5.8 Marine Resources

5.8.1 Introduction

Marine resources is a VC because

- it has ecological importance
- it has importance to Aboriginal and non-Aboriginal peoples who depend on marine resources
- its consideration addresses legislative and regulatory requirements, and
- its consideration addresses concerns raised during consultation with Aboriginal Groups, the EAO Working Group, and the public.

This assessment of marine resources for the Project is divided into two sub-components: marine fish and fish habitat, and marine mammals. The marine fish and fish habitat sub-component addresses fish species (e.g., salmon, eulachon, herring), invertebrate species (e.g., crabs, shrimp, bivalves, sponges), vegetation species (e.g., seagrass, algae), and fish habitat (as defined under the federal *Fisheries Act*) that occur or may occur in the study areas. The marine mammal sub-component addresses cetaceans (i.e., whales, dolphins and porpoises) and pinnipeds (i.e., seals and sea lions). This assessment focuses on the following marine species commonly found in the study areas and surrounding waters:

- marine fish and invertebrate species (referred to collectively as “fish”) that support or are part of commercial, recreational, and Aboriginal (CRA) fisheries
- marine mammal species, and
- fish and marine mammal species designated as *extirpated, endangered*, *threatened*, or *special concern* under the federal *Species at Risk Act* (SARA) or by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (referred to collectively as “species at risk”).

The *Fisheries Act* and associated Marine Mammal Regulations regulate activities that could affect fish, fish habitat, or marine mammals. CEAA 2012 requires an assessment of potential effects on “fish and fish habitat” as defined under the *Fisheries Act* and on “aquatic species” as defined under SARA. SARA requires the adverse effects on species listed in Schedule 1: List of Wildlife Species at Risk under SARA to be addressed and measures proposed to mitigate any such effects. Aboriginal Groups, the EAO Working Group, and the public have also expressed concern about potential effects on marine resources that have ecological, socio-economic, or cultural importance.

There are important links between marine resources and other VCs assessed. Some wildlife species, such as marine birds (e.g., marbled murrelets) and terrestrial species that forage along the coast (e.g., bears, wolves, river otters) depend on marine resources for food (Section 5.6: Wildlife Resources).

Anadromous fish species such as salmon depend on marine, freshwater, and estuarine habitat during various stages of their life cycles (Section 5.7: Freshwater and Estuarine Fish and Fish Habitat). Socio-economic values and uses of marine resources, such as CRA fisheries and marine eco-tourism are considered in Section 7.4 (Marine Transportation and Use).

5.8.2 Scope of Assessment

5.8.2.1 Regulatory and Policy Setting

The *BC Environmental Assessment Act*, CEAA 2012, *Fisheries Act*, SARA, *Oceans Act,* and the *Canadian Environmental Protection Act* (CEPA) are the primary legislative instruments that guide this assessment of effects on marine resources. Other relevant legislation includes the *International Convention for the Prevention of Pollution from Ships* (MARPOL)*, Canada Shipping Act*, 2001 (CSA 2001) and BC *Wildlife Act* and *Environmental Management Act.*

5.8.2.1.1 *Canadian Environmental Assessment Act*, 2012

Subsection 5(1) of CEAA 2012 focuses the environmental assessment on issues under federal jurisdiction, including fish and fish habitat, aquatic species at risk, migratory birds, federal lands, effects that cross provincial or international boundaries, and induced effects on Aboriginal peoples.

5.8.2.1.2 *Fisheries Act*

The *Fisheries Act* regulates Canadian fisheries resources, including the protection of marine fish and fish habitat associated with CRA fisheries. Under subsection 2(1) of the *Fisheries Act*, “fish” and “fish habitat” are defined as follows:

- Fish includes a) parts of fish; b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals; and c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals.
- Fish habitat means spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes.

On November 6, 2013, a new *Fisheries Protection Policy Statement* (DFO 2013a) was released. On November 25, 2013, amendments to the *Fisheries Act* came into force that focus on protecting the productivity of CRA fishery resources. Key fish habitat protection and pollution control provisions under the *Fisheries Act* include:

- subsection 35(1): prohibits *serious harm to fish* that are part of or support CRA fisheries (administered by Fisheries and Oceans Canada [DFO]), and
- subsection 36(3): prohibits deposition of deleterious substances into waters frequented by fish (administered by Environment Canada).

The *Fisheries Act* defines *serious harm to fish* as the death of fish or any permanent alteration to, or destruction of, fish habitat."

DFO interprets "serious harm" as:

> *[T]he death of fish; or any permanent alteration to, or destruction of, fish habitat of a spatial scale, duration, or intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes* (DFO 2013a)*.*

Fish that support CRA fisheries include key prey species, such as herring, and structure-providing species, such as mussel beds and sponges (DFO 2013a; Kenchington et al. 2012). Any works, undertakings or activities associated with a project that would result in *serious harm to fish* that are part of or support CRA fisheries require an authorization under paragraph 35(2)(b) of the *Fisheries Act*.

DFO has published a series of policy statements and guidance papers related to implementation of the amendments to the *Fisheries Act*, including, but not limited to:

- *Fisheries Protection Policy Statement* (DFO 2013a)
- *Fisheries Protection Program Operational Approach* (DFO 2013b)
- *Science Advice to Support Development of a Fisheries Protection Policy for Canada* (DFO 2013a)
- *A Science-based Interpretation and Framework for Considering the Contribution of the Relevant Fish to the Ongoing Productivity of Commercial, Recreational or Aboriginal Fisheries* (Koops et al. 2012)
- *A Science-based Interpretation of Ongoing Productivity of Commercial, Recreational or Aboriginal Fisheries* (DFO 2012), and
- *Identification of Species and Habitats that Support Commercial, Recreational or Aboriginal Fisheries in Canada* (Kenchington et al. 2012).

The Marine Mammal Regulations under the *Fisheries Act* apply to the management and control of fishing for marine mammals and related activities in Canada. Section 7 of the regulations prohibits disturbance of a marine mammal except when fishing for them under the authority of the regulations.

Subsection 36(3) of the *Fisheries Act* prohibits the deposit of "deleterious (toxic or harmful) substances" in any place or under any conditions where it might enter waters frequented by fish.

5.8.2.1.3 *Species at Risk Act*

The purposes of SARA are to prevent the extinction or extirpation of wildlife in Canada and to help in recovery and management of species at risk. DFO is responsible for administering all aspects of SARA related to aquatic species at risk. COSEWIC is designated under SARA as the independent body of experts to assess the status of wildlife species and populations according to their level of conservation concern. As part of the status assessment, COSEWIC assigns each species to one of the following status categories:

- *extinct*—a wildlife species that no longer exists
- *extirpated*—a wildlife species that no longer exists in the wild in Canada, but exists elsewhere
- *endangered*—a wildlife species facing imminent extirpation or extinction
- *threatened*—a wildlife species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction
- *special concern*—a wildlife species that may become threatened or endangered because of a combination of biological characteristics and identified threats
- *not at risk*—a wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances, and
- *data deficient*—a category that applies when the available information is insufficient (a) to resolve a wildlife species' eligibility for assessment or (b) to permit an assessment of the wildlife species' risk of extinction (COSEWIC 2009).

The federal government uses information in the COSEWIC assessments—along with recovery potential assessments, socio-economic assessments, and other information—before making a decision whether to add a species to Schedule 1: List of Wildlife Species at Risk under SARA.

SARA includes measures to protect listed wildlife species, including prohibitions against killing, harming, harassing, capturing or taking of individuals (subsection 32(1)) and against damaging or destroying their residence (section 33). SARA also requires the government to prepare a recovery strategy and action plan for species listed as *endangered*, *threatened*, or *extirpated* (subsections 37(1) and 47) and includes requirements for protection of critical habitat designated in registered recovery strategies or action plans (sections 58 and 61).

Section 79 of SARA contains specific requirements for when project reviews are being undertaken under CEAA 2012. It requires assessment of the adverse effects of a proposed project on any species listed in Schedule 1, and for measures to be taken to avoid or lessen those effects, and to monitor them. All measures must be consistent with any recovery strategies or action plans in place for the species. The section 79 requirement is met by the assessment of marine resources for the Project; through identification of effects (Section 5.8.2.4), Project interactions (Section 5.8.4), and potential residual effects and proposed mitigation measures (Sections 5.8.5 and 5.8.6).

