Appendix D.

Benthic habitat report (Jacobs 2016c)

Barossa Environmental Studies

ConocoPhillips

Benthic Habitat Report

WV04831-NMS-RP-0028 | Rev 2

19 August 2016

Barossa Environmental Studies

Project no:	WV04831 (IW021200)
Document title:	Benthic Habitat Report
Document no:	WV04831-NMS-RP-0028
Revision:	1
Date:	4 August 2015
Client name:	ConocoPhillips
Project manager:	Arne de Vos
Author:	Nadia Aurisch
File name:	T:\Transfer\Aug2016\WVES\TMiley\Barossa OPP Tech Appendices\sent to cop\Benthic Habitat Baseline Report 190816.docx

Jacobs Group (Australia) Pty Limited
ABN 37 001 024 095
Level 11 / 263 Adelaide Terrace
Perth WA 6000
T +61 8 9469 4400
F +61 8 9469 4488
www.jacobs.com

Document history and status

Revision	Date	Description	By	Review	Approved
Rev A	25/06/15	Draft for editorial review	N. Aurisch	J. Phillips	
Rev A	25/06/15	Draft for technical review	N. Aurisch	G. Hooper	
Rev 0	01/07/15	For client issue	N. Aurisch	C. Teasdale	T. Mitchell
Rev 1	04/07/15	Final, issued for use	N. Aurisch	C. Teasdale	T. Mitchell
Rev 2	19/08/16	Final, minor revisions	W. Chisholm	A. de Vos	A.de Vos

Contents

List of Figures

List of Tables

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs is to undertake the studies in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report primarily from the data collected by Jacobs' personnel in accordance with Jacobs sampling and analysis plan. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs' Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Executive Summary

ConocoPhillips Australia Exploration Pty Ltd (ConocoPhillips) are proposing to develop natural gas resources as part of the Barossa area development, located in waters up to 300 m deep in the Bonaparte Basin, in Commonwealth waters offshore of northern Australia. To develop a robust understanding of the existing marine environmental values of the area to inform any future approvals, a targeted baseline marine studies program is being progressed within and surrounding the Barossa field. One component of the baseline marine studies program is a benthic habitat survey. This report summarises the results of this survey, undertaken in late March/early April 2015.

Twenty-five benthic habitat sampling sites were positioned to provide representative coverage of the permit area and nearby areas of regional interest such as shoals and banks. Sites were located in the permit area (eight sites), around Evans Shoal (four sites), around Tassie Shoal (three sites), around Lynedoch Bank (four sites), on seamounts west of the permit area (four sites) and scarps south of the permit area (two sites).

The benthic habitat survey took place over five days, from 31 March to 6 April 2015. At each site, a remotely operated vehicle surveyed several transects along the seafloor capturing both video footage and still images.

Generally, the data collected during this survey indicate that the benthic habitats and biota were typical of those expected in offshore environments and were consistent with studies conducted both in areas with similar features and in areas of a similar geographic location. Key conclusions from this benthic habitat survey include:

- The seabed observed in the permit area was predominantly silty sand generally lacking hard substrate. Fauna groups observed included octocorals (particularly sea pens) and decapod crustaceans (mostly prawns and squat lobsters) in relatively low numbers, however bioturbation was frequently observed. Results from the recent infauna survey indicate bioturbation in this area was predominantly caused by polychaetes, crustaceans, bivalves, molluscs, echinoderms and potentially fish. Sites were generally similar to one another.
- The shoals to the west of the permit area (Evans Shoal and Tassie Shoal) and Lynedoch Bank to the east were comprised of typical tropical coral reef habitat. Biotic assemblages at these sites were generally similar to one another and to other submerged shoals and banks in the broader regional area.
- The seamounts to the west of the permit area supported a diverse range of fish and sharks and contained some of the same benthic taxa as the banks and shoals. Communities varied slightly between each of the sites.
- The scarps to the south of the permit area included areas of hard substrate and supported a diverse range of filter feeders and were generally more similar to the seamount features than to the shoals and bank sites.
- The community composition of these three areas (permit area; banks and shoals; and seamounts and scarps) appeared to be reasonably different to one another with the differences appearing to be driven by depth and substrate type. The least diverse sites were the permit area sites, whilst the most diverse sites were the shoals and banks.

An unexpected observation during the survey was the sighting of four grey nurse sharks (including at least one female that appeared to be pregnant) at a seamount to the west of the permit area, in approximately 130 m water depth. This was considered unusual as neither the east or west coast populations are known to extend that far north and are generally associated with shallower, more coastal waters.

The results of this survey have characterised the benthic habitats of the permit area and selected nearby areas of interest.

1. Introduction

1.1 Background

ConocoPhillips Australia Exploration Pty Ltd (ConocoPhillips), as proponent on behalf of the current and future joint venturers, are proposing to develop natural gas resources as part of the Barossa area development, located approximately 300 kilometres (km) north of Darwin, Northern Territory (NT).

To facilitate the environmental approvals process for any future development of the Barossa field and surrounds, a robust understanding of the existing state of the key environmental values and sensitivities will be necessary. This understanding will be gained from a series of studies and surveys to assess and monitor the baseline state of environmental factors such as water quality, sediment quality, underwater noise, metocean conditions and benthic habitats within petroleum retention lease permit NT/RL5 (referred to as the 'permit area' in this report) and across a broader geographical area. The studies assessing these factors commenced in June 2014.

1.2 Overview of existing regional environment

The Barossa area is located in the North Marine Region (Department of Sustainability, Environment, Water, Population and Communities 2012), which comprises the Commonwealth waters of the Gulf of Carpentaria, Timor Sea and Arafura Sea as far west as the NT and Western Australian border. The North Marine Region contains internationally significant breeding and/or feeding grounds for a number of listed threatened and migratory marine species including nearshore dolphins, turtles, dugongs, seabirds and migratory shorebirds afforded protection under national legislation and international conventions.

The Timor and Arafura Seas support a variety of shark, pelagic finfish and crustacean species of commercial and recreational game-fishing importance, e.g. trawl and various finfish fisheries. The shelf break and slope of the Arafura Shelf is characterised by patch reefs and hard substrate pinnacles that support a diverse array of invertebrate groups, with polychaetes and crustaceans being the most prolific (Heyward et al. 1997, Consulting Environmental Engineers 2002). Surveys indicate that between 50 m and 200 m depth, the benthos consists of predominantly soft, easily resuspended sediments (Heyward et al. 1997, URS 2005, 2007). The diversity and coverage of epibenthos is low and organisms present are predominantly sponges, gorgonians and soft corals (Heyward et al. 1997, URS 2005, 2007).

Numerous shoals (submerged calcareous banks or 'seamounts') exist in the broader region around the permit area; Evans Shoal (60 km west), Tassie Shoal (70 km south-west) and Lynedoch Bank (40 km south-east). In addition, the new Oceanic Shoals Commonwealth marine reserve (multiple use zone) lies to the south and south-east of the permit area.

1.3 Objectives

The benthic habitat survey is a key component of the Barossa marine baseline studies program.

Baseline studies were undertaken with reference to the permit area, as shown in **Figure 1-1**. While this represents the area of primary interest as part of ConocoPhillips' staged field development, the broader surrounds were also characterised.

The survey was completed as a single survey as it was not expected that habitats would vary during different seasonal conditions, based on the remote, offshore location of the Barossa field. The objective of the benthic habitat survey was to characterise the benthic habitats and biota within the permit area and in the vicinity of Evans Shoal, Tassie Shoal and Lynedoch Bank; which represent the nearest seabed features of regional interest to the Barossa field.

This report summarises the results of the benthic habitat survey, undertaken in late March/early April 2015.

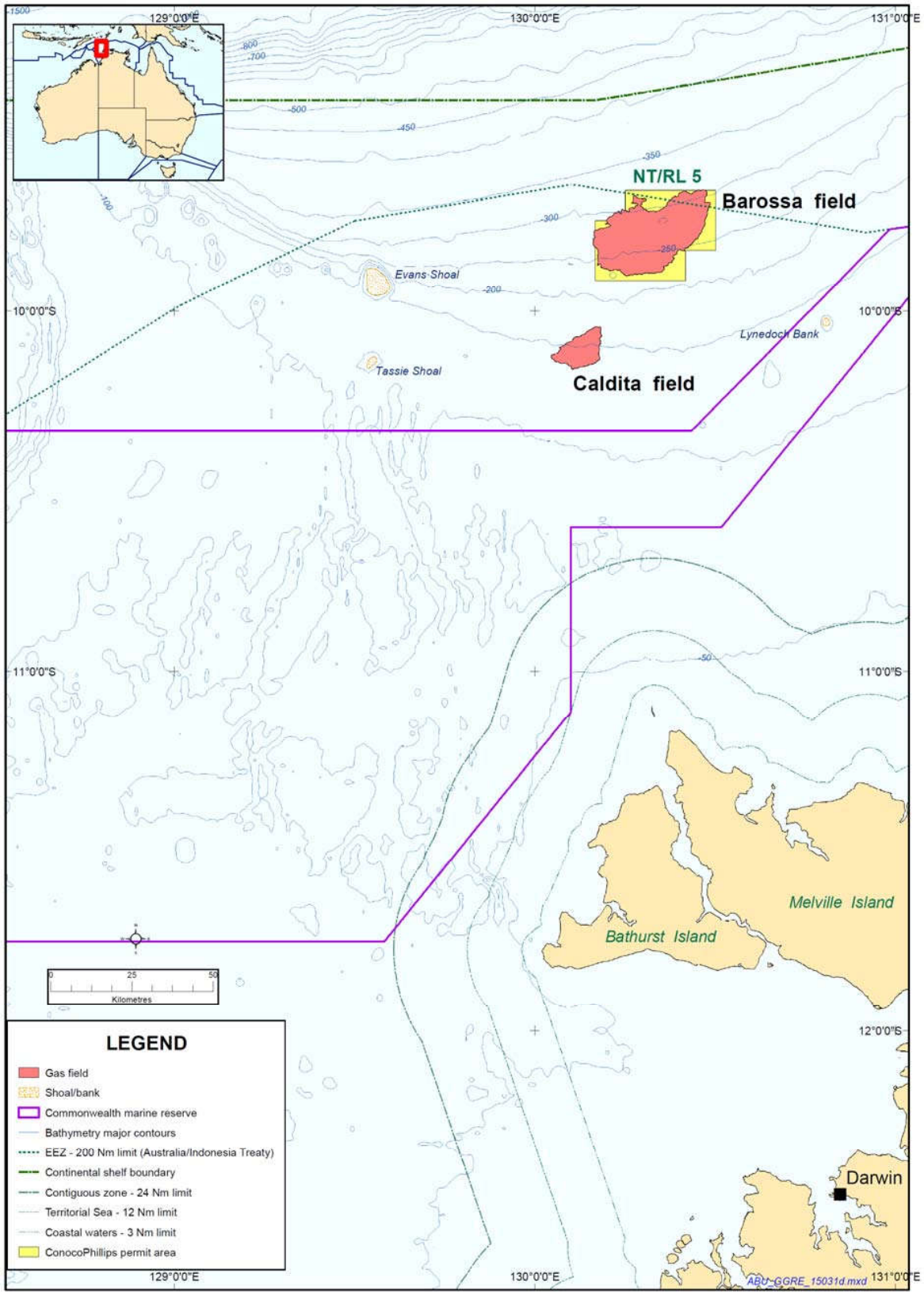


Figure 1-1: Barossa field location

2. Methods

The methods employed during the benthic habitat survey follow those detailed in the *Barossa Environmental Studies: Benthic Habitat Method Statement* (Jacobs 2015). An overview of the methods is provided in the sections below.

2.1 Survey design

The survey was designed to collect data on the distribution of benthic habitats in the immediate vicinity of the permit area, from across the broader region, and from areas of regional interest including shoals and banks and areas with complex topography as a result of the changing bathymetry, e.g. pinnacles/seamounts or scarps. The sampling sites originally identified during design of the study (**Figure 2-1)** were:

- the permit area (eight sites stratified to capture the bathymetric gradient)
- Evans Shoal, approximately 60 km west of the permit area (five sites)
- Tassie Shoal, approximately 70 km south-west of the permit area (three sites)
- Lynedoch Bank, approximately 40 km south-east of the permit area (five sites)
- seamounts, approximately 40 km west of the permit area (three sites)
- scarps, approximately 5–10 km south of the permit area (four sites).

These sites were labelled with a prefix (HM, habitat mapping) and numbered 1–28. Some sites were not visited due to time/weather constraints and are not shown in **Figure 2-1**.

2.2 Sampling sites

Twenty five sites were sampled during the survey (**Table 2-1, Figure 2-1**). Due to weather constraints, five of the original sites were not visited, however, an additional two sites on seamounts to the west of the Barossa field were added to the sampling plan to capture imagery from interesting bathymetric features observed whilst undertaking the field survey. Sites sampled during the field survey are shown in **Table 2-1** and **Figure 2-1**.

2.3 Timing

Benthic habitats were surveyed during a single survey with sampling taking place during daylight hours over 7 days from 31 March to 6 April 2015.

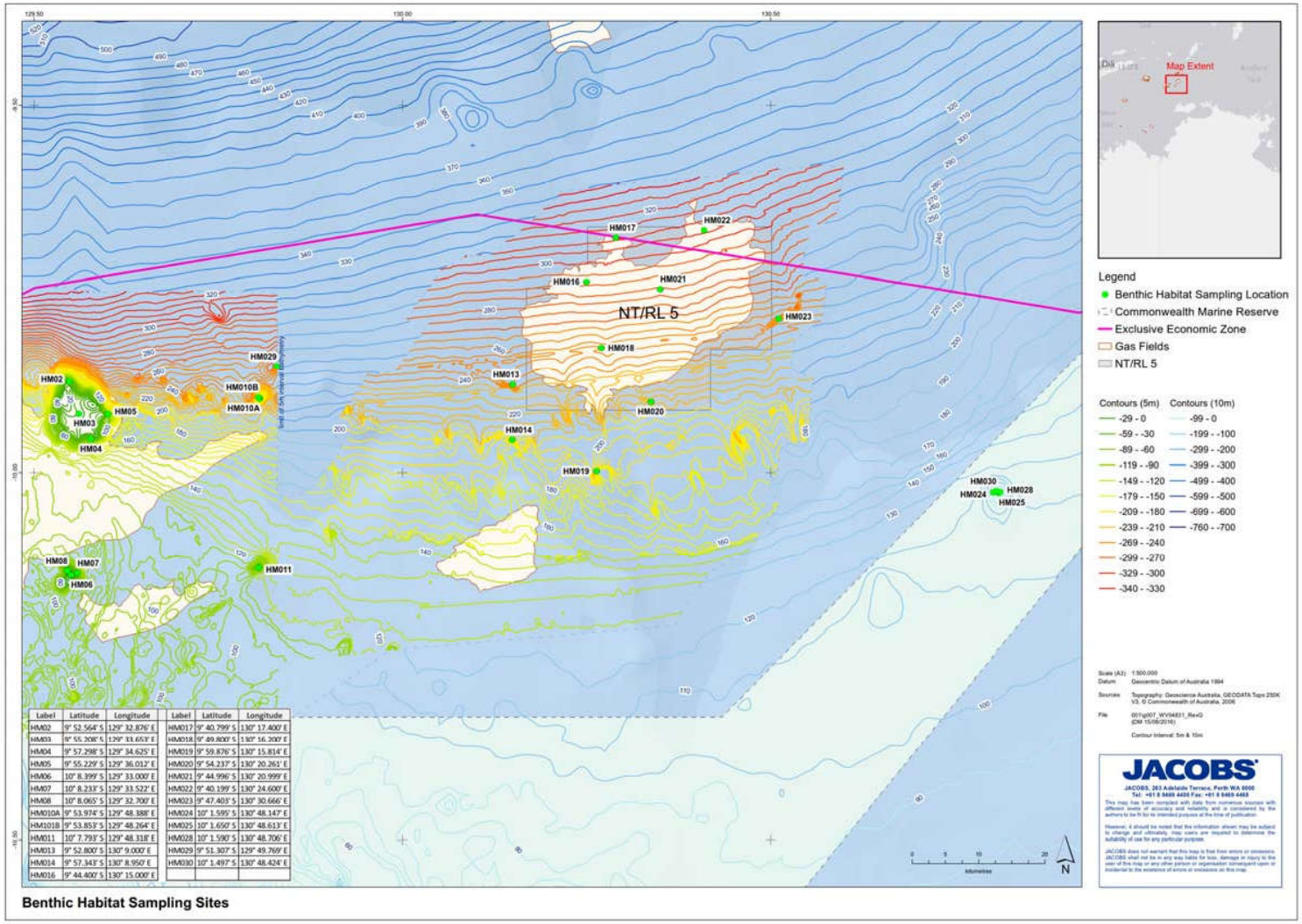
2.4 Sampling equipment

A remotely operated vehicle (ROV) fitted with cameras was used to obtain video footage and digital still images of the seabed for later analysis and data extraction. The ROV was an Ocean Modules V8 Sii, supplied and operated by Intervention Engineering. The ROV was equipped with a high-definition video camera and an 18 megapixel digital single lens reflex (DSLR) camera with four flash units and laser scaling. The ROV was also fitted with four high-intensity lights and positioning was monitored using a Seaprince sonar and two ultra-short baseline (USBL) beacons (Sonardyne Scout Plus and Tritech).

