apparent. There is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes PTS (and TTS) criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018; only the PK criteria defined in NMFS (2018) are applied in this report.

A.3. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

A.3.1. Marine mammal frequency weighting functions

In 2015, a U.S. Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a\left[1+(f/f_{hi})^2\right]^b}\right)\right] \quad \text{(A-6)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2016, NMFS 2018). Table A-1 lists the frequency-weighting parameters for each hearing group; Figure A-1 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018).

Hearing group	a	b	f_{lo} (Hz)	f_{hi} (kHz)	K (dB)
Low-frequency cetaceans (baleen whales)	1.0	2	200	19,000	0.13
Mid-frequency cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
High-frequency cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36

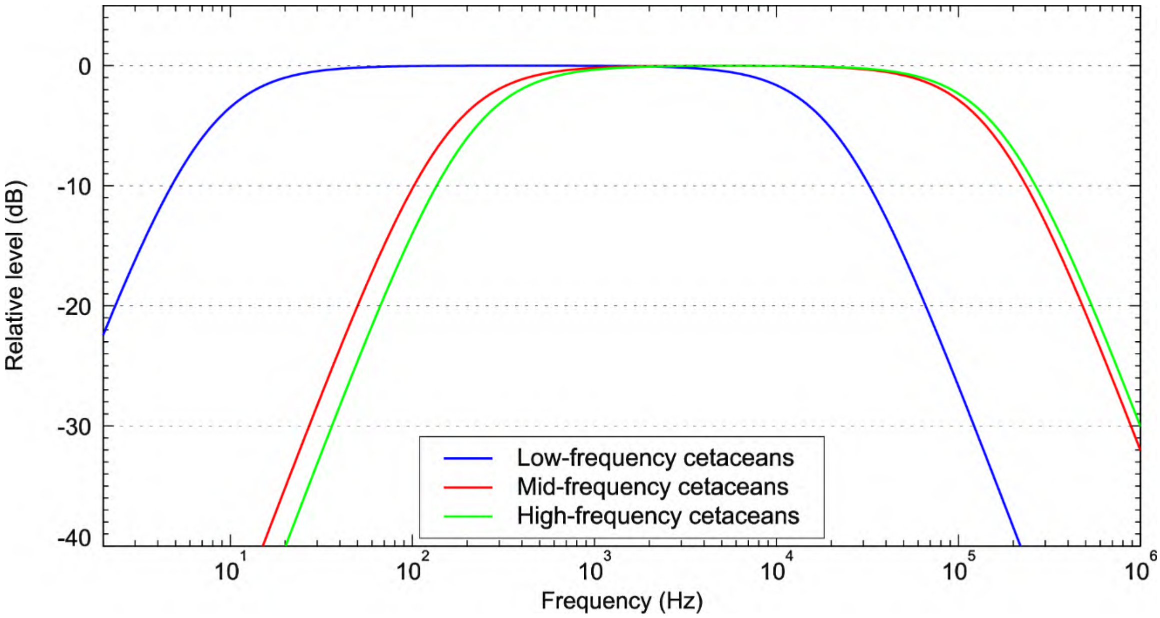

Figure A-1. Auditory weighting functions for functional marine mammal hearing groups used in this project as recommended by NMFS (2018).

Appendix B. Animal Movement and Exposure Modelling

Animal movement and exposure modelling takes into account the movement of both sound sources and animals over time. Acoustic source and propagation modelling are used to generate 3D sound fields that vary as a function of range, depth, and azimuth. Sound sources are modelled at several representative sites and the resulting sound fields are assigned to seismic shot locations using the minimum Euclidean distance. The sound received by an animal at any given time depends on its location relative to the source. Since the true locations of the animals within the sound fields are unknown, realistic animal movements are simulated using repeated random sampling of various behavioural parameters. The Monte Carlo method of simulating many animals within the operations area is used to estimate the sound exposure history of the population of simulated animals (animats).

Monte Carlo methods provide a heuristic approach for determining the probability distribution function (PDF) of complex situations, such as animals moving in a sound field. The probability of an event's occurrence is determined by the frequency with which it occurs in the simulation. The greater the number of random samples, in this case the more simulated animats, the better the approximation of the PDF. Animats are randomly placed, or seeded, within the simulation boundary at a specified density (animats/km^2). Higher densities provide a finer PDF estimate resolution but require more computational resources. To ensure good representation of the PDF, the animat density is set as high as practical allowing for computation time. The animat density is much higher than the real-world density to ensure good representation of the PDF. The resulting PDF is scaled using the real-world density.