5.8.2.1.4 Oceans Act

Canada's *Oceans Act* was introduced in 1997. The Act defines the boundaries of Canada's maritime zones (e.g., internal waters, territorial sea, exclusive economic zone, continental shelf), and provides a legislative framework for Canada's oceans management strategy. DFO is the federal agency responsible for administering the Act.

Section 29 of the *Oceans Act* requires the development and implementation of a national strategy for the management of estuarine, coastal, and marine ecosystems; and section 32 requires the development and implementation of integrated management plans for all activities affecting estuaries, coastal waters, and marine waters. In 2002, the Government of Canada released Canada's Oceans Strategy (DFO 2002) to fulfill the section 29 requirements of the Act. The strategy provides an operational framework for implementing Canada's oceans management strategy. DFO has defined five large ocean management areas (LOMAs) to form the planning basis for implementation of integrated-management plans, including the Pacific North Coast Integrated Management Area (PNCIMA) (DFO 2014a).

Section 35 of the *Oceans Act* sets out the legislative framework for designating marine protected areas (MPAs), and requires the development and implementation of a national system of MPAs. To date, the Endeavour Hydrothermal Vents MPA located 250 km off the west coast of Vancouver Island, and the Bowie Seamount MPA located 180 km from the west coast of Haida Gwaii are the only *Oceans Act* MPAs designated in the Pacific Ocean. DFO has identified two additional Areas of Interest (AOI) for MPAs in the Pacific Ocean, including the Race Rocks AOI in the Juan de Fuca Strait and the Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs AOI (DFO 2014b).

5.8.2.1.5 ***Canadian Environmental Protection Act***

The CEPA is the principal piece of legislation governing pollution prevention and protection of the environment and human health in Canada, and it is administered by Environment Canada. Part 7 of CEPA addresses pollution control and waste management, including release of nutrients into aquatic environments, protection of the marine environment from land-based pollution, and disposal of substances at sea.

The Disposal at Sea Regulations under CEPA outline requirements and procedures for the disposal of suitable dredged or excavated material in marine waters. Permits may be granted for disposal, and each permit application is assessed according to the regulations and an associated set of procedures developed by Environment Canada. The regulations require a sampling program, reviewed and approved by Environment Canada, to assess potential levels of contaminants in, and physical characteristics of, the material to be disposed. The sediment characterization framework to support a Disposal at Sea Permit application is two-tiered.

Tier 1 involves screening of physical and chemical qualities of the material for the presence of certain substances (identified under the National Action List) at specified (Lower Level) concentrations defined within the regulation. This may be further supplemented by assessment of additional substances present based on the known history of the site and as required by Environment Canada. For substances without corresponding Lower Level concentrations, proponents may be referred to the Canadian Council of Ministers of the Environment (CCME) sediment quality guidelines (SQGs) for the protection of aquatic life.

If the prescribed Lower Level concentrations are exceeded, toxicity testing may be conducted in a Tier 2 screening to evaluate the potential bioavailability of the materials as further rationale to support a Disposal at Sea Permit application.

If the application for disposal at sea is approved, the material can be disposed at an approved marine site. Additional permit conditions may be issued by Environment Canada to protect the marine environment and human health.

5.8.2.1.6 International Convention for the Prevention of Pollution from Ships

The purpose of the International Convention for the Prevention of Pollution from Ships (MARPOL) is to prevent pollution of the marine environment by ships from operational or accidental causes. MARPOL is administered by the International Maritime Organization (IMO). MARPOL includes six technical Annexes, which identify Special Areas with strict controls on operational discharges. Annex I sets out regulations for the control of oil pollution in the marine environment, including regulations related to the control and discharge of oil and bilge water originating from machinery spaces and cargo spaces, ballast tank arrangements and locations, double hull requirements, and Shipboard Oil and Marine Pollution Emergency Plans. Annex II sets out regulations for the control of pollution by noxious liquid substances in bulk. Noxious liquid substances include many bulk liquids that do not fall under the definition for oil defined in Annex I (e.g., petrochemicals, solvents, waxes, lube oil additives). This Annex outlines discharge criteria and measures, and evaluates 250 liquid substances. Several of these Annexes have been incorporated in the Vessel Pollution and Dangerous Chemicals Regulations under the *Canada Shipping Act, 2001*.

5.8.2.1.7 Canada Shipping Act, 2001

CSA 2001 governs safety and protection of the environment for all marine transportation including recreational pleasure craft; the Act and its supporting regulations apply to every Canadian vessel operating in all waters worldwide and to all foreign vessels when operating within Canadian waters. CSA 2001 is supported by two primary environmentally focused marine transportation regulations, the Vessel Pollution and Dangerous Chemical Regulations and the Ballast Water Control and Management Regulations (Ballast Water Regulations). Both regulations are based on the international MARPOL convention, for which Canada is a signatory, and associated guidelines from the IMO.

The Ballast Water Regulations describe mandatory ballast management procedures for Canadian waters (ballast management plans, exchange and treatment, reporting requirements, compliance and enforcement, and research). Ballast water is considered managed if it is exchanged mid-ocean, treated, transferred to a reception facility once sediment has settled into tanks, or retained on board the vessel (Transport Canada 2012). In Canada, ballast water exchange is currently the most commonly used method (Casas-Monroy et al. 2013). All ships entering Canadian waters must exchange ballast water outside the 200 nautical mile limit of Canada's exclusive economic zone and in water depths greater than or equal to 2,000 m. Exchange of ballast water in deep ocean areas or open seas lowers the probability that harmful aquatic organisms and pathogens will be transferred. If offshore exchange is not feasible for safety reasons such as poor weather, ballast exchange is allowed in designated alternate exchange zones (any waters more than 50 nautical miles from the coast and west of the 500 m depth contour, with the exception of Bowie Seamount and western Queen Charlotte Sound (Levings and Foreman 2004). Sediment management procedures, such as monitoring, removal, and deposition of sediment in ballast water tanks, must be incorporated into a vessel's ballast water management plan (Casas-Monroy et al. 2013).

The Vessel Pollution and Dangerous Chemicals Regulations under the CSA 2001 incorporate the international MARPOL standards and additional or complementary requirements within Canadian law. Division 1 of the regulations addresses vessel pollution related to oil and bilge water, and Division 2 addresses the transportation of noxious liquid substances. The regulations include mandatory procedures to prevent and reduce the discharge of oil, bilge water, and noxious liquid substances into the marine environment from ships.

5.8.2.1.8 BC *Environmental Management Act*

The BC *Environmental Management Act* (EMA) is the principal provincial legislation regarding the management of the environment. It specifically governs all discharges of waste to the environment. Waste is broadly defined to include air contaminants, effluent, litter, refuse, and hazardous waste. Discharges are regulated under permits issued under the EMA or codes of practice under the Waste

Discharge Regulation which establish limits on the quality and quantity of waste discharges to aquatic environments.

5.8.2.1.9 *BC Wildlife Act* and Provincial Lists of Species at Risk

The BC *Wildlife Act* regulates the management and protection of wildlife (i.e., fish, amphibians, reptiles, birds, and mammals) and wildlife habitat in BC, including species at risk. The Endangered Species and Ecosystems Branch of MOE maintains a list of species at risk. Species are listed as *red*, *blue*, or *yellow*. Red List species include those designated as *extirpated*, *endangered*, or *threatened*, and Blue List species are those designated as *special concern*. Any species that is not on the Red or Blue Lists is on the Yellow List and is considered not at risk in BC. The BC status of a species is based on COSEWIC status and consultation with wildlife experts. Red and Blue List species designations are not legally binding but the lists are used to set conservation priorities for species and ecological communities considered at risk in BC and to inform decisions to list species under the BC *Wildlife Act*.

5.8.2.2 Consultations' Influence on the Identification of Issues and the Assessment Process

The scope of the environmental assessment is based on the AIR document. LNG Canada consulted with Aboriginal Groups, the public, the EAO Working Group, and other interested parties throughout the development of the AIR. The following changes were made to the marine resources environmental assessment as a result of consultation:

- Additional potential effects from Project activities were included (effects of vessel wake and propeller wash on marine fish habitat, physical presence of LNG carriers on the behaviour of fish, effects of bilge water on fish health, and introduction of marine invasive species through the release of ballast water).
- At the request of the EAO Working Group, sediment transport modelling was conducted to assess whether changes in sediment transport in Kitimat Arm from the marine terminal footprint and changes in water depth from dredging could affect marine fish habitat.