Table 2-1: Benthic habitat sampling site coordinates

Site name	Depth (m)	Coordinates (DD° MM'SS.SSS")[1]	
		Latitude	Longitude
Permit area – 8 sites			
HM013	245	9° 52' 48.0" S	130° 09' 0.0" E
HM016	290	9° 44' 24.0" S	130° 15' 0.0" E
HM017	309	9° 40' 47.94" S	130° 17' 0.0" E
HM018	253	9° 49' 48.0" S	130° 16' 12.0" E
HM020	211	9° 54' 14.22" S	130° 20' 15.66" E
HM021	280	9° 44' 59.76" S	130° 20' 59.94" E
HM022	303	9° 40' 11.94" S	130° 24' 36.0" E
HM023	280	9° 47' 24.18" S	130° 30' 39.96" E
Evans Shoal – 4 sites			
HM02	45–130	9° 52' 33.84" S	129° 32' 52.56" E
HM03	28	9° 55' 12.48" S	129° 33' 39.18" E
HM04	18–55	9° 57' 17.88" S	129° 34' 37.5" E
HM05	83–170	9° 55' 13.74" S	129° 36' 0.72" E
Tassie Shoal – 3 sites			
HM06	15	10° 08' 23.94" S	129° 33" 0.0" E
HM07	28–70	10° 08' 13.98" S	129° 33' 31.32" E
HM08	15	10° 08' 3.9" S	129° 32' 42.0" E
Lynedoch Bank – 4 sites			
HM024	20	10° 01' 35.7" S	130° 48' 8.82" E
HM025	16	10° 01' 39.0" S	130° 48' 36.78" E
HM028	26–83	10° 01' 35.4" S	130° 48' 42.36" E
HM030	16	10° 01' 29.82" S	130° 48' 25.44" E
Seamounts (east of field) – 4 sites			
HM010A	77–140	9° 53' 58.44" S	129° 48' 23.28" E
HM010B	77	9° 53' 51.18" S	129° 48' 15.84" E
HM029	80–220	9° 51' 18.42" S	129° 49' 46.14" E
HM011	50–100	10° 07' 47.58" S	129° 48' 19.08" E
Scarps (south of field) – 2 sites			
HM014	190	9° 57' 20.58" S	130° 08' 57.0" E
HM019	162–185	9° 59' 52.56" S	130° 15' 48.84" E

[1] Coordinate System - GDA 1994



Label	Latitude	Longitude
HM002	9° 52.564' S	129° 32.876' E
HM003	9° 55.208' S	129° 33.653' E
HM004	9° 57.298' S	129° 34.625' E
HM005	9° 55.229' S	129° 36.012' E
HM006	10° 8.399' S	129° 33.000' E
HM007	10° 8.233' S	129° 33.522' E
HM008	10° 8.065' S	129° 32.700' E
HM010A	9° 53.974' S	129° 48.388' E
HM1018	9° 53.853' S	129° 48.264' E
HM011	10° 7.793' S	129° 48.318' E
HM013	9° 52.800' S	130° 9.000' E
HM014	9° 57.343' S	130° 8.950' E
HM016	9° 44.400' S	130° 15.000' E

Label	Latitude	Longitude
HM017	9° 40.799' S	130° 17.400' E
HM018	9° 49.800' S	130° 16.200' E
HM019	9° 59.876' S	130° 15.814' E
HM020	9° 54.237' S	130° 20.261' E
HM021	9° 44.996' S	130° 20.999' E
HM022	9° 40.199' S	130° 24.600' E
HM023	9° 47.405' S	130° 30.666' E
HM024	10° 1.595' S	130° 48.147' E
HM025	10° 1.650' S	130° 48.613' E
HM028	10° 1.590' S	130° 48.706' E
HM029	9° 51.307' S	129° 49.769' E
HM030	10° 1.497' S	130° 48.424' E

Figure 2-1: Benthic habitat sampling site locations

2.5 Data collection

The ROV was deployed from the Gun Marine Services vessel *Warrego*. The ROV umbilical was attached to a winch line and clump weight, leaving approximately 50 m of umbilical between the ROV and clump weight. The use of the clump weight was to mitigate the potential impact of tidal drag on the ROV umbilical through the water column. The clump weight was lowered and the ROV flown to approximately 5 m above the seabed, after which the ROV continued to descend to 1 m above the seabed. To keep the clump weight stationary (using the data from USBL beacon for guidance), the vessel engaged thrusters and main engines when required to mitigate the effects of currents, wind and waves so that the full transect length could be filmed.

The ROV was then flown along three transects radiating outwards (the direction was dictated by the prevailing conditions) using the clump weight as the origin. Transects were approximately 50 m long, which resulted in approximately 10 minutes of video footage for each transect. Video and digital still imagery of benthic habitats was collected along each transect. At least one transect at each site was an exploratory transect where the ROV was positioned at a height above the seabed to focus on recording video footage in order to capture a broader perspective of the habitats present. The remaining two transects at a site were of fixed direction, with a focus on maintaining a straight heading whilst capturing video and still images of the seabed for any future analysis and quantification of habitat (these still images were not analysed as part of this report). Along these transects, still images were captured every 5 seconds (video footage was captured continuously). Once the three transects had been surveyed, the ROV was recovered to the vessel and moved to the next sampling site.

On the slopes of shoals, banks or seamounts, single transects were flown both across the top of the feature and down the slope. Transects ended when the slope flattened out at the base of the feature or the habitat changed to sand/silt. The vessel would follow the ROV (using the data from the USBL beacon) with the clump weight being raised and lowed as required so that a transect across the full length of the feature could be completed (maximum length was 500 m).

All collected imagery (video and stills) was downloaded and backed up onto an external hard drive for later analysis and classification of the benthic habitats and biota.

2.6 Habitat and biota classification

2.6.1 Qualitative classification

The data captured from each transect was reviewed and if transects from each site was considered representative of the site, then one transect (exploratory) was classified into broad habitat and fauna categories (**Table 2-2**) by a trained marine ecologist.

2.6.2 Presence/absence data

The results from the habitat and biota classification were analysed for similarity between sites. This was done using multidimensional scaling (MDS) in Primer v6. Cluster analysis was based on Bray Curtis similarity of presence/absence of biological data and was used to illustrate similarities of community composition for each site. Observation of habitat type (e.g. hard/soft substrate) was used as part of the interpretation.

2.6.3 Quantitative classification

Still images were captured every 5 seconds along the fixed transects. These images may be used for quantitative and qualitative analysis in the future if required, but this is beyond the scope of this report.

Still images considered to be representative of each habitat type are presented in the habitat descriptions (**Section 3.1**) and images of unidentified fish types are presented in **Appendix A**.

2.6.4 Quality control procedures

Procedural and record-keeping quality control measures implemented were:

- GPS waypoints and water depth were recorded for all sites sampled from the vessel
- site locations and preliminary analysis notes were logged onto field sheets, which were backed up to a hard drive

- any changes to the field procedures were documented.

2.6.5 Limitations

Water clarity and light conditions were limiting factors for image analysis. The water clarity was affected by the substrate type and the amount of particulates in the water column. The finer the substrate type the easier it was for the ROV thrusters and currents to disturb it and introduce particles into the water column. This generally only applied to the deeper water sites that had a predominantly silty sand bottom. The reliance on artificial lighting at deeper sites also meant that objects on the edge of the image frame were harder to accurately identify than objects at the shallow water reef sites if only part of the object was illuminated.

Table 2-2: Habitat and biota classification categories

Teleosts	Other
Type A – Silver, minnow shaped tail	Tunicates/Ascidians
Type B – Rat tail	Sponge - encrusting
Type C – Silver, bullet shaped	Sponge - sub massive
Type D – Bullet shaped, dark minnow tail	Sponge - cup
Type E – Snake head	Sponge - erect
Type F – Tiger stripes	Tube Worms
Type G – Sword fish	Anemones
Type H – Vertical fish	Halimeda
Type I – Triangle fish	Algae
Type J – Mouth prongs	**Echinoderms**
Type K – Pipefish	Feather Stars (Class Crinoidea)
Type L – Gurnaud	Brittle Stars (Class Ophiuroidea)
Type M – Flounder A	Holothurian
Type N – Flounder B	Sea star
Type O – Flounder C	Urchin
Type P – Pink fish	**Octocorals**
Type Q – Flathead	Unidentified - Filter Feeders/non- Photosynthetic Soft Corals
Type R – Goby shape	Sea Pens
Type S – Bulbous Long-tailed transparent	Gorgonians
Unknown teleost	Sea Whips
Family Lutjanidae - snapper	**Corals**
Family Chaetodontidae - butterfly fish	Branching
Family Labridae - wrasse	Digitate
Family Pomacentridae - damsel	Columnar
Family Pomacanthidae - angelfish	Plate
Family Acanthuridae - unicorn fish	Massive
Family Balistidae - triggerfish	Sub-massive
Family Zanclidae - moorish Idol	Encrusting
Family Monacanthidae - leatherjacket	Free-living
Family Holocentridae - squirrel fish	**Decapods**
Family Carangidae	Prawn/Shrimp Group
Family Caesionidae	Long-Antennae Shrimp Group
Family Serranidae	Small Crab/Squat Lobster Group
Family Priacanthidae	Lobster
Reptilia	Hermit crab
Seasnake	**Chondrichthyes**
Mollusc	Shark – whitetip reef
Gastropod	Shark – silvertip
Bivalve	Shark - grey nurse
Actinopterygii	Shark - tawny nurse
Moray eel	Elasmobranch

3. Results

3.1 Habitat descriptions

Habitat descriptions and representative images are provided for each site in the following subsections. Images considered to be representative of deep water fish types are included in **Appendix A**.

3.1.1 Southern permit area

HM013

HM013 was located in 245 m water depth, just outside the south-west boundary of the permit area in an area where seismic survey derived bathymetry indicated a valley. The substrate at HM013 was predominantly silty sand and slightly undulating (<25 cm in height) with widespread bioturbation (i.e. burrows, mounds and tracks). Observed biota included sea pens, anemones (**Figure 3-1**), decapod crustaceans and four types of fish.

HM018

HM018 was located in 253 m water depth in the southern half of the permit area. The substrate at HM018 was predominantly silty sand (**Figure 3-2**) and was slightly undulating (<25 cm in height) with widespread bioturbation. Observed biota included sea pens and decapod crustaceans and six types of fish.

HM020

HM020 was located in 211 m water depth near the southern boundary of the permit area. The substrate at HM020 was predominantly very silty sand and was slightly undulating (<25 cm in height) with widespread bioturbation. Observed biota included sea pens, starfish, decapod crustaceans and five types of fish.

Figure 3-1: Silty sand substrate with burrowing anemone at site HM013

Figure 3-2: Silty sand substrate with teleost (Type A) fish at site HM018

3.1.1.1 Mid permit area

HM016

HM016 was located in 290 m water depth in the north-west of the permit area. The substrate at HM016 was predominantly fine, silty sand and was slightly undulating (<25 cm in height) with widespread bioturbation. Observed biota included sea pens (**Figure 3-3**), anemones, decapod crustaceans and four types of fish.

HM021

HM021 was located in 280 m water depth near the centre of the permit area. The substrate was slightly undulating (<25 cm in height), fine silty sand, with widespread bioturbation. Observed biota included sea pens, decapod crustaceans and one fish type.

HM023

HM023 was located in 280 m water depth just outside the eastern boundary of the permit area where the seismic derived bathymetry indicated a valley. The substrate at HM023 was predominantly silty sand and was slightly undulating (<25 cm in height) with widespread bioturbation. Observed biota included sea pens, soft corals, anemones, starfish, decapod crustaceans and five types of fish (**Figure 3-4**).

Figure 3-3: Silty sand substrate and a sea pen at site HM016

Figure 3-4: Gravelly silty sand substrate with squat lobster, soft coral and teleost (Type K) fish at site HM023

3.1.1.2 Northern permit area

HM017

HM017 was located in 309 m water depth in the north-west corner of the permit area. The substrate at HM017 was predominantly very silty sand and was slightly undulating (<25 cm in height) with widespread bioturbation. Observed biota included anemones, decapod crustaceans and three types of fish (**Figure 3-5**).

HM022

HM022 was located in 303 m water depth near the northern boundary of the permit area. The substrate at HM022 was predominantly silty sand (**Figure 3-6**) and was slightly undulating (<25 cm in height) with widespread bioturbation. Observed biota included a brittle star, sea pens, decapod crustaceans and three types of fish.

Figure 3-5: Silty sand substrate and a teleost (gurnard - Type L) at site HM017

Figure 3-6: Silty sand substrate with prawn at site HM022

3.1.3 Evans Shoal

HM03 – reef flat

HM03 was located in 28 m water depth in the centre of Evans Shoal (**Figure 3-7**). The substrate was predominantly sand with patchy mixed beds of filter feeders (e.g. sponges and soft corals) and macroalgae. A small bommie was encountered at this site and was covered in hard and soft corals and sponges (**Figure 3-7**), and was inhabited by several taxa of fish including species from families Labridae, (wrasse), Pomacanthidae (damselfish and clownfish), Acanthuridae (surgeonfishes, tangs and unicornfishes), Zanclidae (Moorish idols) and Balistidae (triggerfishes). Small fish (likely Pomacentridae) also inhabited the mixed filter feeder/algal beds. A large leatherjacket (family Monacanthidae) was observed near the sea bed.

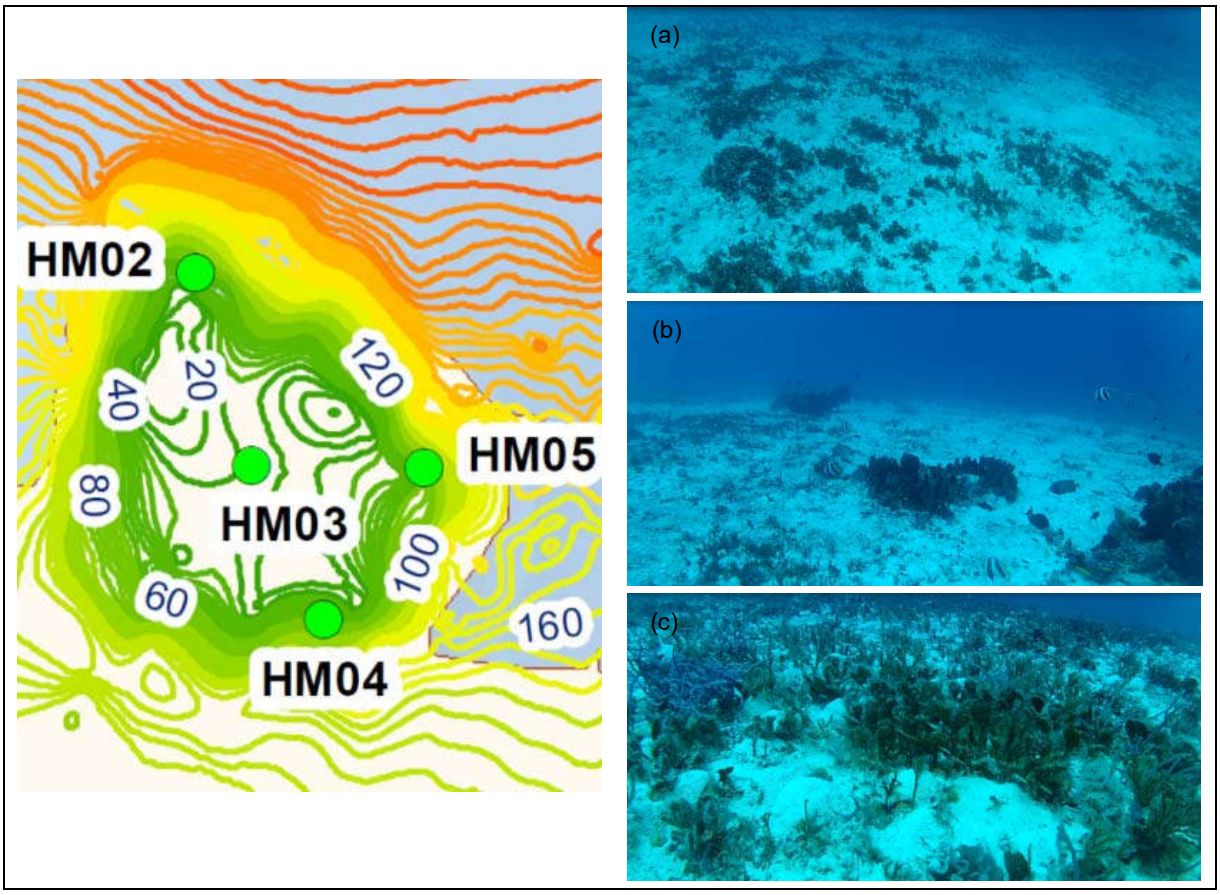


Figure 3-7: Location of sampling site HM03 (left) and indicative habitats comprising (a) sandy substrate with patchy mixed filter feeder/algal beds at HM003, (b) bommie with hard and soft corals, sponges and reef fish and (c) mixed filter feeder and algal beds

HM04 – southern slope

Transects at HM004, south side of Evans Shoal, commenced on the reef flat in 18 m water depth. While the substrate was predominantly sand and rubble, there were areas on the reef flat that had high density coral cover of mostly plate and branching forms (**Figure 3-8**). *Halimeda* spp. (calcareous algae) and soft coral were also recorded. A diverse assemblage of reef fish occurred in these areas and whitetip reef sharks were also observed. The reef crest of the shoal was approximately 32 m deep and was dominated by plate coral (**Figure 3-8**) whereas the upper slope was dominated by sand. At around 42 m water depth, the substrate had nearly 100% cover of plate corals (**Figure 3-8**). At approximately 55 m water depth, the substrate became dominated by macroalgae, including *Halimeda* spp., with scattered sponges and sea cucumbers also present.