Several models for marine mammal movement have been developed (Ellison et al. 1987, Frankel et al. 2002, Houser 2006). These models use an underlying Markov chain to transition from one state to another based on probabilities determined from measured swimming behaviour. The parameters may represent simple states, such as the speed or heading of the animal, or complex states, such as likelihood of participating in foraging, play, rest, or travel. Attractions and aversions to variables like anthropogenic sounds and different depth ranges can be included in the models.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was based on the open-source marine mammal movement and behaviour model (3MB, Houser 2006) and used to predict the exposure of animats (virtual pygmy blue whales) to sound arising from the seismic activities. Animats are programmed to behave like the pygmy blue whales likely to be present in the survey area. The parameters used for forecasting realistic behaviours (e.g., diving, foraging, aversion, surface times, etc.) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species. An individual animat's modelled sound exposure levels are summed over the total simulation duration to determine its total received energy, and then compared to the assumed threshold criteria.

JASMINE uses the same animal movement algorithms as 3MB (Houser, 2006), but has been extended to be directly compatible with MONM and FWRAM acoustic field predictions, for inclusion of source tracks, and importantly for animats to change behavioural states based on time and space dependent modelled variables such as received levels for aversion behaviour, although aversion was not considered in this study.

B.1. Animal Movement Parameters

JASMINE uses previously measured behaviour to forecast behaviour in new situations and locations. The parameters used for forecasting realistic behaviour are determined (and interpreted) from marine species studies (e.g., tagging studies). Each parameter in the model is described as a probability distribution. When limited or no information is available for a species parameter, a Gaussian or uniform distribution may be chosen for that parameter. For the Gaussian distribution, the user determines the mean and standard deviation of the distribution from which parameter values are drawn. For the uniform distribution, the user determines the maximum and minimum distribution from which parameter values are drawn. When detailed information about the movement and behaviour of a species are available, a user-created distribution vector, including cumulative transition probabilities, may be used (referred to here as a vector model; Houser 2006). Different sets of parameters can be defined for different behaviour states. The probability of an animat starting out in or transitioning into a given behaviour state can in turn be defined in terms of the animat's current behavioural state, depth, and the time of day. In addition, each travel parameter and behavioural state has a termination function that governs how long the parameter value or overall behavioural state persists in simulation.

The parameters used in JASMINE describe animal movement in both the vertical and horizontal planes. The parameters relating to travel in these two planes are briefly described below.

Travel sub-models

- **Direction**– determines an animat's choice of direction in the horizontal plane. Sub-models are available for determining the heading of animats, allowing for movement to range from strongly biased to undirected. A random walk model can be used for behaviours with no directional preference, such as feeding and playing. In a random walk, all bearings are equally likely at each parameter transition time step. A correlated random walk can be used to smooth the changes in bearing by using the current heading as the mean of the distribution from which to draw the next heading. An additional variant of the correlated random walk is available that includes a directional bias for use in situations where animals have a preferred absolute direction, such as migration. A user-defined vector of directional probabilities can also be input to control animat heading. For more detailed discussion of these parameters, see Houser (2006) and Houser and Cross (1999).
- **Travel rate**–defines an animat's rate of travel in the horizontal plane. When combined with vertical speed and dive depth, the dive profile of the animat is produced.

Dive sub-models

- **Ascent rate**–defines an animat's rate of travel in the vertical plane during the ascent portion of a dive.
- **Descent rate**–defines an animat's rate of travel in the vertical plane during the descent portion of a dive.
- **Depth**–defines an animat's maximum dive depth.
- **Reversals**–determines whether multiple vertical excursions occur once an animat reaches the maximum dive depth. This behaviour is used to emulate the foraging behaviour of some marine mammal species at depth. Reversal-specific ascent and descent rates may be specified.
- **Surface interval**–determines the duration an animat spends at, or near, the surface before diving again.

B.1.1. Exposure integration time

The interval over which acoustic exposure (L_E) should be integrated and maximal exposure (L_p) determined is not well defined. Both Southall et al. (2007) and the NMFS (2018) recommend a 24 h baseline accumulation period, but state that there may be situations where this is not appropriate (e.g., a high-level source and confined population). Resetting the integration after 24 h can lead to overestimating the number of individual animals exposed because individuals can be counted multiple times during an operation. The type of animal movement engine used in this study simulates realistic movement using swimming behaviour collected over relatively short periods (hours to days) and does not include large-scale movement such as migratory circulation patterns. For this study, seven days were modelled, but then scaled down to 24 h.