In addition, through LNG Canada's consultation program, potentially affected Aboriginal Groups have identified interests and concerns with respect to marine resources, which are assessed, as applicable, in the marine resources assessment as well as in Part C as they relate to potential adverse effects on Aboriginal Interests (Section 14) or Other Matters of Concern (Section 16).

5.8.2.3 Traditional Knowledge and Traditional Use Incorporation

TK and TU information was gathered from Project-specific studies submitted to LNG Canada and from publicly available sources. The available TK/TU information at the time of writing was used to inform the baseline conditions for this assessment. Haisla Nation, Gitxaala First Nation, Gitga'at Nation, Metlakatla

First Nation, and Kitsumkalum First Nation each provided Project-specific studies to LNG Canada (Powell 2013; Calliou Group 2014a,b; Firelight Group 2014; Satterfield et al. 2012; Ritchie and Gill 2014; DM Cultural Services Ltd. 2014; Crossroads CRM 2014). Information from these studies, along with other publicly available TK/TU information (Lax Kw'alaams 2004; Ference Weicker and Company 2009) contributed to the list of Aboriginal fishery species considered in this assessment (see Table 5.8-3). TK from Gitga'at Nation on timing of marine mammal surveys indicated that Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) aggregations were largest (greater than 100 animals) during February (Picard 2013). Based on this information, the timing of the marine mammal field program was adjusted to capture these sightings.

5.8.2.4 Selection of Effects

Potential effects on marine resources are based on Project activities and works; legislative and regulatory requirements (see Section 5.8.2.1); issues identified through consultation with Aboriginal Groups, the public, the Working Group, and other interested parties (see Section 5.8.2.2); and professional judgment and experience of the environmental assessment team. The following potential effects on marine resources are assessed:

- change in fish habitat
- harm (defined as physical injury or mortality) to fish or marine mammals
- change in fish health as a result of toxicity, and
- change in behaviour of fish or marine mammals due to pressure waves or underwater noise.

A change in fish habitat is measured as net change of the quantity (i.e., area) and quality (i.e., productivity) of fish habitat from Project activities and works. This recognizes both decreases (e.g., related to marine construction or dredging) and increases (e.g., related to habitat creation or restoration). Consideration of this effect addresses subsection 5(1) of CEAA 2012, subsection 35(1) of the *Fisheries Act* (see Section 5.8.2.1) and concerns identified through consultations with Aboriginal Groups, the public, the Working Group, and other interested parties.

Change in fish health as a result of toxicity addresses potential effects related to release of contaminants that may be present in sediment and dispersed due to Project activities and works. At the marine terminal, dredging and marine construction will disturb sediment, which may result in dispersal of existing contaminants. Uptake by fish, either directly or through consumption of prey containing contaminants, may result in decline in health through toxicity. Consideration of this effect addresses regulatory requirements related to fish habitat under subsection 5(1) of CEAA 2012, subsections 35(1) and 36(3) of the *Fisheries Act*, section 79 of SARA (see Section 5.8.2.1), and concerns identified through consultations with Aboriginal Groups, the public, the Working Groups, and other interested parties.

Harm (defined as physical injury or mortality) to fish or marine mammals may result directly (e.g., burial, crushing, auditory injury) and indirectly (e.g., hydrographic alterations to fish habitat that result in desiccation of fish) from Project activities and works. Consideration of this effect addresses subsection 5(1) of CEAA 2012, subsection 35(1) of the *Fisheries Act*, section 7 of the Marine Mammal Regulations, subsection 32(1) and section 79 of SARA (see Section 5.8.2.1) and concerns identified through consultations with Aboriginal Groups, the public, the Working Group, and other interested parties. Potential harm to marine mammals due to vessel strikes is considered to be an unplanned event and is therefore assessed under accidents or malfunctions (see Section 10).

Behavioural changes (temporary or permanent physical responses or changes in activity) in fish and marine mammals may result from underwater noise or pressure waves associated with marine construction and marine transportation activities. Responses can range from small startle movements or changes in communication, to changes in life cycle processes (e.g., timing of reproductive activity, migration patterns). Consideration of this effect addresses subsection 5(1) of CEAA 2012, section 7 of the Marine Mammal Regulations, subsection 32(1) and section 79 of SARA (see Section 5.8.2.1), and concerns identified through consultations with Aboriginal Groups, the public, the Working Group, and other interested parties.

5.8.2.5 Selection of Measurable Parameters

Measurable parameters facilitate quantitative or qualitative measurement of potential effects based on standards or guidelines, legislative and regulatory requirements, and the professional judgment of the assessment team (Table 5.8-1).

For change in fish habitat, the measurable parameters (i.e., total area and qualitative assessment of productive capacity of fish habitat permanently altered or destroyed) provide a direct measure and a qualitative description of how much the productive capacity of fish habitat may be affected by the Project. An understanding of these parameters is also required to address subsection 35(1) of the *Fisheries Act* and the *Fisheries Protection Policy Statement* (DFO 2013a).

Table 5.8-1: Potential Project Effects on Marine Resources and Measurable Parameters

Potential Effects	Measurable Parameters
Change in fish habitat	▪ Total area of fish habitat permanently altered or destroyed (m^2) ▪ Productive capacity[a] of fish habitat permanently altered or destroyed (qualitative)
Harm to fish or marine mammals	▪ Likelihood[b] of harm to fish species that support or are part of CRA fisheries ▪ Likelihood of harm to marine mammals ▪ Likelihood of harm to species at risk[c]
Change in fish health as a result of toxicity	▪ Chemical composition of sediment and water (unit depends on the contaminant)
Change in behaviour of fish or marine mammals due to underwater noise or pressure waves	▪ Likelihood[b] of exposure to underwater noise relative to recommended acoustic thresholds

NOTES:

[a] DFO (1986) defines productive capacity as the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend.

[b] The term 'likelihood' is used in this context as a qualitative measure of reasonably predicted or expected harm or change in behaviour, based on current scientific understanding, use of underwater acoustic thresholds and modelling (where applicable) and professional judgment. It is not meant to imply statistical likelihood or results of a quantitative risk assessment.

[c] For the purposes of this assessment, species at risk refers to species designated as *extirpated*, *endangered*, *threatened*, or *special concern* under Schedule 1 of SARA or by COSEWIC.

For change in fish health as a result of toxicity, the measurable parameter (chemical composition of sediment and water compared to federal and provincial guidelines for protection of marine life) reflects the potential for acute or chronic effects on fish that may affect viability of populations, depending on the number of individuals affected. Comparing chemical composition of sediment and water to guidelines for protection of marine life allows effects to fish health to be inferred, while recognizing the conservative safety factors incorporated in the guidelines.

For harm to fish or marine mammals, the measurable parameters are likelihood of harm to fish species that support or are part of CRA fisheries (based on qualitative predictions), to marine mammals, and to species at risk (marine fish, marine invertebrates, or marine mammals). Likelihood of harm is a function of the distribution and abundance of marine species in relation to Project activities and individual species' sensitivities to those activities. Physical injury or mortality may affect viability of fish and marine mammal populations. An assessment of harm to fish that are part of or support CRA fisheries is required to address subsection 35(1) of the *Fisheries Act*, and subsection 32(1) and section 79 of SARA.

For change in behaviour of fish or marine mammals due to underwater noise or pressure waves, the measurable parameter is likelihood of exposure to Project-related underwater noise relative to recommended acoustic thresholds, or professional judgment if thresholds are not available. Change in behaviour is influenced, in part, by characteristics of the acoustic input and the oceanographic environment; change in behaviour is highly dependent on the species and their distribution, along with other parameters. Comparing modelled underwater noise levels to recommended behavioural change thresholds allows the potential for behavioural changes to fish and marine mammal populations to be inferred.