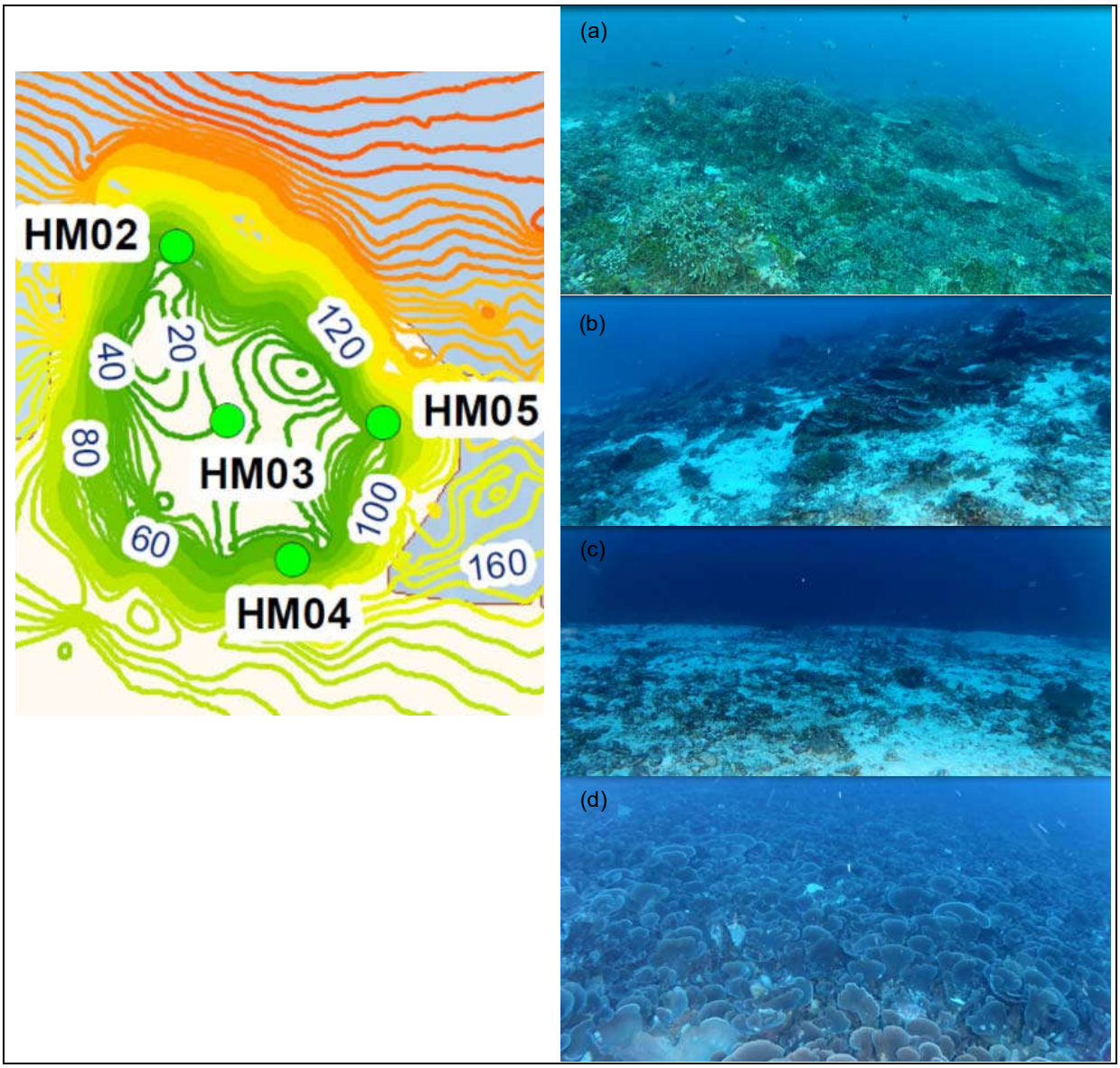


Figure 3-8: Location of sampling site HM04 (left) and habitats observed including (a) reef flat (b) reef crest with plate corals (c) sand, rubble and low-lying epibiota on upper reef slope, and (d) dense plate coral between 42–55 m water depth

HM05

HM05 was located on the eastern slope of Evans Shoal (**Figure 3-9**), with transects starting at approximately 83 m water depth. The submerged reef flat had a predominantly sandy substrate with occasional small macroalgae. Silvertip sharks were observed in this habitat (**Figure 3-9**). The crest of the shoal was approximately 88 m deep and along the edge was a rocky overhang, with various types of filter feeders. The slope itself was quite steep (**Figure 3-9**) and predominantly steep rock faces and rocky overhangs with small sandy ledges. The hard substrate supported filter feeders (such as gorgonians, feather stars, sea whips, sponges) with small reef fish seen in the shelter of the overhangs (**Figure 3-9**).

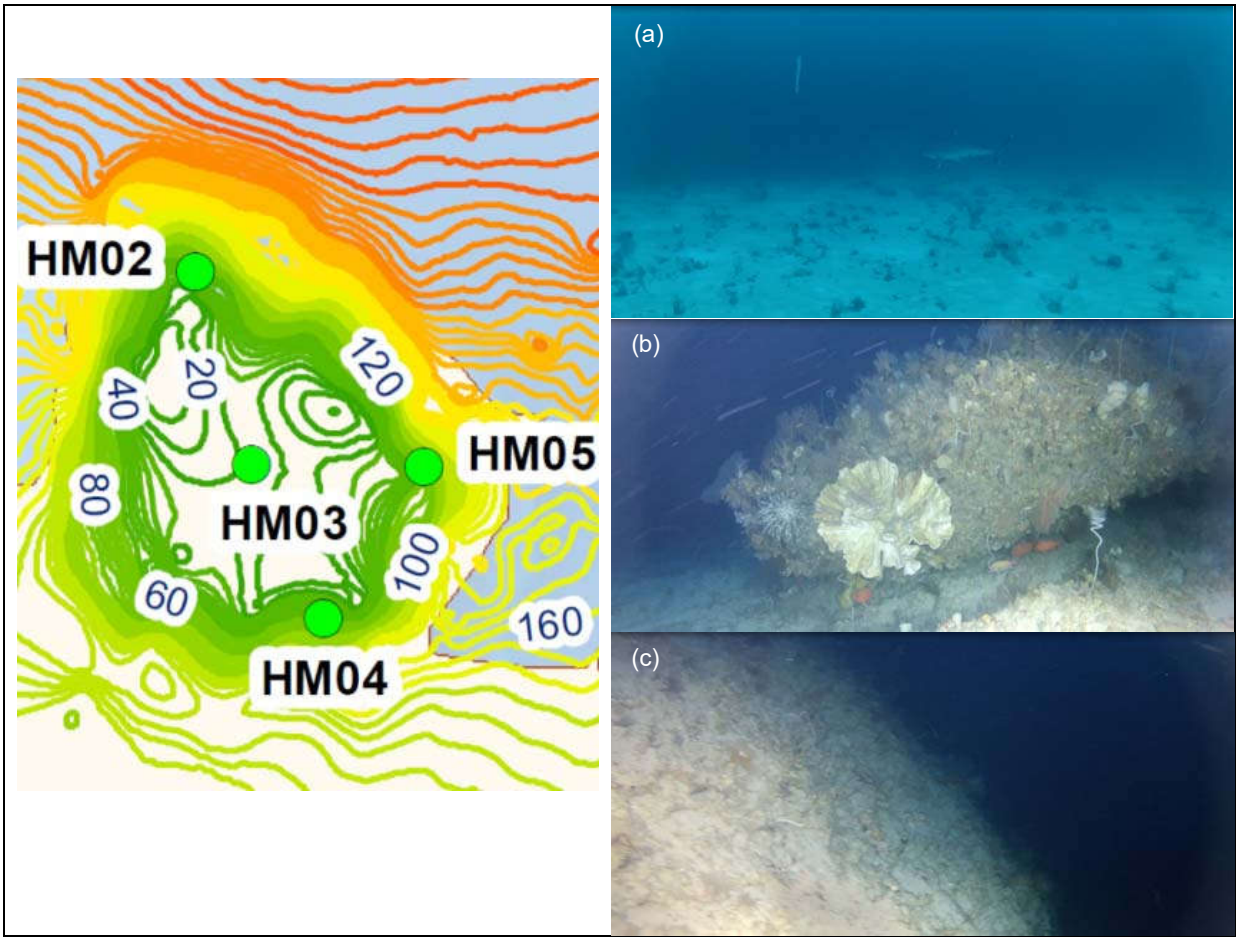


Figure 3-9: Location of sampling site HM05 (left) with habitats at this site found to include (a) sandy upper slope with silvertip shark (b) large boulder on reef slope with soft corals, feather stars, sea whips and squirrel fish, and (c) an example of the steep reef slope profile

HM02 – northern slope

HM02 was located on the northern slope of Evans Shoal (**Figure 3-10**), with transects starting at approximately 45 m water depth. The submerged reef flat alternated between areas dominated by plate coral, sub-massive coral (**Figure 3-10**) and macroalgae (including *Halimeda*) with sponges. Whitetip reef sharks and one tawny nurse shark were observed on the reef flat as were representatives from the fish families Labridae, Pomacentridae and Pomacanthidae. Small discrete piles of rubble were observed and were likely to be triggerfish nests. The crest of the shoal was approximately 80 m deep and was colonised by sponges, filter feeders and algae. The slope was predominantly rock and was reasonably steep and interspersed with small sand-covered ledges (**Figure 3-10**). The hard substrate of the slope supported communities dominated by sponges and filter feeders (such as gorgonians, feather stars, sea whips, sponges). One moray eel (Muraenidae) (**Figure 3-11**) and various species of fish were observed in the rocky overhangs. Representatives of fish families Chaetodontidae (butterflyfish), Carangidae (queenfishes, runners, scads and trevallies), Caesionidae (fusiliers), Serranidae (groupers and reef cod) and Holocentridae (squirrelfish) were also observed close to the reef slope. The slope profile shallowed into a sandy flat at approximately approximately 130 m water depth.

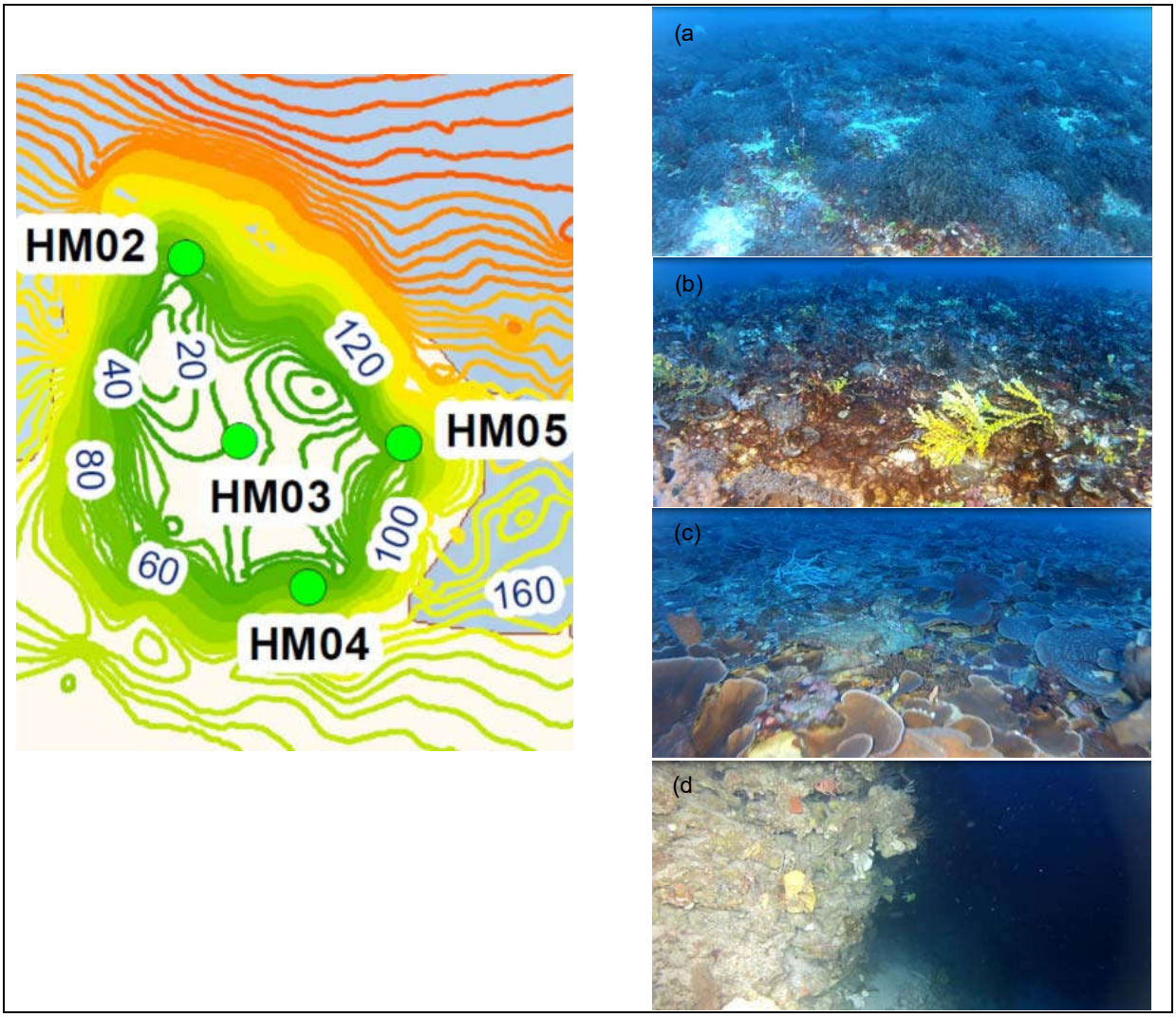


Figure 3-10: Location of sampling site HM02 (left) with representative habitats including (a) hard coral (*Goniopora* with tentacles out) on the reef flat (b) macroalgae and filter feeders on the reef flat (c) plate coral on reef flat and (d) steep rocky slope dominated by sponges and soft corals/filter feeders, with squirrelfish and a sandy ledge below

Figure 3-11: Moray eel in rocky overhang surrounded by sponges and gorgonians on reef slope at site HM02

3.1.4 Tassie Shoal

HM06 – reef top transect

HM06 was located on the submerged reef flat of Tassie Shoal in approximately 15 m water depth (**Figure 3-12**). The substrate consisted of sand, rubble and patchy reef structure. The reef structure was dominated by massive, sub-massive, plate and branching coral forms, and the hard substrate supported a range of sea whips, soft corals, *Halimeda* spp., turf algae and sponges. Feather stars, large clams and a decapod crustacean were recorded. A diverse range of tropical fish species were sighted including representatives from the families Labridae, Pomacentridae, Zanclidae, Pomacanthidae and Acanthuridae.