Ideally, a simulation area is large enough to encompass the entire range of a population so that any animal that could approach the seismic survey area during an operation is included. However, there are limits to the simulation area, and computational overhead increases with area. For practical reasons, the simulation area is limited in this analysis to a maximum distance from the seismic survey operations. In the simulation, every animat that reaches a border is replaced by another animat entering at the opposing border—e.g., an animat crossing the northern border of the simulation is replaced by one entering the southern border at the same longitude. When this action places the animat in an inappropriate water depth, the animat is randomly placed on the map at a depth suited to its species definition. The exposures of all animats (including those leaving the simulation and those entering) are kept for analysis. This approach maintains a consistent animat density and allows for longer integration periods with finite simulation areas.

B.1.2. Seeding density and scaling

The exposure criteria for impulsive sounds were used to determine the number of animats exceeding exposure thresholds. To generate statistically reliable probability density functions, all simulations were seeded with an animat density of 0.5 animats/km^2 over the entire simulation area. To evaluate potential injury or behavioural disruptions, threshold exceedance was determined in a 24 h time window. From the numbers of animats exceeding threshold, the numbers of individual pygmy blue whales predicted to exceed threshold were determined by scaling the animat results by the ratio of local real-world density to modelling density.

B.2. Pygmy blue whale species details

Table B-1. *Foraging pygmy blue whales*: Data values and references input in JASMINE to create diving behaviour (number values represent means [standard deviations] unless otherwise indicated).

Behaviour	Variable	Value	Reference
Deep foraging dive	Travel direction	Correlated random walk	Houser (2006), D. Houser, pers.comm.
	Perturbation value	10	Houser (2006), D. Houser, pers.comm.
	Termination coefficient	0.2	Houser (2006), D. Houser, pers.comm.
	Travel rate (m/s)	Gaussian 1.25 (0.42)	Sears and Perrin (2009)
	Ascent rate (m/s)	Gaussian 1.6 (0.5)	Goldbogen et al. (2011)
	Descent rate (m/s)	Gaussian 2.6 (0.5)	Goldbogen et al. (2011)
	Dive depth (m)	Gaussian 129.0 (183.0)	Owen et al. (2016)
	Reversals	3.5 (1.1)	Goldbogen et al. (2011)
	Probability of reversal	0.7	Approximated
	Reversal ascent dive rate (m/s)	Random 1.7–0.37	Goldbogen et al. (2011)
	Reversal descent dive rate (m/s)	Random 1.4–0.46	Goldbogen et al. (2011)
	Time in reversal (s)	Random 26.3–52.5	Approximated
	Surface interval (s)	Gaussian 162.0 (66.0)	Goldbogen et al. (2011)
	Bout duration (s)	Gaussian 12600 (1800)	Owen et al. (2016)
General	Shore following (m)	30	Approximated
	Depth limit on seeding (m)	100.0 (minimum), 110000.0 (maximum)	Approximated

Table B-2. *Migrating pygmy blue whales*: Data values and references input in JASMINE to create diving behaviour (number values represent means [standard deviations] unless otherwise indicated).

Behaviour	Variable	Value	
Migratory dive	Travel direction	Correlated random walk	Houser (2006), D. Houser, pers.comm.
	Perturbation value	10	Houser (2006), D. Houser, pers.comm.
	Termination coefficient	0.2	Houser (2006), D. Houser, pers.comm.
	Travel rate (m/s)	Gaussian 0.78 (0.61)	Sears and Perrin (2009)
	Ascent rate (m/s)	Gaussian 0.7 (0.2)	Goldbogen et al. (2011)
	Descent rate (m/s)	Gaussian 1.5 (0.1)	Goldbogen et al. (2011)
	Dive depth (m)	Gaussian 14.0 (4.0)	Owen et al. (2016)
	Reversals	No	Owen et al. (2016)
	Surface interval (s)	Gaussian 60.0 (66.0)	Owen et al. (2016), approximated
	Bout duration (s)	Gaussian 12060 (1800)	Owen et al. (2016)
Exploratory dive	Travel direction	Correlated random walk	Houser (2006), D. Houser, pers.comm.
	Perturbation value	10	Houser (2006), D. Houser, pers.comm.
	Termination coefficient	0.2	Houser (2006), D. Houser, pers.comm.
	Travel rate (m/s)	Gaussian 1.25 (0.42)	Sears and Perrin (2009)
	Ascent rate (m/s)	Gaussian 1.6 (0.5)	Goldbogen et al. (2011)
	Descent rate (m/s)	Gaussian 2.6 (0.5)	Goldbogen et al. (2011)
	Dive depth (m)	Gaussian 107.0 (81.0)	Owen et al. (2016)
	Reversals	No	Owen et al. (2016)
	Surface interval (s)	Gaussian 162.0 (66.0)	Goldbogen et al. (2011)
	Bout duration (s)	Gaussian 516 (120)	Owen et al. (2016)
General	Shore following (m)	30	Approximated
	Depth limit on seeding (m)	100.0 (minimum), 110000.0 (maximum)	Approximated