5.8.2.6 Boundaries

5.8.2.6.1 Spatial Boundaries

Spatial boundaries consider the geographic extent over which Project activities may affect marine resources. Due to differences in potential effects associated with the LNG facility (i.e., marine terminal) and Project-related shipping, the following six spatial boundaries are defined:

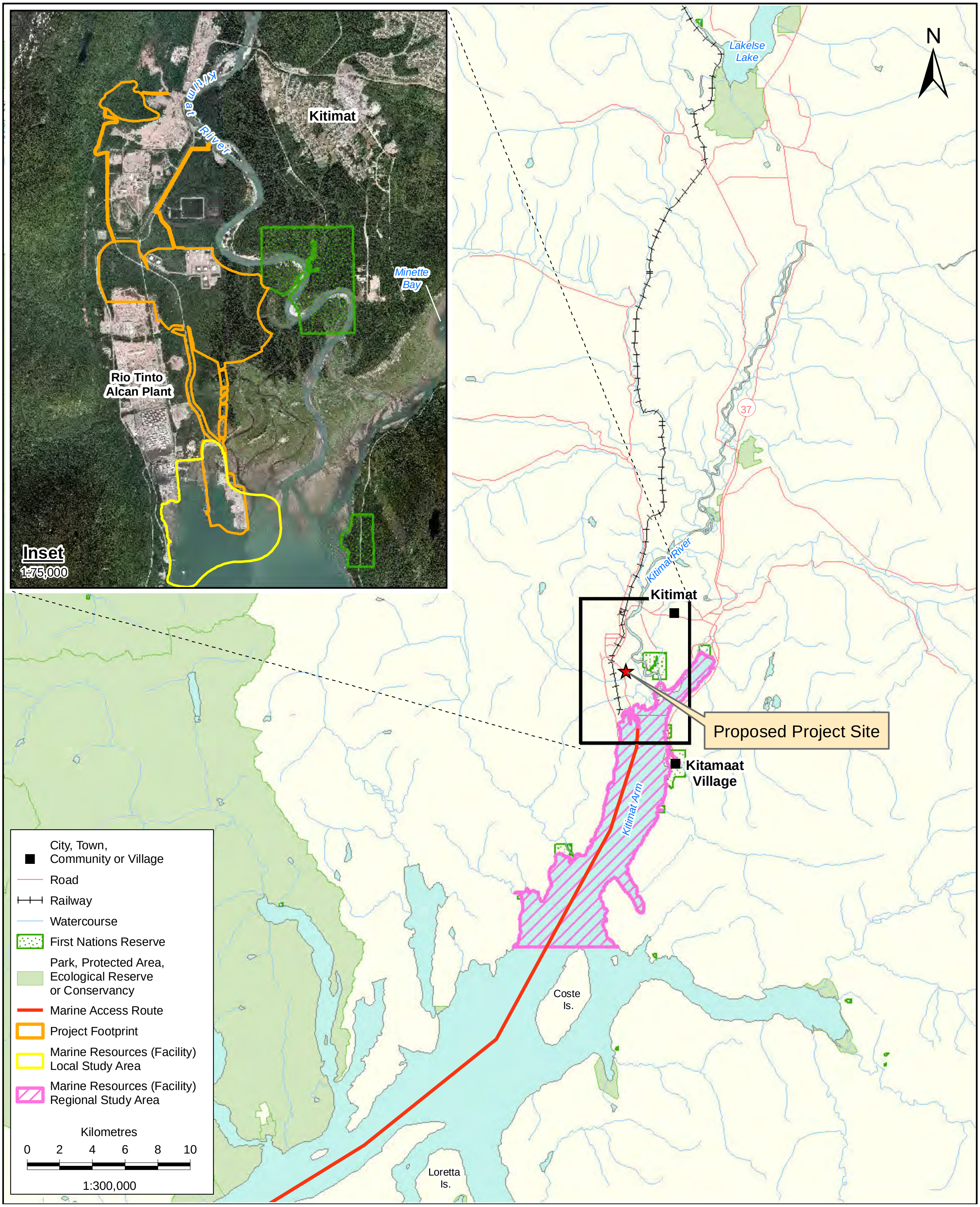
- The **Project footprint** is defined as the area of direct physical disturbance to marine habitat and is equivalent to the area occupied by the marine terminal and related infrastructure upgrades (see Figure 5.8-1).
- The **facility LSA** is defined by a 500 m buffer around the marine terminal to encompass the marine terminal footprint, LNG carrier berthing areas, and marine waters affected by underwater noise from construction, operation, and decommissioning activities (Figure 5.8-1). The 500 m buffer is based on professional judgment and past experience of the environmental assessment team. This area overlaps with the traditional territory of Haisla Nation.
- The **shipping LSA** is defined as the confined channels along the marine access route and marine waters extending 6 km to either side of the marine access route between Browning Entrance and the Triple Island Pilot Boarding Station (Figure 5.8-2). The 6 km buffer encompasses the potential extent of the majority of area where underwater noise might exceed recommended acoustic thresholds. The shipping LSA overlaps to a great extent with the marine transportation and use LSA (Section 7.4) and the wildlife (marine birds) LSA (Section 5.6). This area overlaps with the traditional territories of Haisla Nation, Gitxaala Nation, Gitga'at First Nation, Metlakatla First Nation, Kitsumkalum First Nation, Lax Kw'alaams First Nation, and Kitselas First Nation.
- The **facility RSA** encompasses marine waters from the head of Kitimat Arm south to the northern tip of Coste Island (Figure 5.8-1) and is based on professional judgment and past experience of the environmental assessment team. It encompasses habitats used during sensitive life stages of fish species that may be affected by the Project, including important spawning areas and migration routes. This area overlaps with the traditional territory of Haisla Nation.

- The **shipping RSA** (Figure 5.8-2) encompasses the extent of shipping activities and surrounding waters within the confined channels (e.g., Kitimat Arm, Douglas Channel, Squally Channel, Principe Channel), Whale Channel, Caamaño Sound, and marine waters along the marine access route out to the Triple Island Pilot Boarding Station in the north. Where the marine access route is not confined by geography, a buffer of 10 km is used on either side around the route. The 10 km buffer is based on professional judgment and past experience of the environmental assessment team to provide context for marine mammal presence within the area. Much of the shipping RSA overlaps with the marine transportation and use RSA (Section 7.4) and marine birds RSA. This area overlaps with the traditional territories of Haisla Nation, Gitxaala Nation, Gitga'at First Nation, Metlakatla First Nation, Kitsumkalum First Nation, Lax Kw'alaams First Nation, and Kitselas First Nation.
- **Basin study areas** (BSAs) in upper Kitimat Arm are identified by LNG Canada as locations within which a disposal at sea site will be selected (Figure 5.8-3). The BSAs under consideration are considerably larger in spatial extent than the expected disposal footprint because they are intended to represent investigative areas and not physical receiving sites. The BSAs selected are based on the following criteria:
  - located within 30 km of the berth pocket (see Section 5.8.3)
  - located in waters deeper than 175 m chart datum (CD), and
  - uniform bottom topography with avoidance of steeply sloped areas that may be physically unstable.

5.8.2.7 Temporal Boundaries

Based on the current Project schedule, the temporal boundaries are:

- construction, Phase 1 (trains 1 and 2) to be completed approximately five to six years following issuance of permits, the subsequent phase(s) (trains 3, 4) to be determined based on market demand
- operation, minimum of 25 years after commissioning, and
- decommissioning, approximately two years at the end of the Project life.