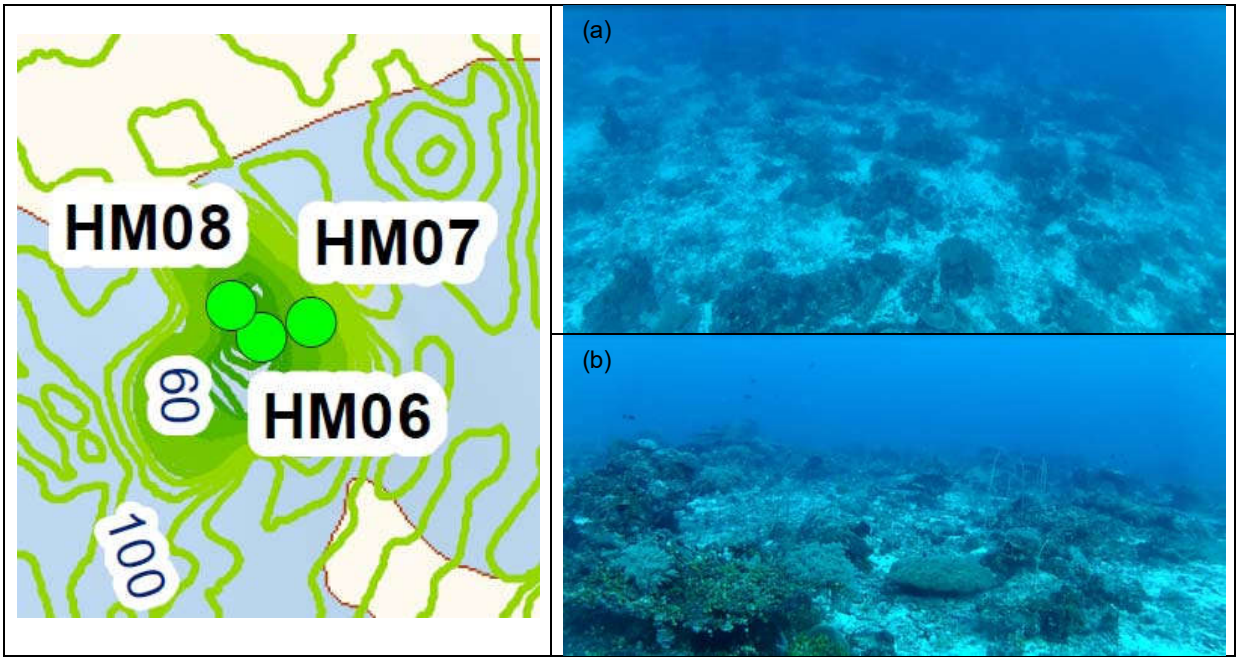


Figure 3-12: Location of sampling site HM06 (left) and images of (a) sand rubble substrate with patchy coral cover and (b) close up of substrate showing hard corals, soft corals, sea whips and *Halimeda* algae

HM07 – eastern slope

HM07 was located on the eastern crest and slope of Tassie Shoal, with the transect commencing in approximately 28 m water depth (**Figure 3-13**). The reef crest was dominated by hard coral, soft coral and sponges. *Halimeda* spp. were also observed, Butterfly fish (family Chaetodontidae), sea snakes and schools of Acanthurids (**Figure 3-13**) and Carangids were observed on both the reef flat and upper slope. The top of the reef slope (30–50 m) was dominated by sponges and soft corals, such as gorgonians and sea whips. A sea snake and a whitetip reef shark were observed at the bottom of the slope at around 48 m. At approximately 50 m the substrate became dominated by sand and rock and at 70 m began to flatten out and become dominated by sand.

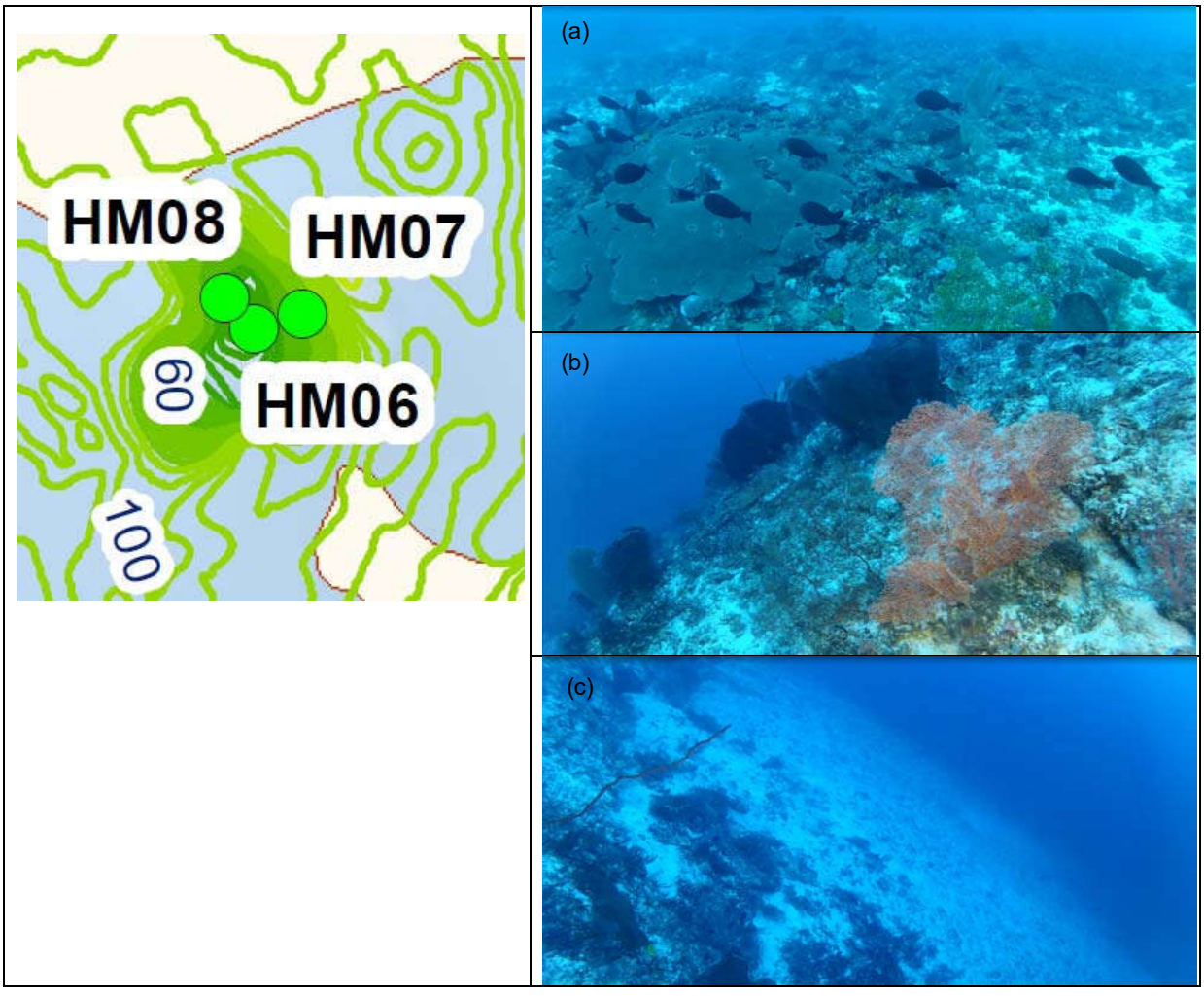


Figure 3-13: Location of sampling site HM07 (left) and images of (a) schools of Acanthurids (b) steep reef profile and predominantly hard substrate with soft corals (gorgonians) and sponges (c) sandy slope with patchy hard corals, whip corals and other filter feeders

HM08 – reef flat

HM08 was located on the submerged reef flat of Tassie Shoal in approximately 15 m water depth (**Figure 3-14**). The substrate was predominantly sand and rubble with hard corals (mostly comprised of plate, branching and massive forms) present although coral cover at this site was noticeably lower than at HM06. The hard substrate also supported a range of sponges, soft corals and *Halimeda* spp., and turf algae were seen growing on dead coral. The types of fish observed at this site appeared to be smaller, site attached fish. Two whitetip reef sharks were also observed.

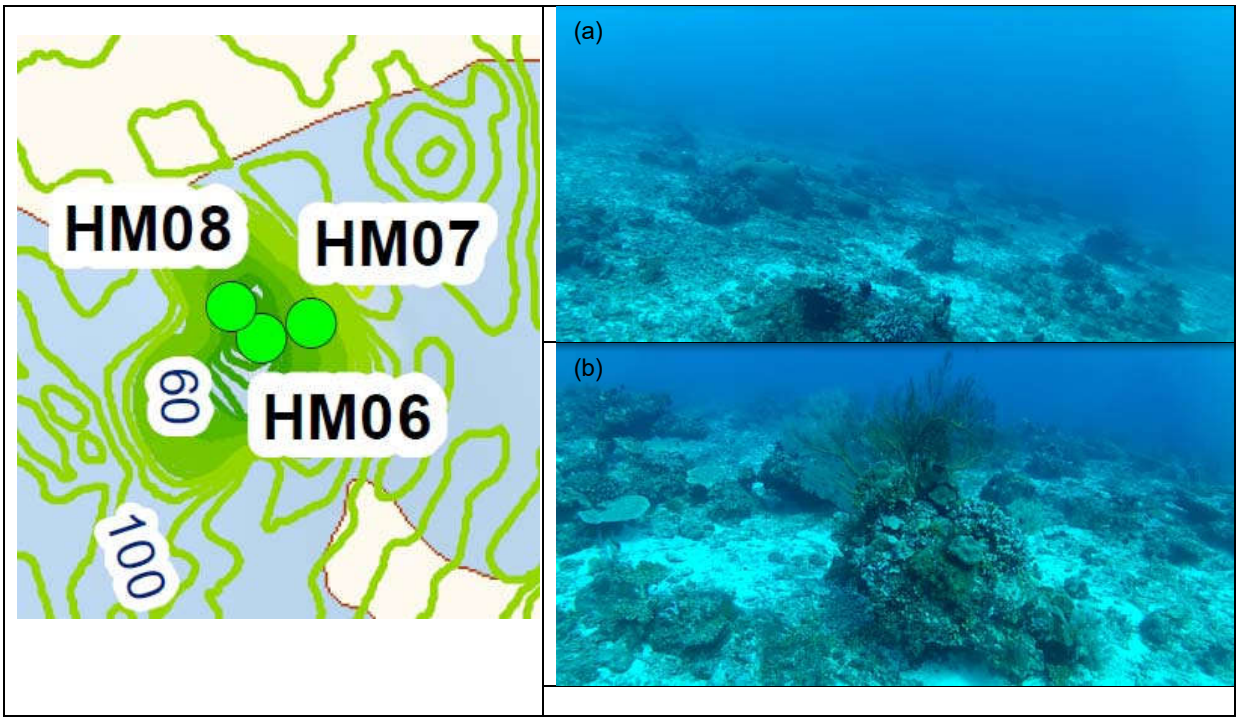


Figure 3-14: Location of sampling site HM08 (left) and images of (a) sand and rubble substrate with hard and soft corals and (b) close up of a coral bommie showing hard and soft corals (gorgonians)

3.1.5 Lynedoch Bank

HM024 – western slope

HM024 was located on the western slope of Lynedoch Bank, with the transect starting on the reef flat in approximately 20 m water depth (**Figure 3-15**). The reef flat was predominantly sand and rubble with hard corals (mostly branching, encrusting and massive forms), sponges and *Halimeda* spp. present. Small triggerfish (Balistidae) were common and sharks (most likely silvertip and whitetip reef sharks) were observed in the periphery of the frame (making identification of some individuals difficult). The reef crest was in approximately 40 m water depth and the slope was again dominated by sand and rubble, with occasional sponges, sea stars, sea cucumbers, and reef fish (Pomacanthidae) (**Figure 3-16**, **Figure 3-17**). The slope flattened out at approximately 70 m deep and became dominated by sand.

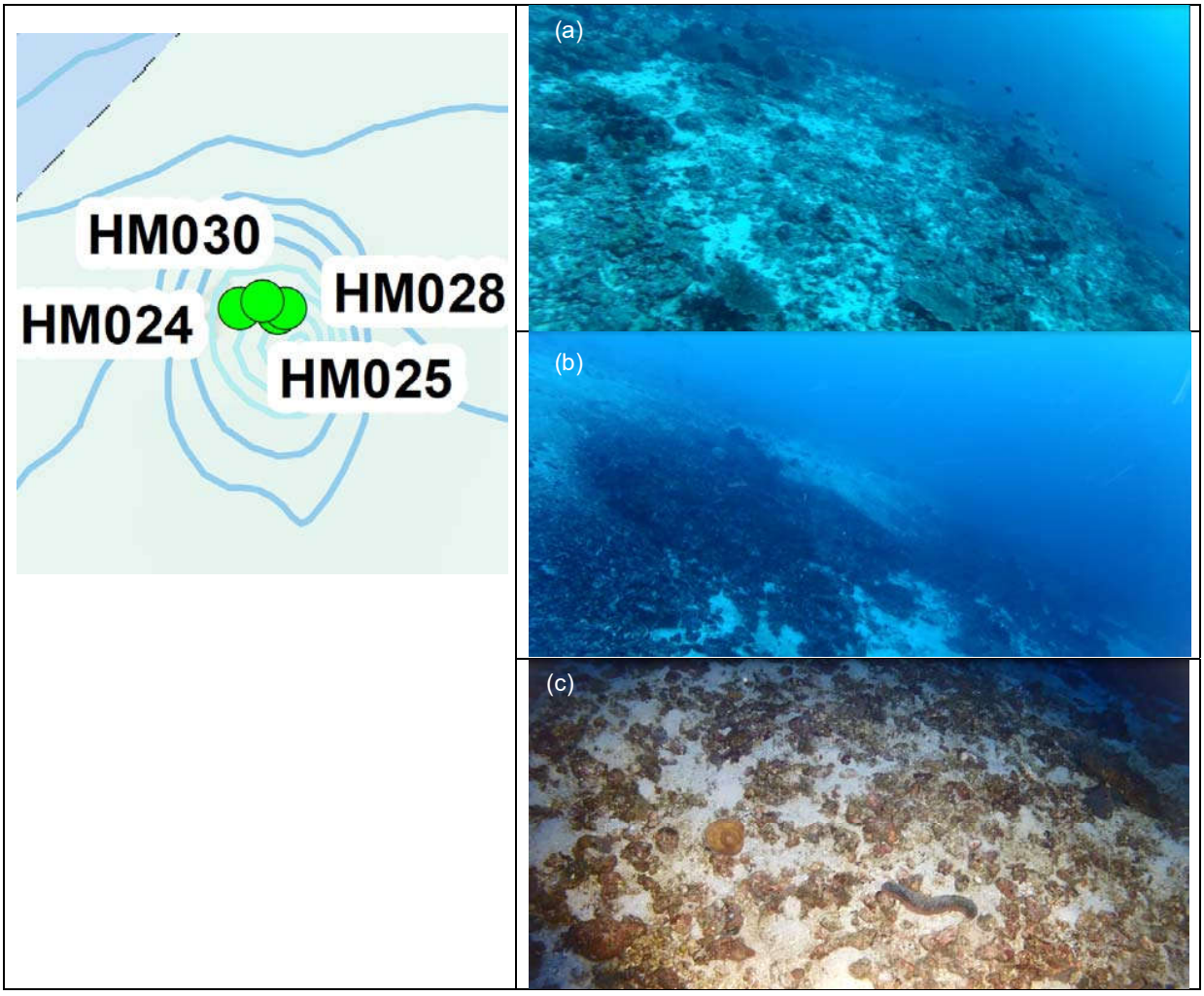


Figure 3-15: Location of sampling site HM024 (left) and images of (a) triggerfish and silvertip shark on reef flat (b) reef slope dominated by sand and rubble and (c) sand/rubble bottom with encrusting coralline algae and bryozoans, sponge and sea cucumber

Figure 3-16: Sea snake on slope at site HM024

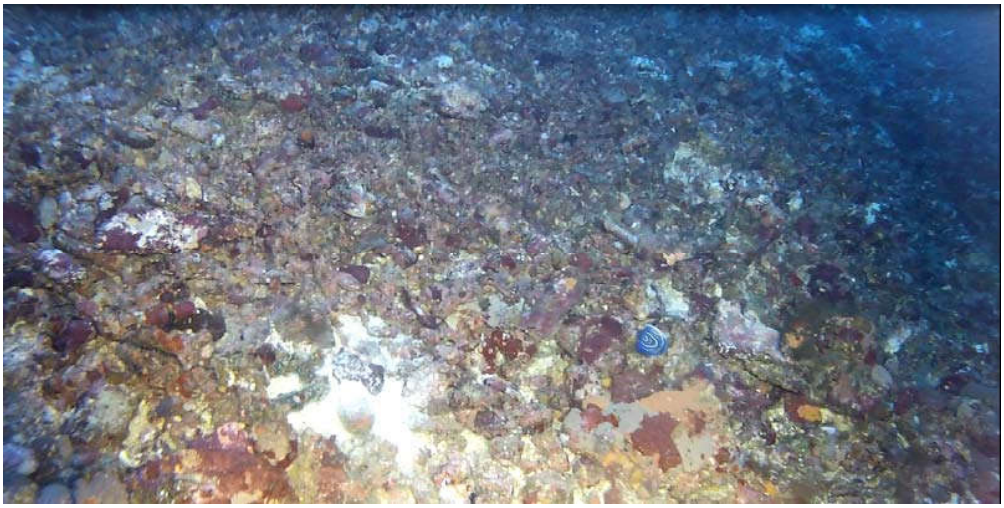


Figure 3-17: Juvenile angelfish on slope at site HM024

HM025 – reef flat

HM025 was located on the submerged reef flat of Lynedoch Bank, in approximately 16 m water depth (**Figure 3-18**). The reef flat was predominantly sand and rubble with hard corals (mostly branching, massive and sub-massive), sponges, soft coral and *Halimeda* spp. present. Small reef fish were common including representatives of the families Chaetodontidae, Labridae and Zanclidae. Whitetip reef sharks, a sea snake and a moray eel were also observed.