APPENDIX I: PASSIVE ACOUSTIC MONITORING

As described in the North-west Australia Marine Seismic Survey Environment Plan, the Petroleum Activities Program will utilise PAM as a complementary control to mitigate potential impacts from seismic noise to sperm and beaked whales that might be present in the Areas A, B and C during operations.

Application

The PAM system will be deployed directly off the seismic vessel and is run out parallel to the streamers, and it will be set up to detect the range of frequencies of cetacean vocalisations expected to be present in Areas A, B and C (1 Hz-200 kHz) and will be used to establish a bearing a distance from the source array to the vocalising cetaceans. Note that while the system has the potential to detect low frequency (e.g. 10 Hz) vocalisations, it is likely that the flow noise generated by the movement of the hydrophone through the water during towing can drown out some low-frequency vocalisations. The system is more sensitive to medium to high-frequency vocalisations (sperm and beaked whales) and will be used to target these species.

Mitigation measures (i.e. shutdown) will be implemented on the detection of sperm or beaked whale within the shutdown zone (2 km). Usual visual surveillance, prior to start-up, will be undertaken by the MFOs. Any bioaccoustic detection of sperm or beaked whales within 2 km of the operating source will require an immediate shutdown, or a delay in start-up of operations.

The PAM Operators will work closely with the visual observation team (MFOs). During daylight hours, PAM detections will be validated against MFO observations and ranges in order to determine the error (if any) in PAM detection distances. If the PAM Operators detect a marine mammal, then they will notify the Lead MFO who will assess the location of the individual relative to the mitigation zones. If they are found to be within the agreed zones, then the Lead MFO will notify seismic operations, who will then initiate shutdown as appropriate. All observations and mitigation actions will be formally recorded and available to the Regulator for review.

Once this calibration has been established, then PAM will be used to trigger shutdown procedures at night and during periods of low visibility when sperm or beaked whales enter the appropriate precaution zones. If PAM records are shown inaccurate in estimating distances, the seismic source will be shutdown in the event of a confirmed detection (comprising three or more detection records for an individual whale) and not power-up until 30 minutes have passed without detection.

The integration of PAM with visual observations provides effective control of operations ensuring the Petroleum Activities Program meets the requirements of the EP, via implementation of appropriate mitigation actions when sperm and beaked whales are detected within the specified mitigation zones. These methods represent international best practice for seismic surveys and all personnel will be experienced in the application of these methods and the overall mitigation process.

Standards

Australia has no formal State or Commonwealth technical specifications for a PAM system, and therefore Woodside proposes to implement the *IAGC Guidance on the Use of Towed Passive Acoustic Monitoring during Geophysical Operations* (IAGC, 2014).

PAM Operator Competencies

As per the *Guidance on the Use of Towed Passive Acoustic Monitoring during Geophysical Operations*, PAM Lead Operators will have a minimum 10 weeks of experience (IAGC, 2014). Additionally, all PAM Operators aboard the survey vessel during the Petroleum Activities Program will meet at least one of the following competency standards and have suitable experience in PAM operations:

- Passed the NZ PAM Operators course and be approved to work in NZ by the NZ Government;

- Passed the US PAM Operators course and be approved to work in the US by the Bureau of Ocean Energy Management (BOEM) and/or the Bureau of Safety and Environmental Enforcement (BSEE);
- Passed the JNCC PAM Operators course and be approved to work in the UK by the Joint Nature Council of the UK; and
- Demonstrate suitable experience in the set-up, operation, troubleshooting and analysis of PAM systems and data on marine science surveys and/or seismic surveys.