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MARINE RESOURCES ENVIRONMENTAL EFFECTS ASSESSMENT

MARINE RESOURCES FACILITY LSA AND RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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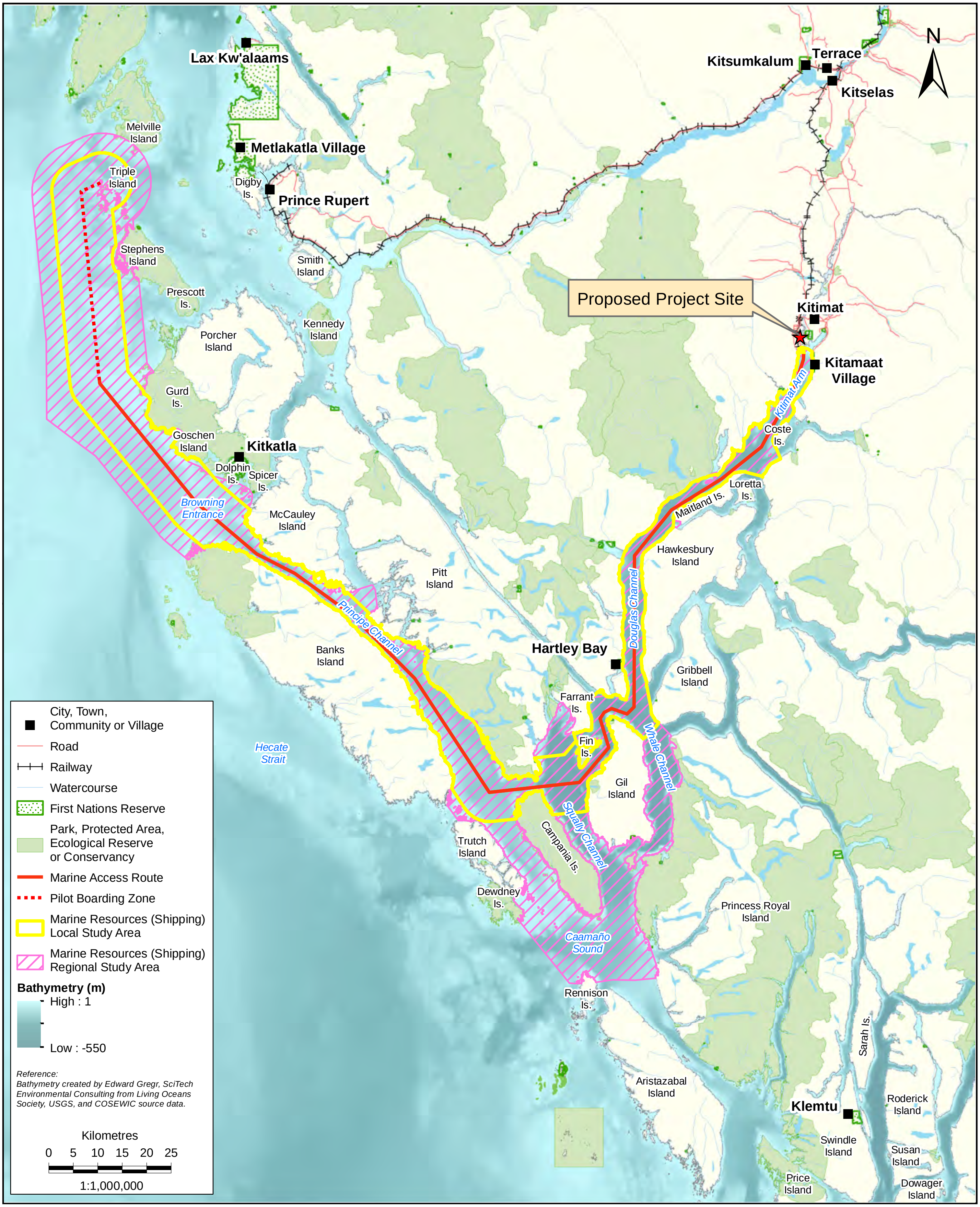

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MARINE RESOURCES ENVIRONMENTAL EFFECTS ASSESSMENT

MARINE RESOURCES SHIPPING LSA AND RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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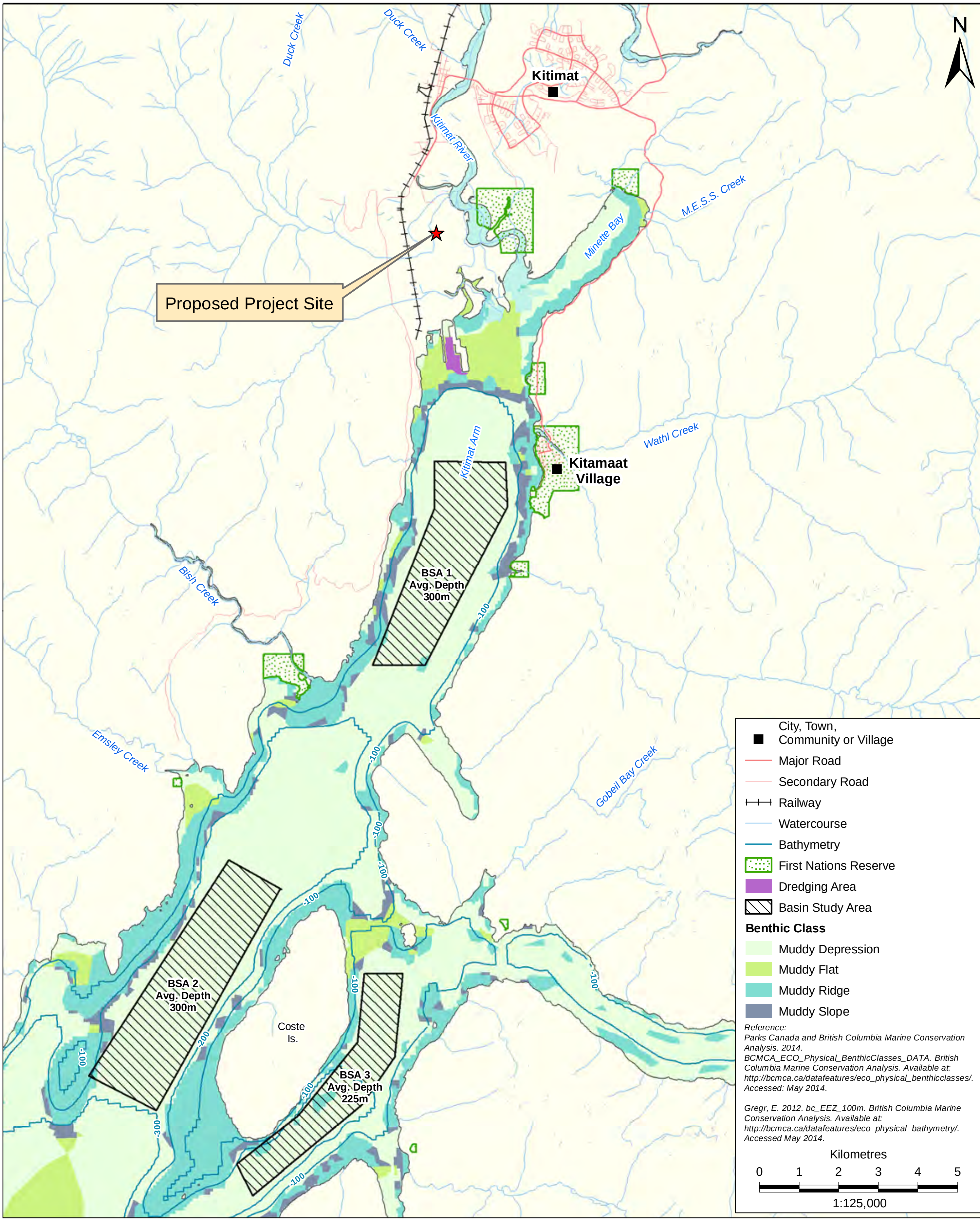