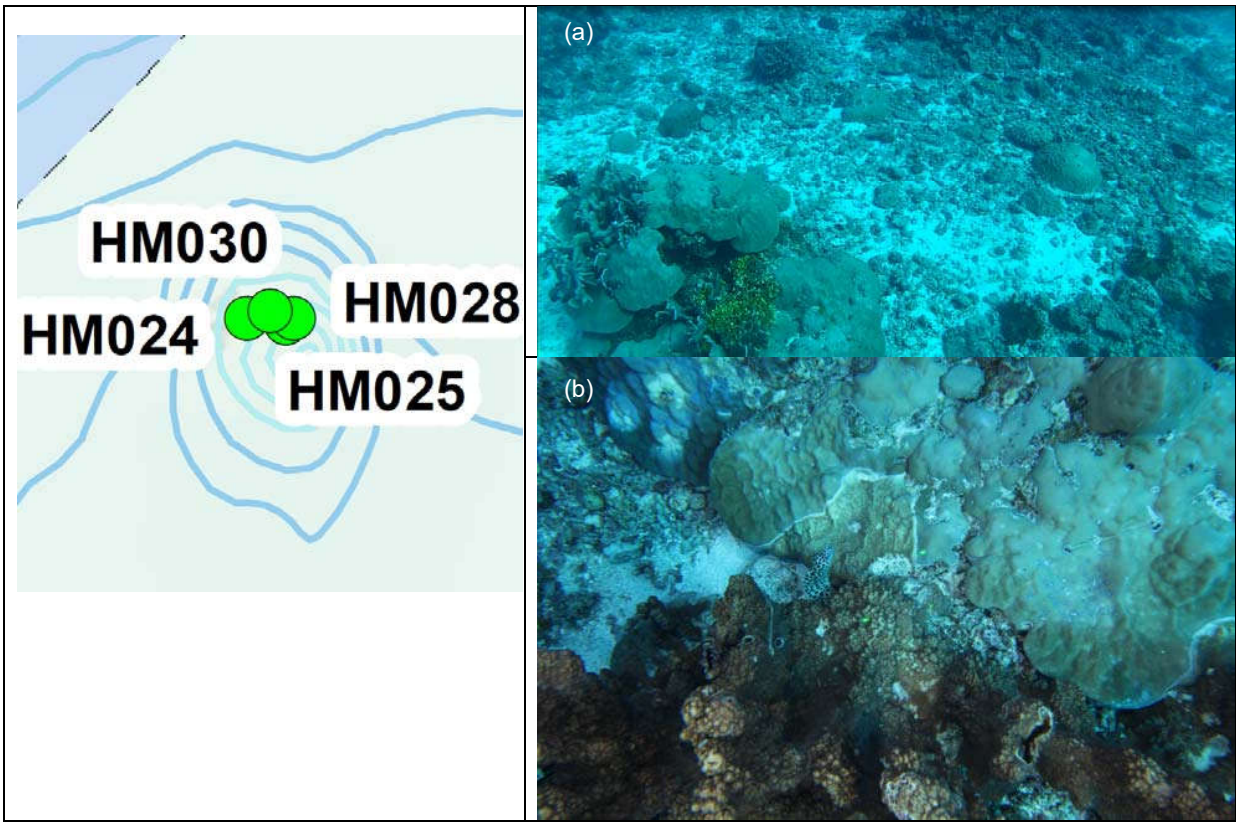


Figure 3-18: Location of sampling site HM025 (left) and images of (a) patchy sand and rubble with hard corals (branching, massive and sub-massive forms), sponges and *Halimeda* spp. and (b) moray eel in hard coral habitat

HM028 – eastern slope

HM028 was located on the eastern slope of Lynedoch Bank, with the transect starting on the reef flat in approximately 26 m water depth (**Figure 3-19**). The reef flat was predominantly sand and rubble with hard corals (mostly branching, encrusting and massive forms) and soft corals present. The reef sloped gently to a depth of approximately 85 m. The slope was predominantly sand and rubble and there was a noticeable low abundance of fish, sharks and other motile biota.

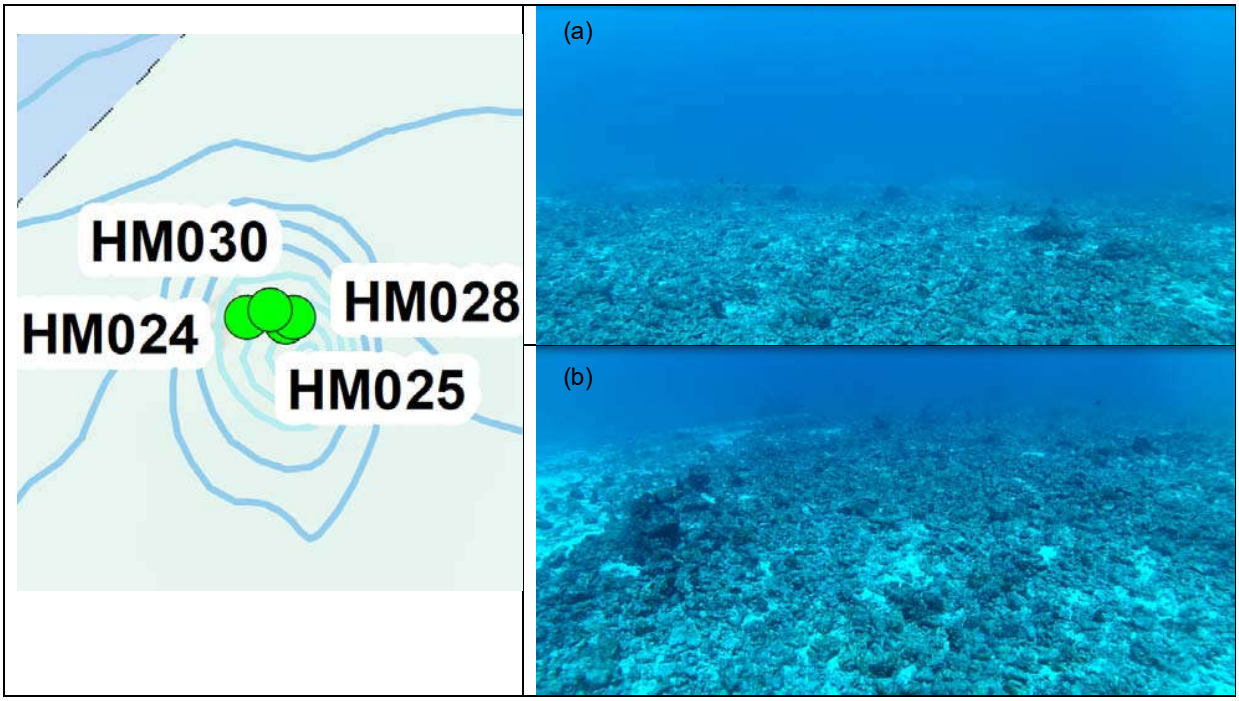


Figure 3-19: Location of sampling site HM028 (left) and images of (a) sand/rubble slope with whitetip reef shark and (b) sand/rubble slope with angelfish

HM030 – reef flat

HM030 was located on the submerged reef flat of Lynedoch Bank, 500 m north-west of HM025 in approximately 16 m water depth (**Figure 3-20**). The substrate on the reef flat was sand and rubble with hard corals (mostly branching and sub-massive forms), sponges and *Halimeda* spp. present. Small triggerfish were common as were other small reef fish including representatives of the families Chaetodontidae, Labridae and Zanclidae. Whitetip reef sharks were also observed.

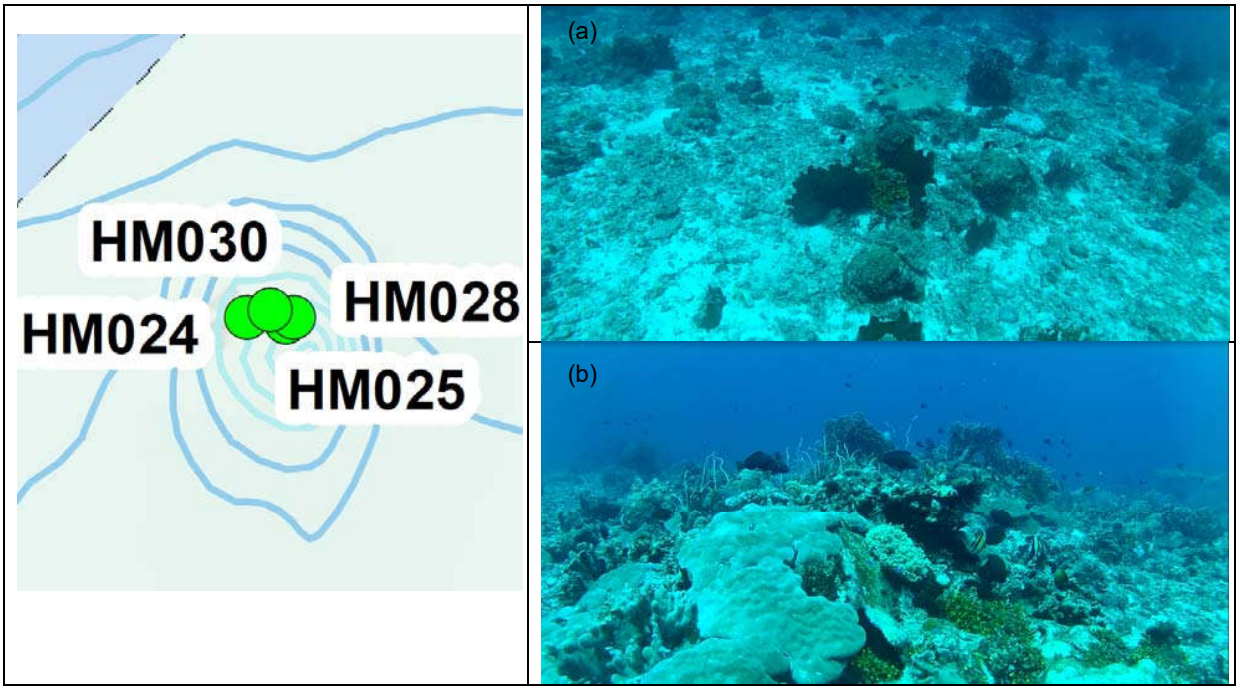


Figure 3-20: Location of sampling site HM030 (left) and images of (a) hard substrate with rubble and a coarse sand veneer with outcrops of hard and soft corals on the reef flat, and (b) hard and soft coral substrate with *Halimeda* sp. algae, reef fish and a whitetip reef shark

3.1.6 Seamounts (west of the permit area)

HM010A

HM010A was located on the south-eastern slope of a seamount approximately 35 km west of the permit area (**Figure 3-21**). The transect started in approximately 77 m water depth and ended at a depth of approximately 170 m. The substrate at the top of the transect was predominantly sand and rubble, with the occasional sea whip and holothurian. Numerous silvertip sharks were observed in this area to a depth of approximately 100 m. The edge of the seamount occurred at approximately 100 m depth. Small discrete piles of rubble were observed and were likely to either be fish nests or as a result of tidal/current action. Gorgonians, sea whips and other soft corals were also recorded. The slope was rock with small patches of sand deposits and sponges and soft corals occurred on the hard substrate. Individual and schools of fish were very common on the slope including representatives of the families Acanthuridae, Lutjanidae, Caesionidae, Serranidae and Zanclidae. At around 130 m depth, a large grey nurse shark with a wide girth was observed, which may have indicated a pregnancy. Three other grey nurse sharks (including at least one male) were also observed cruising back and forth to a depth of approximately 160 m (**Figure 3-21**). The transect ended in sand with large boulders that supported sponges and hard coral.

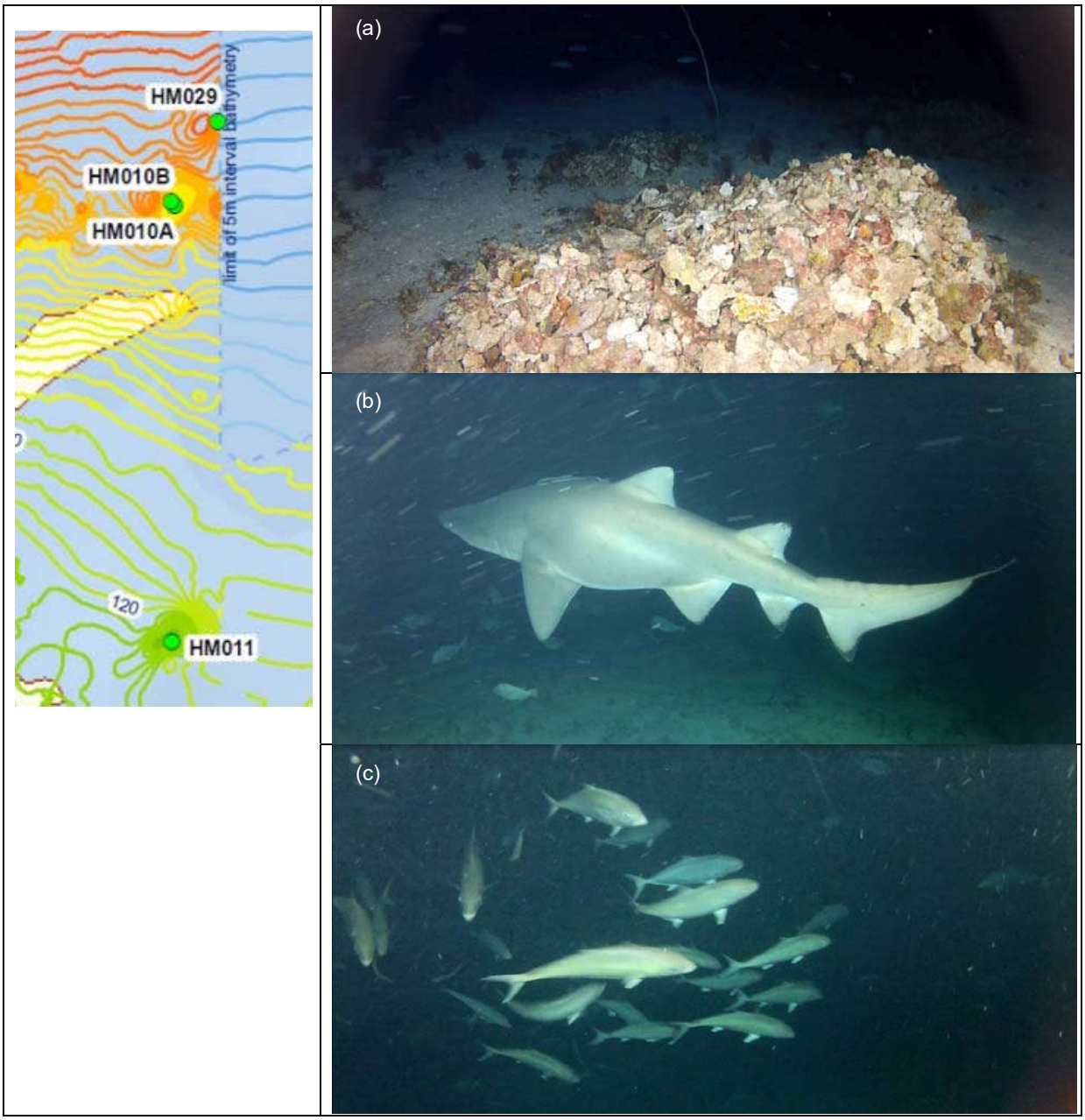


Figure 3-21: Location of sampling site HM010A (left) and images of (a) piles of rubble potentially from fish nests or tidal /current action, (b) grey nurse shark, and (c) school of trevally (family Carangidae)

HM010B

HM010B was located on the top of the same seamount as HM010A, in approximately 77 m water depth (**Figure 3-22**). The top of the seamount was sand and algae-covered rubble with soft corals and sponges also present. Small triggerfish were very common as were schools of Caranigae and Lutjanidae. Representatives of the families Labridae, Pomacentridae and Zanclidae as well as silvertip sharks were also observed.

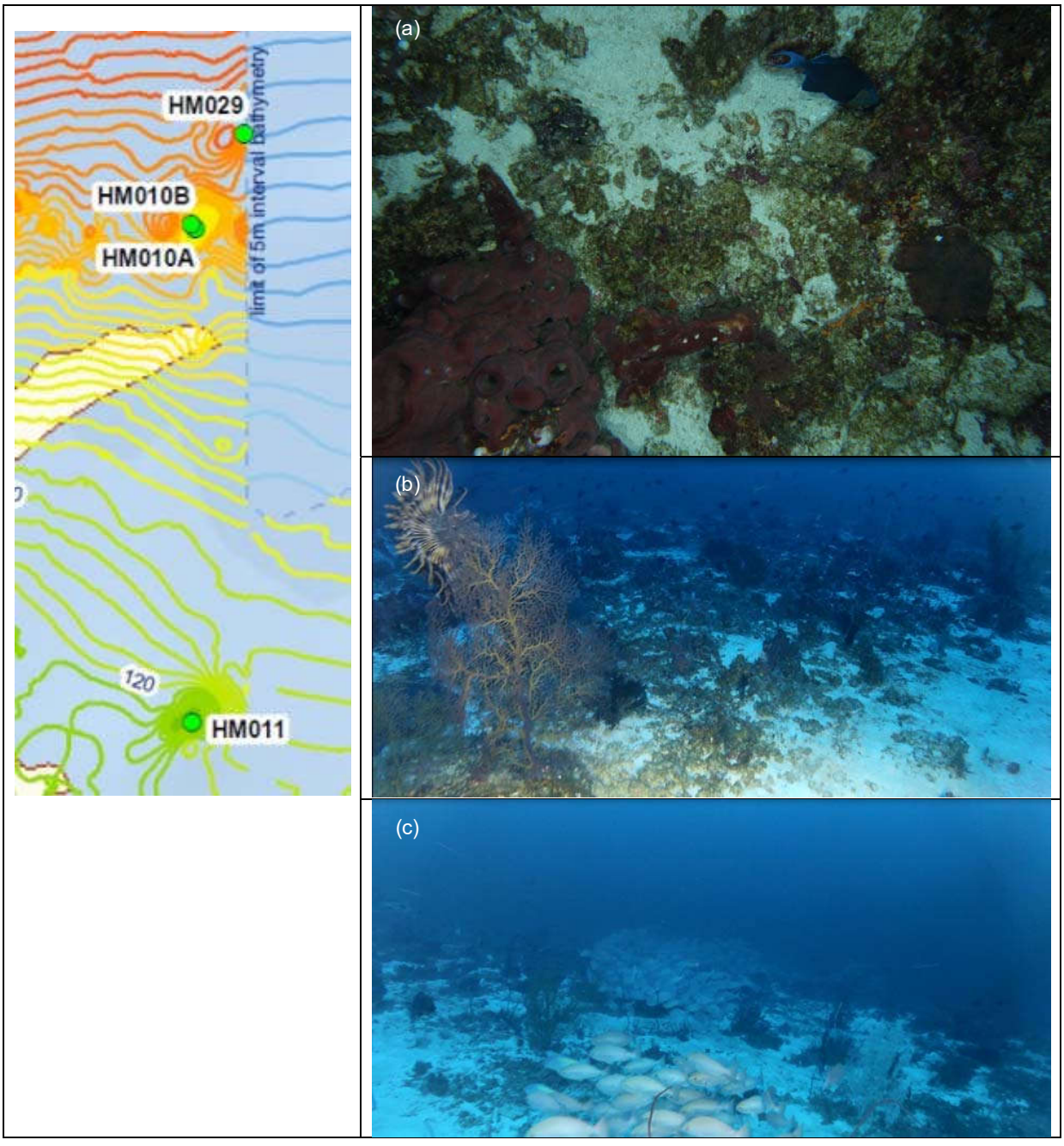


Figure 3-22: Location of sampling site HM010B (left) and images of (a) triggerfish, (b) substrate with soft coral (gorgonians) and feather star, and (c) school of Lutjanidae

HM029

HM029 was located on the eastern slope of a seamount, 6 km north-north-east of HM010A (**Figure 3-23**). The transect started in approximately 80 m water depth and the substrate was predominantly sand, rubble and algae with the occasional sea whip, sponge, soft coral and sea cucumber. Small triggerfish (family Balistidae) were observed in areas with rubble. Gorgonians begin to appear at approximately 90 m water depth, and this habitat continued to the reef edge in approximately 100 m water depth. The slope had a rocky face with coarse sand deposits, with the hard substrate supporting sea whips, sea fans, other soft corals and sponges. At approximately 130 m water depth a school of trevally (family Carangidae), members of the Lutjanidae family and a silvertip shark were recorded. A nautilus shell was found at 178 m depth. At 190 m water depth the substrate was sand with an occasional large boulder. Representatives of the Holocentridae family were observed on these boulders. A small ray was also observed in the sand at 220 m water depth where the transect concluded. It is estimated from the vessel sounder that the seamount continued to a depth of 260 m.

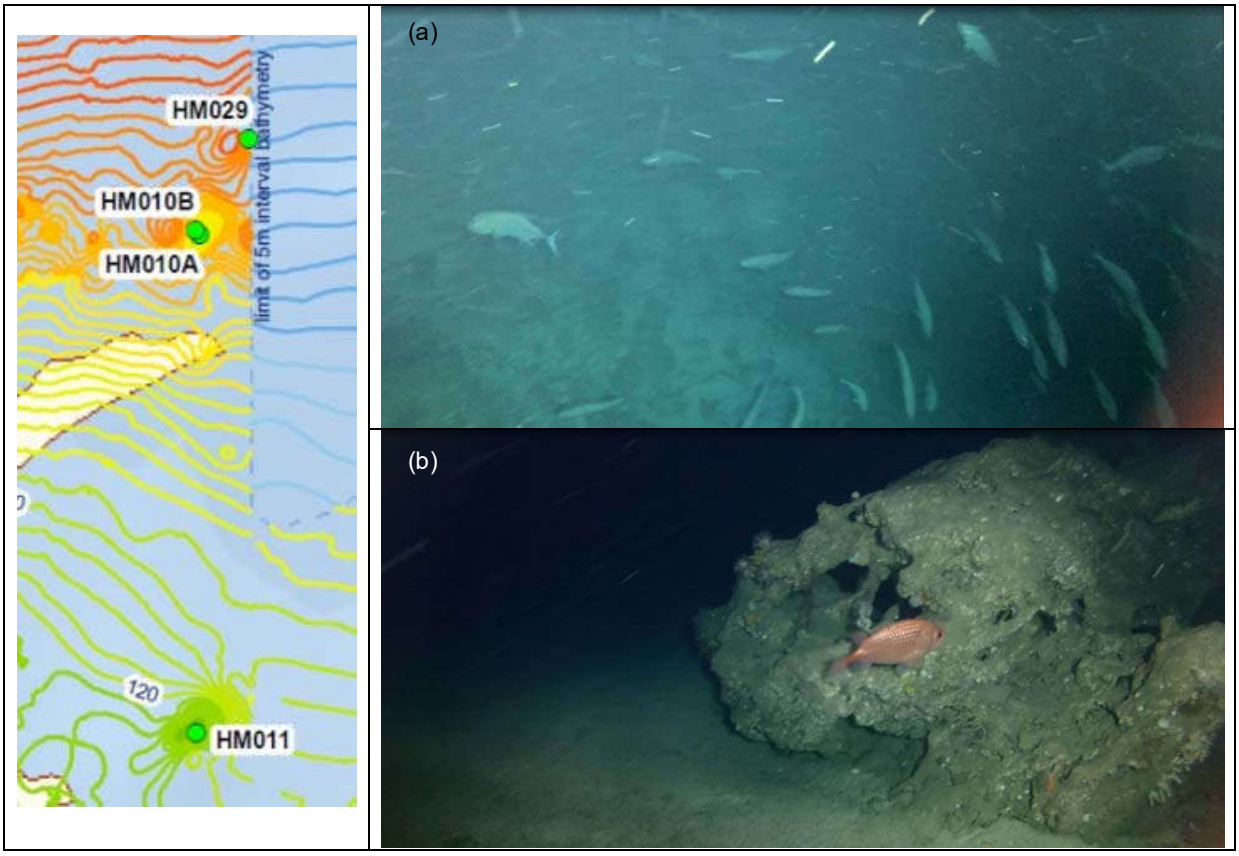


Figure 3-23: Location of sampling site HM029 (left) and images of (a) school of trevally and (b) a squirrel fish (family Holocentridae) near boulders at the base of the slope

HM011

HM011 was located on a seamount, 28 km east of Tassie Shoal (**Figure 3-24**). The top of the seamount was in approximately 50 m water depth and was predominantly sand, rubble, algae and soft coral. Large circular areas were recorded where surface rubble had been removed exposing the sand and clean coral rubble beneath. These appeared to be nests made by trigger fish. Nests were excavated reasonably close together and over a large area, with trigger fish were observed in the vicinity. A silver tip shark and a sea snake were also observed. The lower section of the slope was mostly rock ledges and sand patches, with sea whips, filter feeders and sponges present. Larval or juvenile fish were observed on the edge of the rock ledges at 78 m and 85 m.

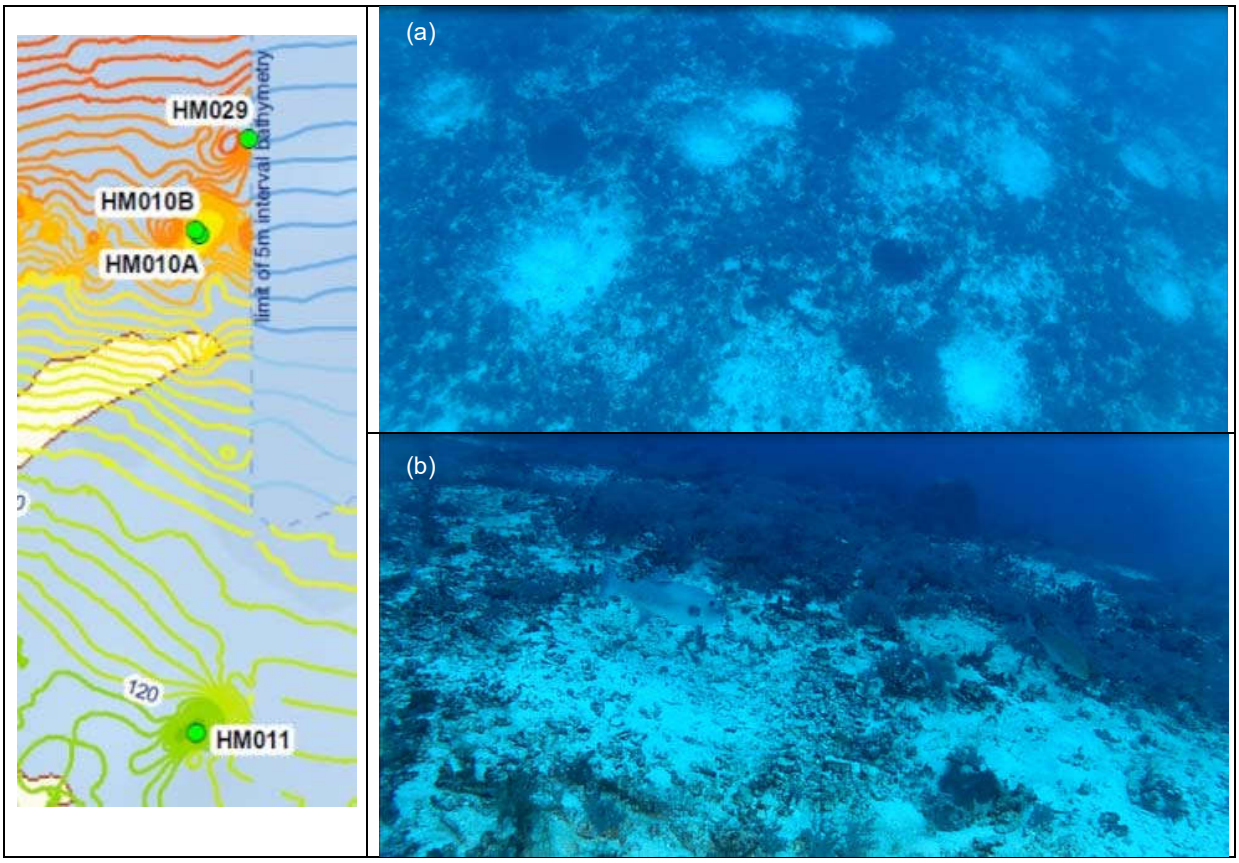


Figure 3-24: Location of sampling site HM011 (left) and images of (a) distribution of triggerfish nests and (b) close up of triggerfish near the nests

3.1.7 Scarps (south of the permit area)

HM019

HM019 was located on a scarp feature 10 km south of the permit area (**Figure 3-25**). The scarp ran in a north-south direction with the shallower side of the scarp (western side) in approximately 160 m water depth and the deeper side of the scarp (eastern side) in approximately 185 m water depth. The higher side appeared to be unbroken rock covered in silty sand and hydroid/bryozoan turf. Gorgonians, sea whips and other filter feeders and sponges were reasonably common on this substrate. The scarp profile was rock boulders and consolidated shell grit and sediment. Feather stars, gorgonians and other filter feeders were present on the slope. The lower side of the scarp was predominantly sand. One deep water snapper species (possibly gold band snapper) was observed in a rocky overhang at the base of the slope and small silver fish and one ray were observed on the sand flat.

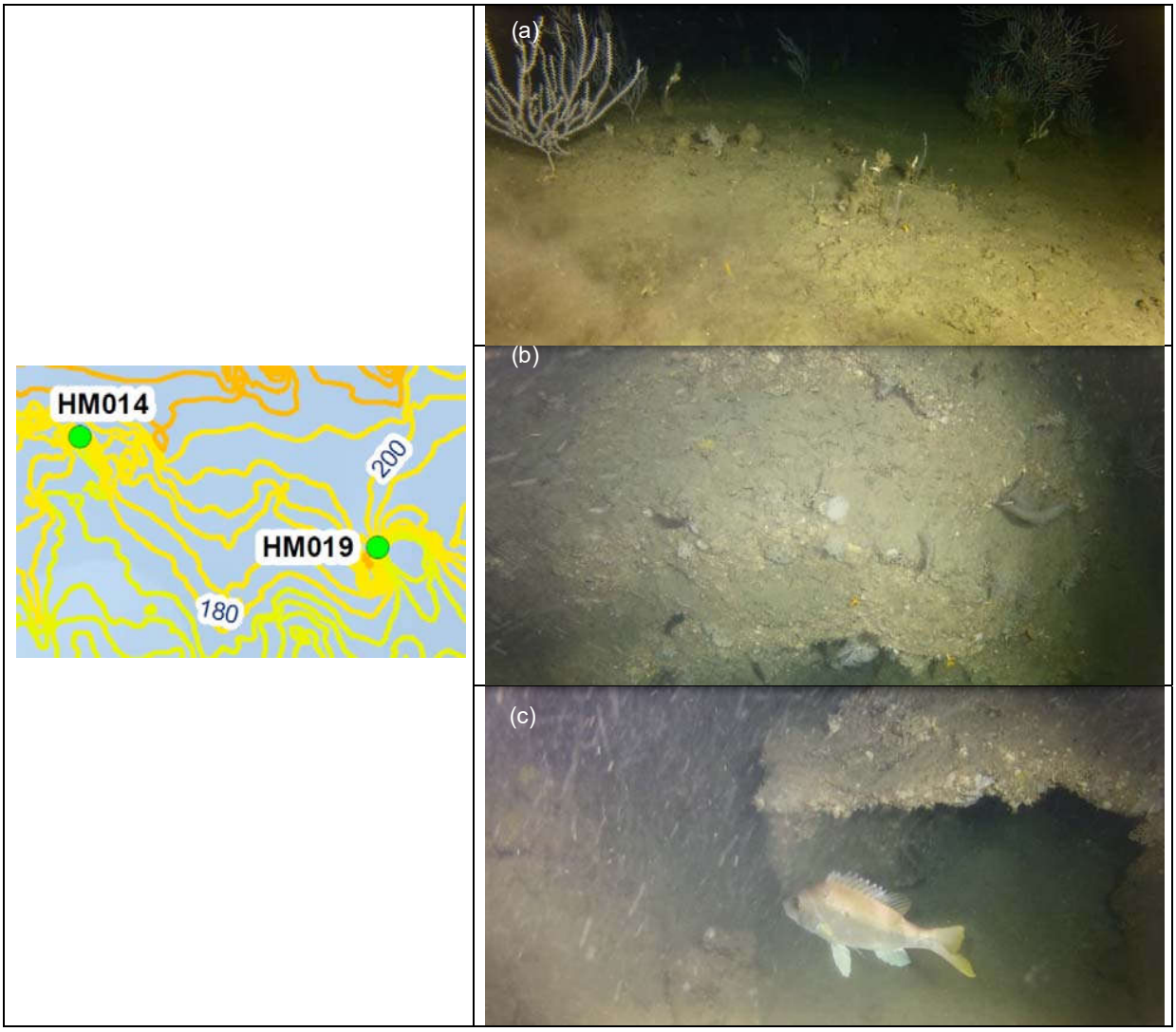


Figure 3-25: Location of sampling site HM019 (left) and images of (a) rocky substrate covered with silty sand with gorgonians and other filter feeders on the high side of the scarp, (b) rocky scarp profile with filter feeders, and (c) deepwater representative from family Lutjanidae in rocky overhang and base of scarp

HM014

HM014 was located on another scarp feature approximately 5 km south of the permit area and 13 km west of HM019 (**Figure 3-26**). The scarp ran in a north-westerly to south-easterly direction with the bottom of the scarp in 190 m water depth. The slope here appeared to be shorter than at HM019 (2–4 m), although the substrate and biota were very similar to that observed at HM019. The shallower side of the scarp (south-western side) appeared to be unbroken rock covered in silty sand and hydroid/bryozoan turf with gorgonians, feather stars and other filter feeders common on this substrate. The scarp profile was comprised of rock boulders and consolidated shell gravel and finer particulate sediment. Feather stars, gorgonians and other filter feeders also appeared on the slope. The deeper side (north-east) of the scarp was predominantly sand.