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MARINE RESOURCES ENVIRONMENTAL EFFECTS ASSESSMENT

BASIN STUDY AREAS FOR A DISPOSAL AT SEA SITE IN KITIMAT ARM

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
03-JUL-14	**5.8-3**

5.8.2.8 Administrative and Technical Boundaries

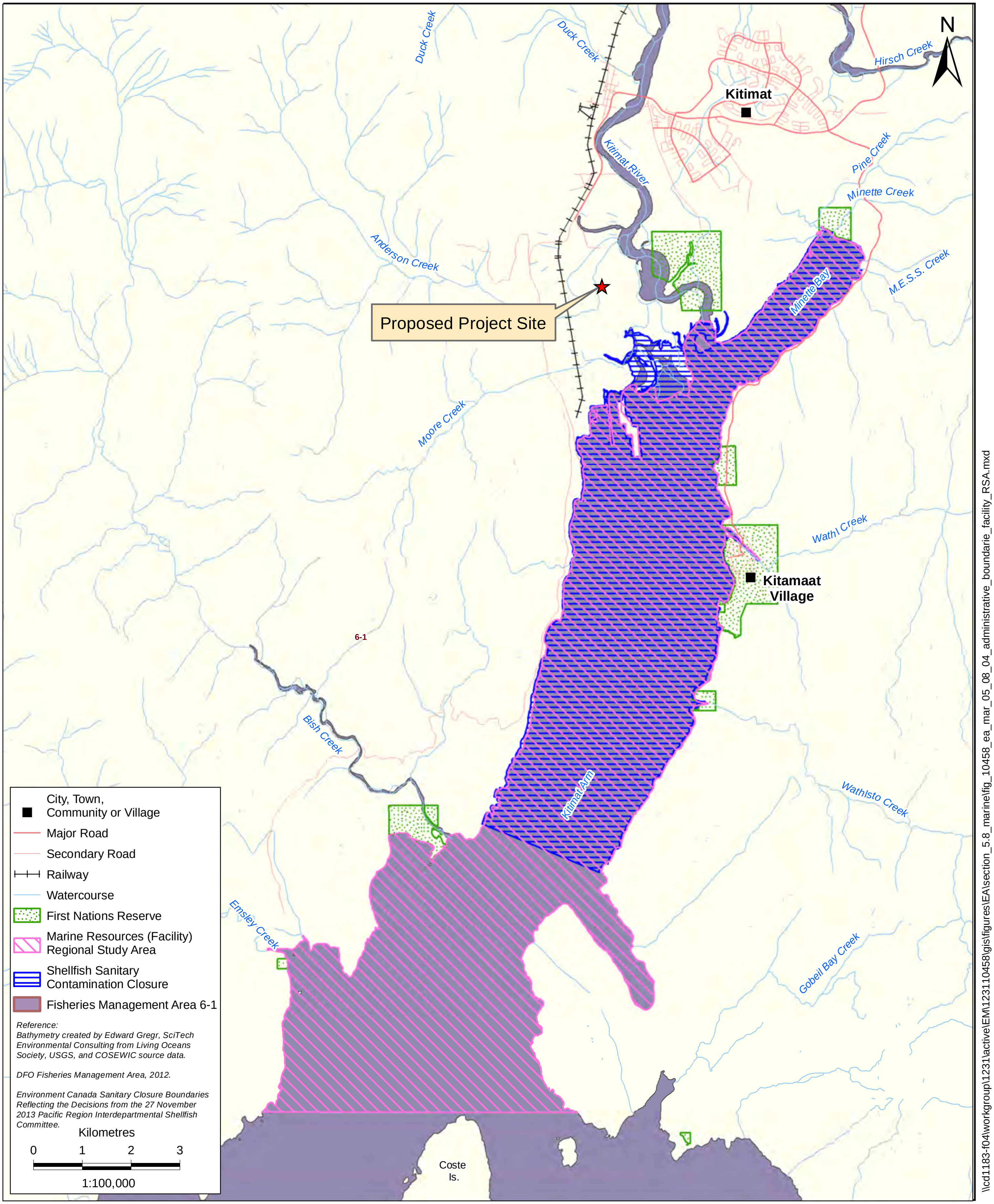
Administrative boundaries for the marine resources environmental assessment are:

- legislative and regulatory requirements prescribed in statues and regulations (see Section 5.8.2.1)
- DFO Fisheries Management Areas (FMA) defined under the Pacific Fishery Management Area Regulations (Figure 5.8-4 and Figure 5.8-5)
- DFO bivalve shellfish biotoxin and sanitary contamination closures (Figure 5.8-4 and Figure 5.8-5)
- federal and provincial parks, protected areas, ecological reserves and conservancies (Figure 5.8-5)
- humpback whale critical habitat and potential northern resident killer whale critical habitat (Figure 5.8-6)
- DFO important areas for humpback whales, northern resident killer whales and fin whales (Figure 5.8-7)
- the PNCIMA LOMA under the *Oceans Act*, and
- the Marine Planning Partnership for the North Pacific Coast study area.

DFO bivalve shellfish biotoxin closures are in effect for FMAs 4 through 6, with the exception of FMA sub-areas 6-13 and 6-17, which are closed to all bivalve shellfish harvesting except geoduck and horse clams (DFO 2013c) (Figure 5.8-5). Bivalve shellfish sanitary contamination closures are in effect for FMA sub-areas 6-1 and 6-3 (DFO 2013c) (Figure 5.8-4 and Figure 5.8-5).

Potential northern resident killer whale critical habitat in the shipping RSA is identified in DFO's resident killer whale recovery strategy as an area for further study because currently there is insufficient information to characterize it as critical habitat (DFO 2011).

The humpback whale critical habitat in the shipping RSA was designated in the humpback whale recovery strategy, due to the species listing as *threatened* in SARA in 2003 (DFO 2013d). In May 2014, the Minister of Fisheries and Oceans recommended the status of the humpback whale be amended from *threatened* to *special concern* (Government of Canada 2014). This recommendation is based on a COSEWIC assessment and status update as a result of upward trends in population growth rates and increased abundance (COSEWIC 2011). At the time of preparing this assessment, the Governor in Council has not made a decision on the recommendation and thus, at this time, the humpback whale is listed as *threatened* under Schedule 1 of SARA. This assessment considers the humpback whale in accordance with its current listing status and recovery strategy.



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MARINE RESOURCES ENVIRONMENTAL EFFECTS ASSESSMENT

ADMINISTRATIVE BOUNDARIES IN THE FACILITY RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
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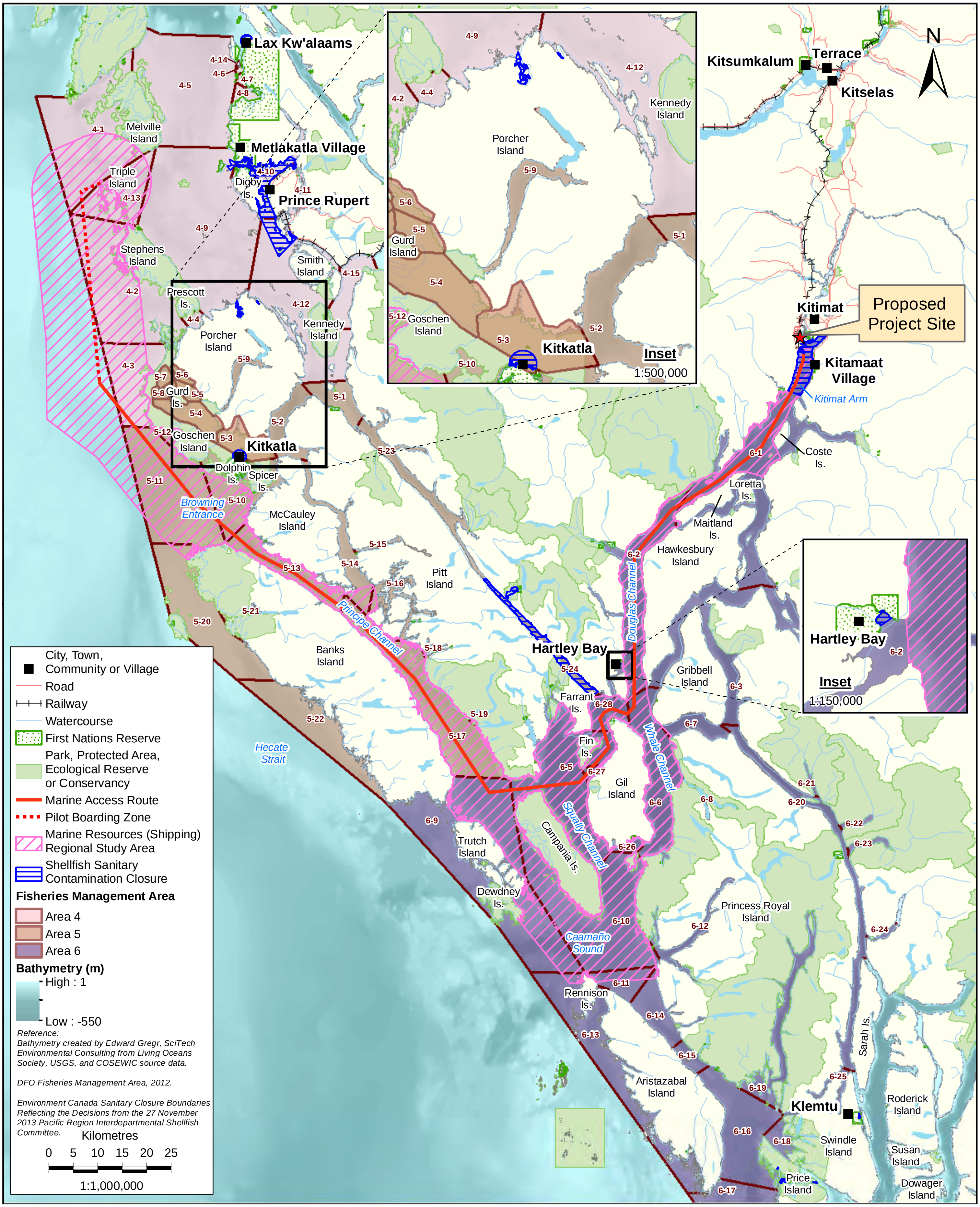
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
27-JUN-14	**5.8-4**