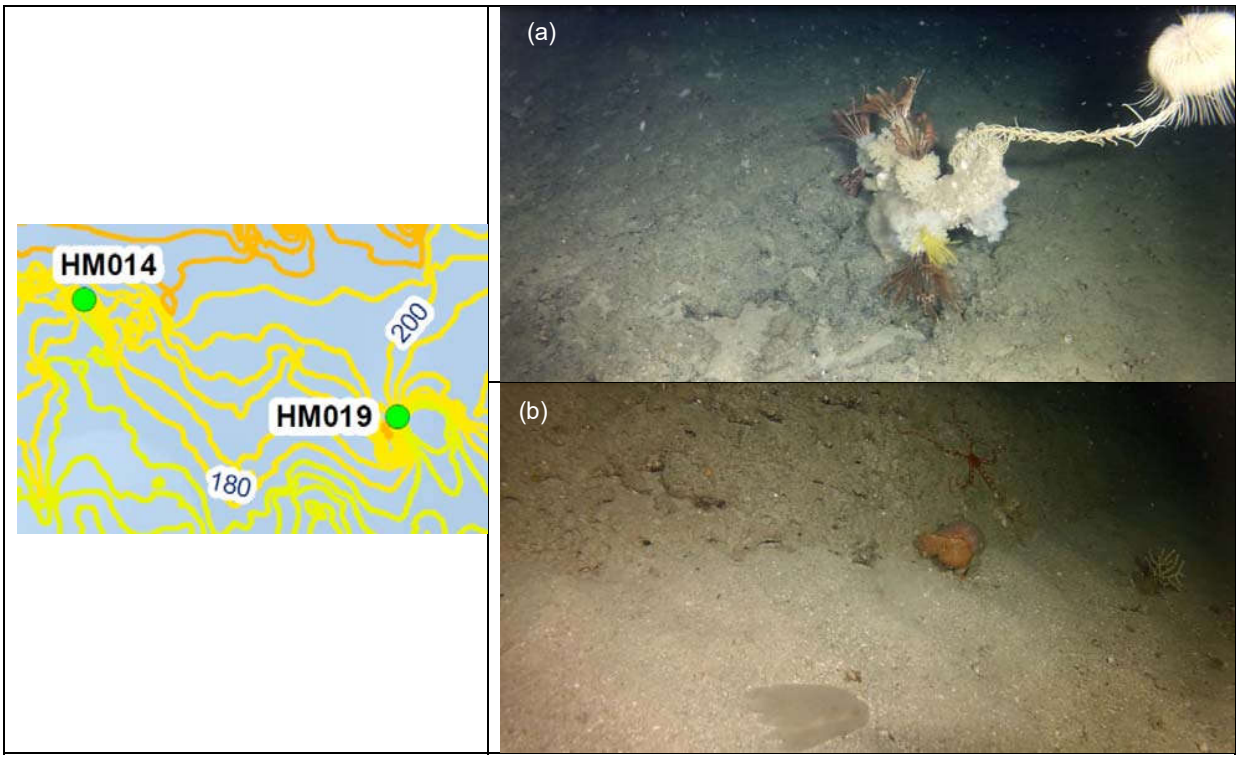


Figure 3-26: Location of sampling site HM014 (left) and images of (a) feather stars on soft coral and (b) crinoid, soft coral and hermit crab at bottom of scarp

3.2 Multidimensional scaling results

MDS was performed on the presence/absence data to determine the similarity between habitats. Raw presence/absence data are provided in **Appendix B**.

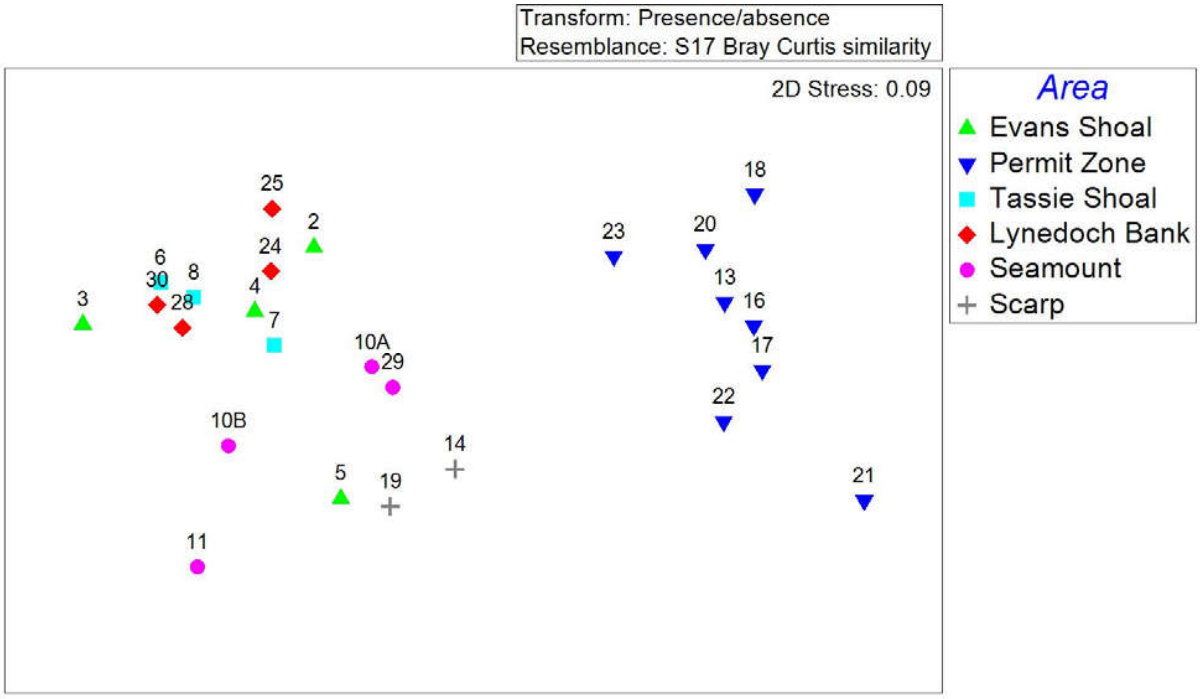


Figure 3-27: MDS plot of sampling sites

The MDS plot (**Figure 3-27**) shows that the sites in the permit area were grouped closely together and away from other sites. This indicates that the permit area sites were similar to each other, but relatively different to the other sites. This is most likely due to the depth and substrate type of these sites. The permit area sites were all deeper than 200 m and the substrate type was predominantly silty sand. The other sites were not clustered as closely together as the permit area sites, indicating more variation among these sites. The shoals and bank sites were generally similar, most likely due to similarities in depth and structure type, meaning reef habitat and biotic assemblages on the reef flats and slopes were reasonably similar. The seamounts and scarps sites appeared to group out separately and potentially due to the depths they occurred at and that they lacked the reef top communities of the banks and shoals (again due to water depth). The eastern slope of Evans Shoal (site HM05) appeared to be more similar to the scarps and seamounts. This slope was noticeably sparser and lacked the diversity in habitats and biota observed on the other slopes, again potentially due to the deeper depth at which this transect started.

4. Discussion

The benthic habitat survey aimed to characterise the distribution of benthic habitats and biota in the immediate vicinity of the Barossa field, from across the broader region, and from areas of regional interest including shoals and banks and areas with complex topography. Sites surveyed ranged in depth from around 10 m–30 m on top of shoals and banks through to 309 m at the deepest site in the permit area.

Three main groupings of benthic habitat types were identified in the MDS plot; the permit area; the banks and shoals; and the seamounts and scarps.

The permit area is located on a plain in 200 m–300 m of water. This area represents the least complex geomorphic features of the Joseph Bonaparte Gulf and the Timor Sea, comprising homogenous flat, soft sediments (Przeslawski et al. 2011). The seabed observed in the permit area was predominantly silty sand lacking in any hard substrate, with relic sea bed features (namely sand waves <25 cm in height) widespread. Due to the lack of hard substrate, the associated epibenthos was expected to be sparse. Fauna groups included octocorals (particularly sea pens) and motile decapod crustaceans (mostly prawns and squat lobsters) and were observed in relatively low numbers. However, it must be noted that bioturbation (burrows, mounds and tracks) was frequently recorded, and many burrow-living decapods (such as prawns) may be more active at dawn, dusk or at night in habitats which lack cover (Taylor and Ko 2011) and hence less likely to be recorded during daylight surveys. These results are similar to those reported in comparable offshore surveys. Surveys around the Greater Poseidon Field in the Browse basin (Jacobs 2013), approximately 970 km south-west of the permit area and in 450 m–550 m water depth, found the substrate was flat, silty sand and that epibenthic macroinvertebrates such as crinoids, filter feeders and decapod crustaceans were common. Surveys for the Sunrise Gas Project (Sinclair Knight Merz 2001), approximately 200 km north-west of the permit area and in 160 m water depth, found that epifauna were sparse and were predominantly comprised of hydroids, sponges and crinoids.

Given the lack of topographic features in the permit area, fish abundance was expected to be low in this survey. Conversely, approximately 20 types of teleost fish were observed within the permit area in varying densities and diversities across the sites. The Greater Poseidon survey (Jacobs 2013) recorded only ten types of teleosts, which may have been a function of the deeper bathymetry or potentially the amount of food sources available (of which bioturbation is one indicator). Prior to this survey, not much was known about the habitat and biota of the permit area. However, based on the bathymetry and expected geomorphological features of the permit area and in comparison with surveys conducted across the wider region, the habitat and biota observed within the permit area was generally as expected. The MDS plot showed that the permit area sites were considerably different from all of the other sites surveyed based on the less diverse habitat features and biota present at these sites.

The shoals to the west of the permit area (Evans Shoal and Tassie Shoal) and the shallow bank to the east (Lynedoch Bank) were expected to be similar in habitat and biota type to other submerged shoals and banks in the broader area. The MDS plot showed that the shoals and bank sites were very similar to one another, likely due to the similar depths at which these features occurred, as well as the consistent substrate type. One exception to this was the eastern slope of Evans Shoal, which was more similar to a scarp feature, most likely due to the depth where this feature occurred, and possibly also due to greater exposure to predominant currents and weather. The substrate on the reef flats was generally sand and algae-covered rubble with communities dominated by hard corals, soft corals and sponges which were present in varying degrees of diversity and abundance. Gorgonians and sea whips often dominated the crests, whereas the hard substrate of the slopes predominantly supported sponges and filter feeders (such as gorgonians, feather stars, sea whips). Of particular note were the northern and southern slopes of Evans Shoal; both slopes supported large areas of dense plate coral (at 40 m–50 m water depth) and the northern slope also supported large areas of dense sub-massive coral in approximately 47 m water depth. These slopes supported a diverse range of fish species typical of reef fish assemblages (families Pomacentridae, Pomacanthidae, Chaetodontidae, Labridae Zanclidae and Ballistidae) as well as pelagic species (families Carangidae and Caesionidae). Whitetip reef and silvertip sharks were also observed at a number of sites. Similarly, Heyward et al. (1997) found some banks of the Big Bank Shoals to be coral-dominated systems with a reefal structure and that as many as 200 species of fish may inhabit each hectare of coral reef in the shoals. In a 2011 GeoScience Australia (GA) survey, raised geomorphic features were found to support sponge and octocoral gardens that in turn provided habitat for other fauna (Przeslawski et al. 2011) and reef-forming hard corals were found on the banks of the Van Diemen Rise

(approximately 100 km south-west of the permit area) but were rare in other areas surveyed. These hard coral communities were often dense (up to 90% cover) but overall cover was very low (<1%), whilst octocorals were found to be a major habitat forming taxa on the seafloor across all surveyed sites (Przeslawski et al. 2011). The corals found on the GA survey were diverse and potentially distinct from those found elsewhere in northern Australia and included five species that were on the International Union for Conservation of Nature (IUCN) Red List (considered near threatened, vulnerable and endangered) (Przeslawski et al. 2011). Analysis of the stills images captured during the Barossa benthic habitat survey may be useful to provide robust comparative data on the community composition and cover estimates for comparison with other surveys undertaken in the area. It may also be feasible from the image analysis to determine whether these banks and shoals contain threatened coral species.

The habitat and biota of the seamounts and scarps in the study area were previously unsurveyed. The tops of the seamounts were generally in 50 m–80 m water depth and the substrate was predominantly sand and rubble. The hard substrate of the slope supported epibenthic communities dominated by sponges and filter feeders (such as gorgonians, feather stars, sea whips). Of particular note, at one seamount (HM010A) four grey nurse sharks were observed in approximately 130 m water depth including at least one female that appeared to be pregnant. This was considered unusual as neither the east or west coast populations are known to extend that far north and are generally associated with shallower, more coastal waters (DoE 2015). However, a recently published paper recorded four grey nurse sharks (three female, one male) being caught in the vicinity of Browse Island (offshore Western Australia) and describe the catch as the first known from the Timor Sea (Momigliano and Jaiteh 2015). It is unknown whether the individuals observed during this survey would be linked to the east (listed as critically endangered) or west coast (listed as vulnerable) populations, or another discrete population. Internationally, the species is listed as vulnerable in the IUCN Red List of Threatened Animals (IUCN 2015).

Triggerfish nesting areas were apparent at the seamounts, and the triggerfish appeared to make depressions in the sand and rubble at the top of the southernmost seamount surveyed. Triggerfish were observed in and around these depressions. At a seamount directly west of the Barossa field (HM010A), small, discrete piles of rubble had been accumulated that also may have been fish nests or as the result of tidal/current movement. These piles were also observed on the northern slope of Evans Shoal. The seamounts also appeared to support schools of fish (predominantly from families Lutjanidae, Carangidae and Caesionidae) both on the top of the seamount and at depth. Goldband snapper individuals were tentatively identified at depth at seamount sites, with one individual also observed at the scarps south of the permit area.

The MDS plot showed that the seamount and scarp sites were not as similar to one another as the shoals and bank sites, but this was likely due to the deeper depth of these sites. The substrate on the scarps south of the field appeared to be hard bedrock pavement at the top of the scarp, with a rocky profile along the ridge and sand habitats at the base, with both sites appearing very similar. Not only did the scarps provide hard substrate for filter feeders and sponges, but this is also important information that can be relevant for engineering in the planning of a potential pipeline route to Darwin.

This benthic habits survey identified several different habitat groupings that were predominantly influenced by depth and habitat type. The habitats with the lowest diversity occurred within the permit area, whilst the habitats with the highest diversity occurred at the shoals and banks sites, which were the survey sites located furthest from the permit area.

In summary, the results of this survey further contribute to an appropriate baseline characterisation, to inform risk assessment, of the benthic habitats and biota in the permit area and broader regional surrounds, particularly nearest seabed features of interest.