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MARINE RESOURCES ENVIRONMENTAL EFFECTS ASSESSMENT

ADMINISTRATIVE BOUNDARIES IN THE SHIPPING RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
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17-JUN-14	5.8-5

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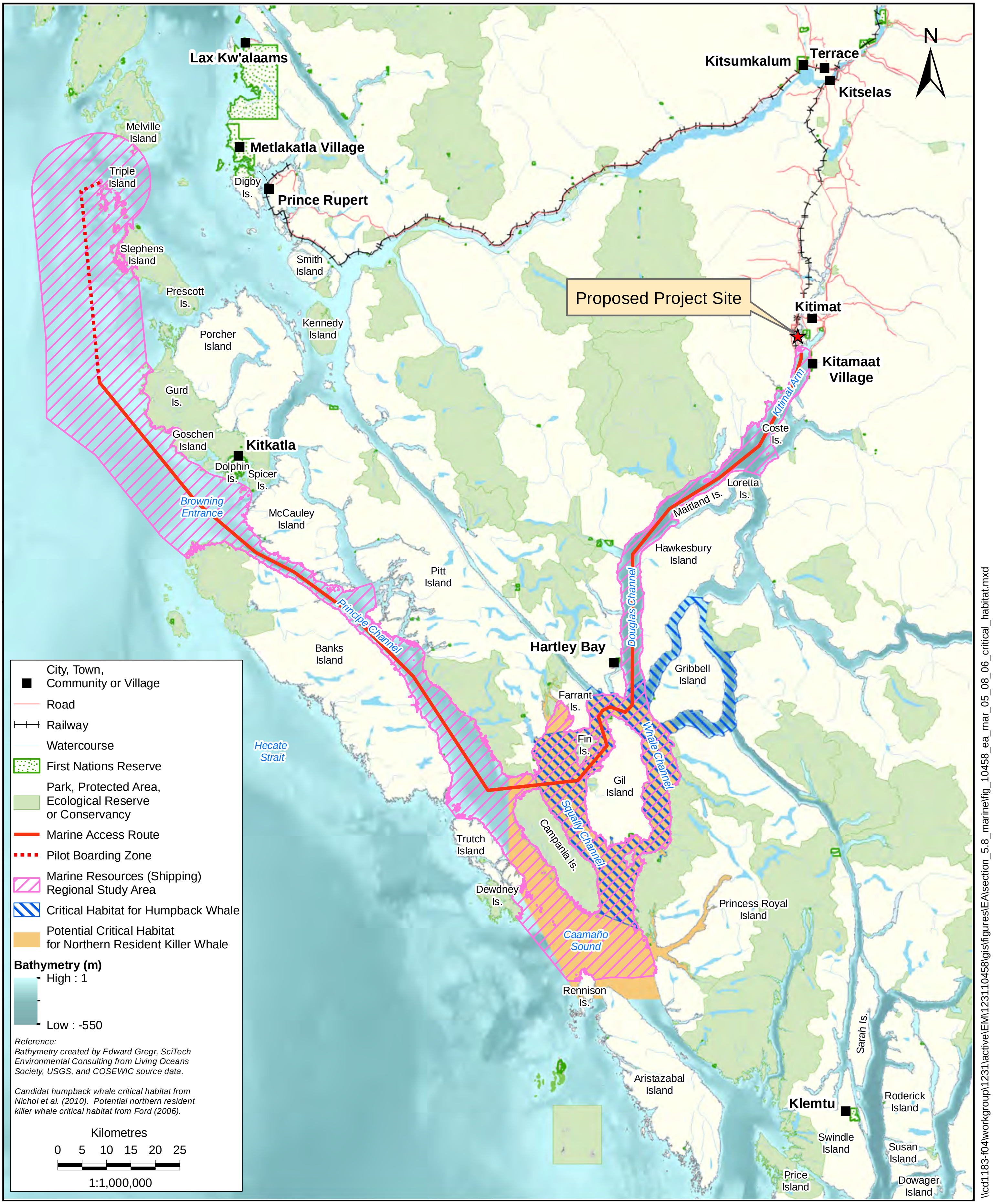

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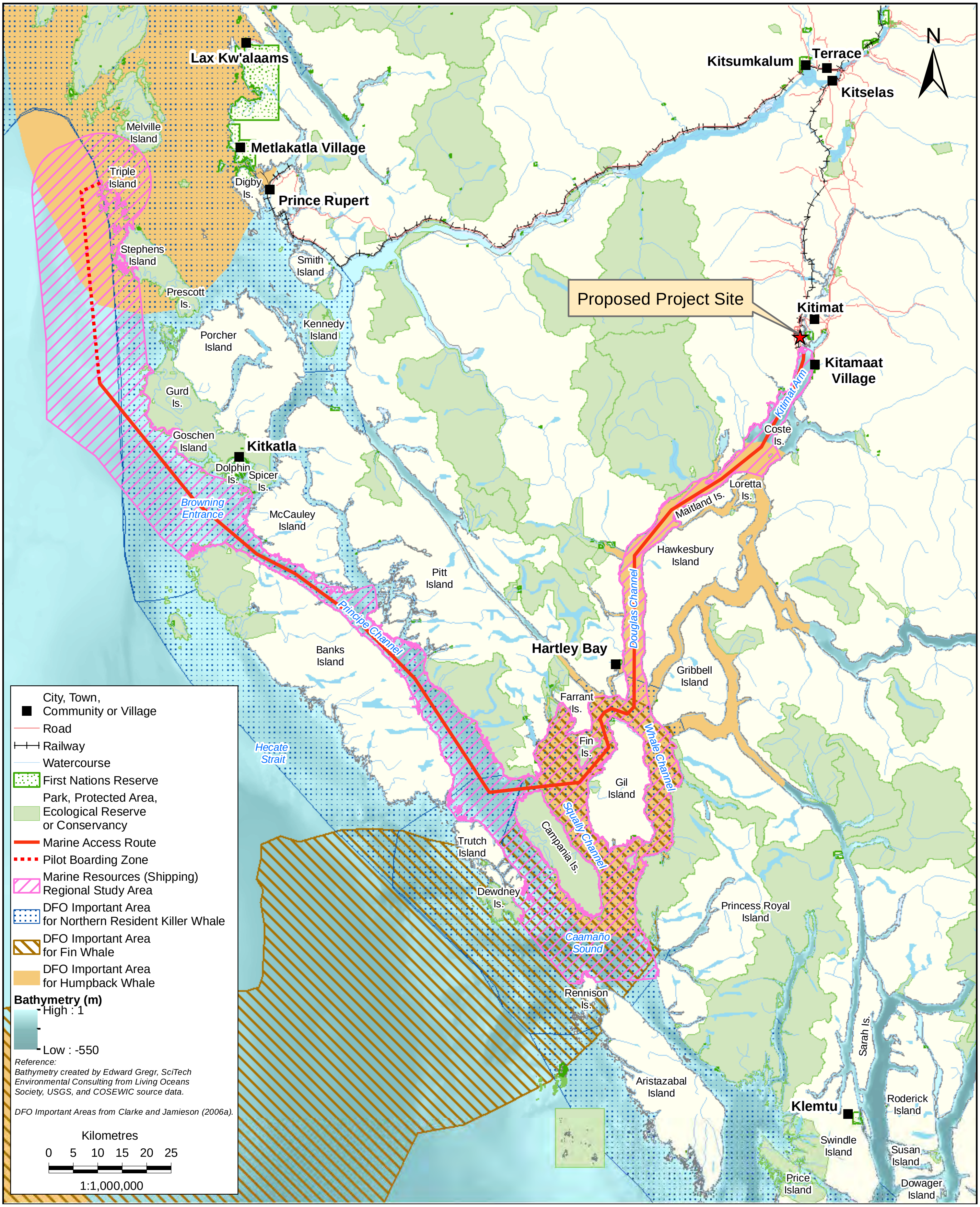
MARINE RESOURCES ENVIRONMENTAL EFFECTS ASSESSMENT

DESIGNATED AND POTENTIAL CRITICAL HABITAT OVERLAPPING WITH THE SHIPPING RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION UTM9	DRAWN BY SS
DATUM NAD 83	CHECKED BY SW
DATE 04-JUL-14	FIGURE NO. **5.8-6**



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MARINE RESOURCES ENVIRONMENTAL EFFECTS ASSESSMENT

DFO IMPORTANT AREAS FOR MARINE MAMMALS OVERLAPPING WITH THE SHIPPING RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
17-JUN-14	5.8-7

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The technical boundary regarding the scale of changes in behaviour of fish and marine mammals due to underwater noise is uncertain: it is difficult, as stated in peer-reviewed research, to quantify changes and differentiating responses of individuals from general population or species responses.