5. References

Consulting Environmental Engineers (2002) *Environmental Impact Statement for Tassie Shoal Methanol Project*. Prepared for Methanol Australia Limited by Consulting Environmental Engineers, Richmond, Victoria

Department of the Environment (DoE) (2015) *Grey Nurse Shark (Carcharias taurus)*. Department of the Environment, Commonwealth of Australia, Canberra, Australian Capital Territory. Available at <http://www.environment.gov.au/marine/marine-species/sharks/greynurse> [Accessed 23 June 2015]

Department of Sustainability, Environment, Water, Population and Communities (2012) *Marine Bioregional Plan for the North Marine Region*. Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory

Heyward A, Pinceratto E and Smith L (1997) *Big Bank Shoals of the Timor Sea: An Environmental Resource Atlas*. Australian Institute of Marine Science, Science Communications Section, Melbourne, Victoria

International Union for Conservation of Nature (IUCN) (2015) *IUCN Red List of Threatened Species, 2015.2*. International Union for Conservation of Nature, Cambridge, UK. Available at <http://www.iucnredlist.org/> [Accessed 23 June 2015]

Jacobs (2013) *Browse Basin Environmental Studies, Poseidon Gas Field – Survey 2 Field Report*. Prepared for ConocoPhillips Australia Exploration Pty Ltd by Jacobs Group (Australia) Pty Ltd, Perth, Western Australia

Jacobs (2015) *Barossa Environmental Studies: Benthic Habitat Field Sampling Plan*. Prepared for ConocoPhillips Australia Exploration Pty Ltd by Jacobs Group (Australia) Pty Ltd, Perth, Western Australia

Momigliano P and Jaiteh VF (2015) *First records of the grey nurse shark Carcharias taurus (Lamniformes: Odontaspididae) from oceanic coral reefs in the Timor Sea*. Marine Biodiversity Records 8, March 2015

Przeslawski R, Daniell J, Anderson T, Barrie JV, Heap A, Hughes M, Li J, Potter A, Radke R, Siwabessy J, Tran M, Whiteway T and Nichol S (2011) *Seabed Habitats and Hazards of the Joseph Bonaparte Gulf and Timor Sea, Northern Australia*. Geoscience Australia, Record 2011/40, pp. 69

Taylor MD and Ko A (2011) Monitoring acoustically tagged king prawns *Penaeus* (*Melicertus*) *plebejus* in an estuarine lagoon. *Marine Biology* **158:** 835-844

URS (2005) *Caldita-1 Pre-drilling Marine Environmental Survey 2005*. Prepared for ConocoPhillips Australia Exploration Pty Ltd by URS Australia Pty Ltd, December 2005

URS (2007) *Barossa-1 Pre-drilling Marine Environmental Survey 2006/2007*. Prepared for ConocoPhillips Australia Exploration Pty Ltd by URS Australia Pty Ltd, December 2007

Sinclair Knight Merz (2001) *Sunrise Gas Project – Environmental Impact Statement*. Report prepared for Woodside Pty Ltd by Sinclair Knight Merz, Perth, Western Australia

Appendix A. Deepwater fish types

Type A – Silver, minnow shaped tail	Type B – Rat tail
 (example from HM020)  (example from HM013)  (example from HM018)  (example from HM018)	 (example from HM013)

Type C – Silver, bullet shaped	Type D – Bullet shaped, dark minnow tail
 (example from HM016)	 (example from HM016)
Type E – Snake head	Type F – Tiger stripes
 (example from HM023)	 (example from HM023)
Type G – Sword fish	Type H – Vertical fish
 (example from HM023)	 (example from HM023)
Type I – Triangle fish	Type J – Prongs
 (example from HM018)	 (example from HM020)

Type K – Pipefish	Type L – Gurnaud
 (example from HM016)	 (example from HM017)
Type M – Flounder A	Type N – Flounder B
 (example from HM016)	 (example from HM018)
Type O – Flounder C	Type P – Pink
 (example from HM022)	 (example from HM013)
Type Q – Flathead	Type R – Goby shape
 (example from HM013)	 (example from HM013)

<table>
<tr>
<td> 
(example from HM016)
 
(example from HM020)</td>
<td> 
(example from HM018)</td>
</tr>
<tr>
<td>Unknown teleost</td>
<td></td>
</tr>
<tr>
<td> 
(example from HM013)
 
(example from HM016)
 
(example from HM016)</td>
<td></td>
</tr>
</table>

 (example from HM016)	

Appendix B. Presence/absence site data

PERMIT AREA: Site ID	HM013	HM016	HM017	HM018	HM020	HM021	HM022	HM023
Depth (m)	245	290	309	253	211	280	303	280
Sediment Structure	Soft, Flat (<25cm) Moderately Bioturbated Silty sand	Soft, Flat (<25cm) Moderately Bioturbated Versy silty sand	Soft, Flat (<25cm) Moderately Bioturbated Versy silty sand. Similar to HM016	Soft, Flat (<25cm) Moderately Bioturbated Silty sand	Soft, Flat (<25cm) Moderately Bioturbated Versy silty sand. Similar to HM016	Soft, Flat (<25cm) Moderately Bioturbated Versy silty sand. Similar to HM016	Soft, Flat (<25cm) Moderately Bioturbated Silty sand	Soft, Flat (<25cm) Moderately Bioturbated Silty sand/rubble
Water Clarity/Average Field of View	Medium particulate load / 2–4 m2	High particulate load / 2–4 m2	High particulate load / 2–4 m2	Medium particulate load / 2–4 m2	High particulate load / 2–4 m2	High particulate load / 2–4 m2	Medium particulate load / 2–4 m2	Medium particulate load / 2–4 m2
Other								
Brittle Stars (Class Ophiuroidea)							x	
Feather Stars (Class Crinoidea)								
Tunicates/Ascidians								
Sponge								
Sea Pens	x	x		x	x		x	x
Gorgonians								
Sea Whips								
Unidentified - Filter Feeders/non-Photosynthetic Soft Corals								x
Anemones	x	x	x					x
Tube Worms	x							
Sea cucumber								
Sea star					x			x
Decapods								
Prawn/Shrimp Group	x	x	x		x	x	x	
Long-Antennae Shrimp Group		x				x		
Small Crab/Squat Lobster Group	x	x	x	x				x
Burrowing Lobster								
Decorator Crab								
Teleosts								
Type A – Silver, minnow shaped tail	x							
Type B – Rat tail	x							

PERMIT AREA: Site ID	HM013	HM016	HM017	HM018	HM020	HM021	HM022	HM023
Type C – Silver, bullet shaped	x	x	x	x	x	x	x	x
Type D – Bullet shaped, dark minnow tail		x		x	x			
Type E – Snake head								x
Type F – Tiger stripes								x
Type G – Sword fish								x
Type H – Vertical fish								x
Type I – Triangle fish				x				
Type J – Prongs					x			
Type K – Pipefish		x					x	x
Type L – Gurnaud			x					
Type M – Flounder A		x						
Type N – Flounder B				x				
Type O – Flounder C							x	
Type P – Pink fish	x							
Type Q – Flathead	x	x			x			
Type R – Goby shape	x			x				
Type S – Bulbous Long-tailed transparent				x	x			
Unknown teleost	x	x	x	x	x		x	x
Molluscs								
Octopus								
Squid								
Elasmobranch	x							

EVANS: Site ID	HM003	HM004	HM002	HM005
Depth (m)	28	54	46-130	80 - 170
Sediment Structure	Sand	Sand and reef	Sand and reef	Sand and reef
Water Clarity/Average Field of View	> 20 m	> 20 m	~ 15 m	> 20 m
Other				
Tunicates/Ascidians			x	
Sponge - encrusting			x	
Sponge - sub massive				x
Sponge - cup		x		x
Sponge - erect		x	x	
Non-BPP Zoanthids				
Tube Worms				
Anemones			x	
Halimeda	x	x	x	
Algae	x	x	x	
Echinoderms				
Brittle Stars (Class Ophiuroidea)				
Basket stars (Class Ophiuroidea)				
Feather Stars (Class Crinoidea)			x	x
Holothurian		x	x	
Starfish		x	x	
Octocorals				
Filter Feeder/Non-BPP Soft Corals	x	x	x	x
Sea Pens			x	
Gorgonians		x	x	x
Sea Whips	x	x	x	x
Corals				
Branching		x		
Digitate				
Columnar				
Plate		x	x	
Massive		x		
Sub-massive			x	

EVANS: Site ID	HM003	HM004	HM002	HM005
Encrusting				
Free-living		x	x	
Decapods				
Prawn/Shrimp Group				
Long-Antennae Shrimp Group				
Small Crab/Squat Lobster Group				
Lobster			x	
Decorator Crab				
Teleosts				
Unknown teleost				x
Family Lutjanidae		x		x
Family Chaetodontidae - Butterfly fish		x	x	x
Family Labridae - Wrasse	x	x	x	
Family Pomacentridae	x		x	
Family Pomacanthidae - Angelfish	x		x	
Family Acanthuridae - Unicorn fish	x	x		
Family Balistidae - Triggerfish	x	x		
Family Zanclidae - Moorish Idol	x	x		
Family Monacanthidae - Leatherjacket	x			
Family Holocentridae - squirrel fish				x
Family Carangidae			x	
Family Caesionidae			x	
Family Serranidae			x	x
Chondrichthyes				
Shark - white tip		x	x	
Shark - silver tip				x
Shark - grey nurse				
Shark - tawny nurse			x	
Elasmobranch				
Reptilia				
Seasnake			x	
Cephalopods				

EVANS: Site ID	HM003	HM004	HM002	HM005
Octopus				
Squid				
Bivalve				
Clam				
Mollusc				
Gastropod				x
Actinopterygii				
Moray eel			x	

TASSIE: Site ID	HM006	HM007	HM008
Depth (m)	15	28 - 79	15
Sediment Structure	Platform reef structure (<1 m over 2 m); cobble and boulders	Platform reef structure (<1 m over 2 m); cobble and boulders	Platform reef structure (<1 m over 2 m); cobble and boulders
Water Clarity/Average Field of View	10 m; 40 m2	10 m; 40 m2	10 m; 40 m2
Other			
Tunicates/Ascidians	x	x	x
Sponge - encrusting			
Sponge - massive	x	x	x
Sponge - cup		x	
Sponge - erect		x	
Tube Worms			
Anemones			
Halimeda	x	x	x
Echinoderms			
Brittle Stars (Class Ophiuroidea)			
Basket stars (Class Ophiuroidea)			
Feather Stars (Class Crinoidea)	x	x	x
Holothurian			x
Starfish		x	
Octocorals			
Unidentified - Filter Feeders/non- Photosynthetic Soft Corals			
Filter Feeder/Non-BPP Soft Corals	x	x	x
Sea Pens			
Gorgonians		x	
Sea Whips	x	x	x
Corals			
Branching	x	x	x
Digitate	x		
Columnar	x		x
Plate	x	x	x

TASSIE: Site ID	HM006	HM007	HM008
Massive	x	x	x
Sub-massive	x	x	x
Encrusting	x	x	
Free-living		x	
Decapods			
Prawn/Shrimp Group			
Long-Antennae Shrimp Group			
Small Crab/Squat Lobster Group			
Burrowing Lobster			
Decorator Crab			
Teleosts			
Unknown teleost			
Family Lutjanidae			
Family Chaetodontidae - Butterfly fish		x	
Family Labridae - Wrasse	x		x
Family Pomacentridae	x		x
Family Pomacanthidae - Angelfish	x		
Family Acanthuridae - Unicorn fish	x	x	
Family Balistidae - Triggerfish			x
Family Zanclidae - Moorish Idol	x		
Family Monacanthidae - Leatherjacket			
Family Holocentridae - squirrel fish			
Family Carangidae		x	
Family Caesionidae			
Family Serranidae			
Chondrichthyes			
Shark - white tip		x	x
Shark - silver tip			
Shark - grey nurse			
Elasmobranch			
Reptilia			
Seasnake		x	

TASSIE: Site ID	HM006	HM007	HM008
Molluscs			
Octopus			
Squid			
Clam	x		x
Unidentified gastropod			

LYNEDOCH: Site ID	HM024	HM025	HM028	HM030
Depth (m)	20	16	26-83	16
Sediment Structure	Sand/rubble/reef	Sand/rubble/reef	Sand/rubble/reef	Sand/rubble/reef
Water Clarity/Average Field of View	20	20	20	20
Other				
Tunicates/Ascidians				
Sponge - encrusting	x	x	x	
Sponge - sub massive		x	x	x
Sponge - cup	x			
Sponge - erect				
Non-BPP Zoanthids				
Tube Worms				
Anemones				
Halimeda	x	x	x	x
Algae	x	x	x	
Echinoderms				
Brittle Stars (Class Ophiuroidea)				
Basket stars (Class Ophiuroidea)				
Feather Stars (Class Crinoidea)	x		x	x
Sea cucumber	x	x		
Sea star	x	x		
Octocorals				
Unidentified - Filter Feeders/non- Photosynthetic Soft Corals	x	x	x	x
Sea Pens	x			
Gorgonians				
Sea Whips			x	x
Corals				
Branching	x	x	x	x
Digitate				
Columnar				
Plate	x			
Massive	x	x	x	

LYNEDOCH: Site ID	HM024	HM025	HM028	HM030
Sub-massive	x	x	x	x
Encrusting	x		x	
Free-living	x			
Decapods				
Prawn/Shrimp Group				
Long-Antennae Shrimp Group				
Small Crab/Squat Lobster Group				
Burrowing Lobster				
Decorator Crab				
Teleosts				
Unknown teleost		x		
Family Lutjanidae				
Family Chaetodontidae - Butterfly fish		x		
Family Labridae - Wrasse	x	x		x
Family Pomacentridae		x		x
Family Pomacanthidae - Angelfish	x			x
Family Acanthuridae - Unicorn fish				
Family Balistidae - Triggerfish	x		x	
Family Monacanthidae - Leatherjacket				
Family Zanclidae - Moorish idol		x	x	x
Chondricthyes				
Shark - white tip	x	x	x	x
Shark - silver tip	x			
Shark - grey nurse				
Reptilia				
Seasnake	x			
Cephalopods				
Octopus				
Squid				
Elasmobranch				
Bivalve				
Clam				

LYNEDOCH: Site ID	HM024	HM025	HM028	HM030
Actinopterygii				
Moray eel		x		

SEAMOUNTS: Site ID	HM029	HM010A	HM010B	HM011
Depth (m)	80–220	77 - 140	77	50-100
Sediment Structure	Sand/rock	Sand/rock	Sand/rock	Sand/rock
Water Clarity/Average Field of View	10	10	10	10
Other				
Tunicates/Ascidians		x		
Sponge - encrusting				
Sponge - sub massive	x	x	x	
Sponge - cup			x	x
Sponge - erect	x	x		
Non-BPP Zoanthids				
Tube Worms	x	x		
Anemones	x			
Halimeda				
Algae	x	x	x	
Echinoderms				
Brittle Stars (Class Ophiuroidea)				
Basket stars (Class Ophiuroidea)				
Feather Stars (Class Crinoidea)	x	x	x	
Holothurian	x	x		
Starfish	x	x		
Urchin	x	x		
Octocorals				
Unidentified - Filter Feeders/non- Photosynthetic Soft Corals	x	x	x	x
Sea Pens		x		
Gorgonians	x	x	x	
Sea Whips	x	x	x	x
Corals				
Branching	x			
Digitate				
Columnar				
Plate		x	x	

SEAMOUNTS: Site ID	HM029	HM010A	HM010B	HM011
Massive				
Sub-massive				
Encrusting			x	
Free-living				
Decapods				
Prawn/Shrimp Group	x			
Long-Antennae Shrimp Group				
Small Crab/Squat Lobster Group				
Lobster		x		
Decorator Crab				
Teleosts				
Unknown teleost	x	x		
Family Lutjanidae	x	x		
Family Chaetodontidae - Butterfly fish				
Family Labridae - Wrasse				
Family Pomacentridae			x	
Family Pomacanthidae - Angelfish				
Family Acanthuridae - Unicorn fish		x		
Family Balistidae - Triggerfish	x	x	x	x
Family Carangidae	x	x		
Family Caesionidae		x		
Family Serranidae	x	x		
Family Holocentridae	x			
Family Priacanthidae	x			
Family Monacanthidae - Leatherjacket				
Chondrichthyes				
Shark - white tip				
Shark - silver tip	x	x	x	x
Shark - grey nurse		x		
Elasmobranch	x			
Reptilia				
Seasnake				x

SEAMOUNTS: Site ID	HM029	HM010A	HM010B	HM011
Cephalopods				
Octopus				
Squid				
Bivalve				
Clam				
Mollusc				
Gastropod		x		

SCARPS: Site ID	HM014	HM019
Depth (m)	190	185
Sediment Structure	Coarse/rubble, distinct rocky ridge	Rock with silty, shell grit sand, rocky ridge and sandy bottom
Water Clarity/Average Field of View	Medium bioload / 2–4 m2	Medium bioload / 2–4 m2
Other		
Tunicates/Ascidians	x	x
Sponge - encrusting		
Sponge - sub massive	x	x
Sponge - cup	x	x
Sponge - erect		
Non-BPP Zoanthids		
Tube Worms		x
Anemones	x	
Halimeda		
Algae		
Echinoderms		
Brittle Stars (Class Ophiuroidea)	x	x
Basket stars (Class Ophiuroidea)		
Feather Stars (Class Crinoidea)	x	x
Sea Cucumber		
Sea Star	x	
Octocorals		
Unidentified - Filter Feeders/non- Photosynthetic Soft Corals	x	x
Sea Pens		
Gorgonians		x
Sea Whips		x
Decapods		
Prawn/Shrimp Group		x
Long-Antennae Shrimp Group		
Small Crab/Squat Lobster Group		

SCARPS: Site ID	HM014	HM019
Burrowing Lobster		
Decorator Crab		
Hermit crab	x	
Teleosts		
Unknown teleost	x	
Family Lutjanidae		x
Family Labridae - Wrasse		
Family Pomacentridae		
Family Pomacanthidae - Angelfish		
Family Acanthuridae - Unicorn fish		
Family Balistidae - Triggerfish		
Family Monacanthidae - Leatherjacket		
Chondricthyes		
Shark - white tip		
Shark - silver tip		
Shark - grey nurse		
Shark - tawny nurse		
Elasmobranch		
Reptilia		
Seasnake		
Cephalopods		
Octopus		
Squid		