5.8.2.9 Residual Effects Description Criteria

The definitions used to characterize residual effects for marine resources are listed in Table 5.8-2.

5.8.2.10 Significance Thresholds for Residual Effects

The significance thresholds for residual effects on marine resources address subsections 35(1) and 36(3) of the *Fisheries* Act, subsection 32(1) of SARA, and the *Fisheries Protection Policy Statement* (DFO 2013a):

- any residual effect with a high likelihood of affecting population viability of fish that support or are part of CRA fisheries, or of marine mammals, or of species at risk
- any residual effect with a high likelihood of causing harm to species designated as *endangered* or *threatened* under Schedule 1 of SARA or by COSEWIC.

5.8.3 Baseline Conditions

This section summarizes the data sources and existing baseline conditions for marine resources in the facility and shipping LSAs and RSAs. For a more detailed description of baseline conditions for marine resources, refer to the Marine Resources TDR (Stantec Consulting Ltd. 2014a).

5.8.3.1 Baseline Data Sources

Data and information sources used to characterize baseline conditions were gathered through a review of TK and TU information, relevant literature and data, previous environmental assessments, and field studies. The literature review included a search of relevant scientific literature, government reports, “grey” literature including technical reports, and publicly available data. Literature review sources are detailed in the Marine Resources TDR (Stantec Consulting Ltd. 2014a).

Table 5.8-2: Characterization of Residual Effects for Marine Resources

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Characterization of Residual Effects		
Magnitude	The expected size or severity of effect. Low magnitude effects may have negligible to little effect, while high magnitude effects may have a substantial effect.	**Negligible**—no detectable or measurable change from existing baseline conditions **Low**—a measurable change from existing baseline conditions but is below environmental and/or regulatory thresholds and does not affect the ongoing viability of fish or marine mammal populations **Moderate**—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds but does not affect the ongoing viability of fish or marine mammal populations **High**—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds and adversely affects the ongoing viability of fish and marine mammal populations
Geographic Extent	The spatial scale over which the residual effects of the Project are expected to occur. The geographic extent of effects can be local or regional. Local effects may have a lower effect than regional effects.	**Project footprint**—residual effects are restricted to the marine terminal footprint **LSA**—residual effects extend into the LSA **RSA**—residual effects extend into the RSA
Duration	The length of time the residual effect persists. The duration of an effect can be short term or longer term.	**Short-term**—residual effect restricted to Project construction and/or decommissioning phases and is predicted to return to existing baseline conditions with no lasting effect. **Medium-term**—residual effect continues for up to two years following Project construction phase before returning to existing baseline conditions. **Long-term**—residual effect continues for more than two years after the Project construction phase, or continues during Project operation and decommissioning phases, before returning to existing baseline conditions. **Permanent**—residual effect is unlikely to return to existing baseline conditions.
Frequency	How often the effect occurs. The frequency of an effect can be frequent or infrequent. Short term and/or infrequent effects may have a lower effect than long term and/or infrequent effects.	**Single event**—occurs once **Multiple irregular event (no set schedule)**— occurs sporadically at irregular intervals **Multiple regular event**—occurs on a regular basis and at regular intervals **Continuous**—occurs continuously
Reversibility	Whether or not the residual effect on the VC can be reversed once the physical work or activity causing the disturbance ceases. Effects can be reversible or permanent. Reversible effects may have lower effect than irreversible or permanent effects.	**Reversible**—effect will recover to existing baseline conditions after decommissioning phase or sooner. **Irreversible**—effect is permanent.

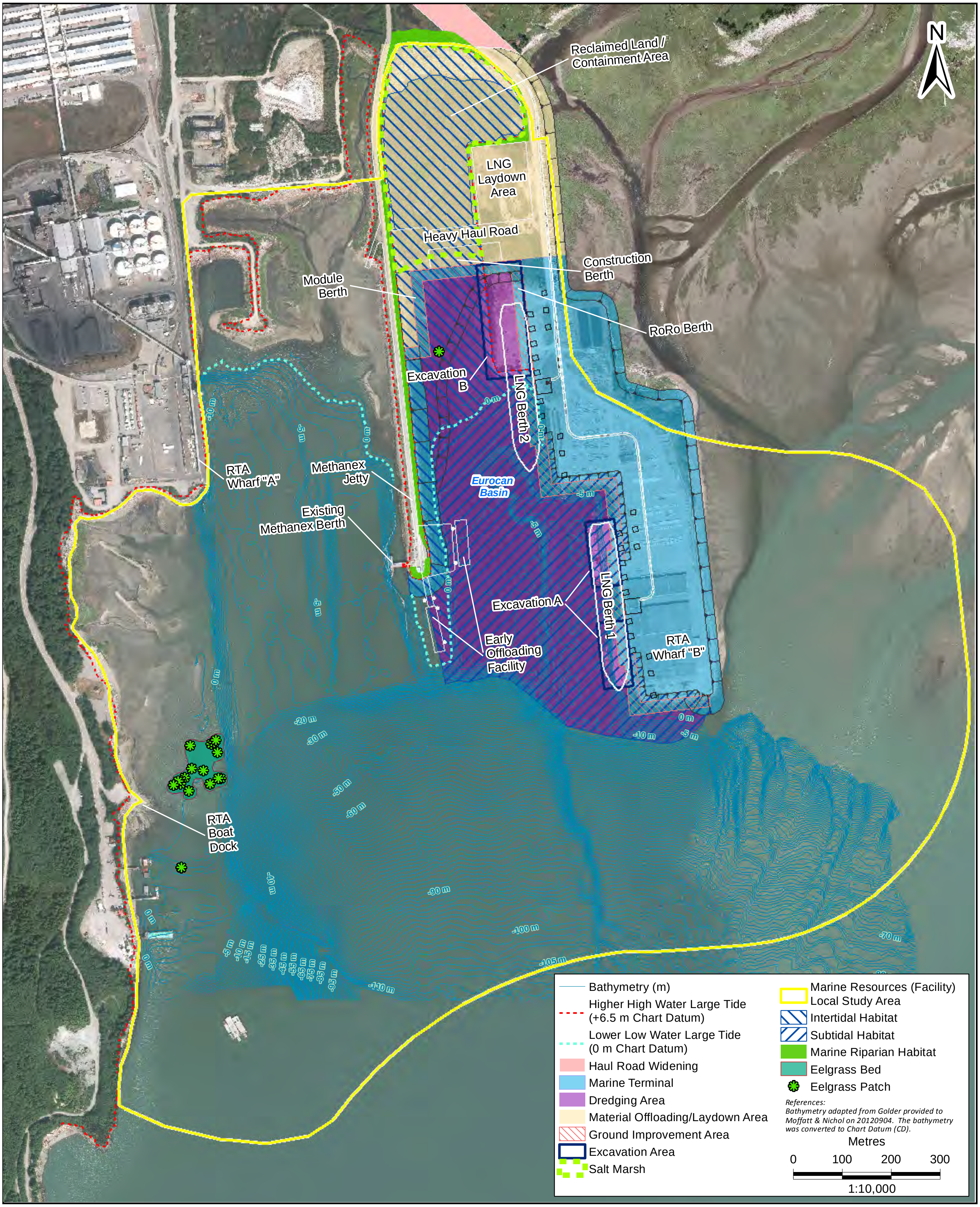
Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Context	Refers primarily to the sensitivity and resilience[a] of the VC. Consideration of context draws heavily on the description of existing conditions of the VC, which reflect cumulative effects of other projects and activities that have been carried out, and information about the impact of natural and human-caused trends on the condition of the VC. Project effects may have a higher effect if they occur in areas or regions that: ▪ Have already been adversely affected by human activities (i.e., disturbed or undisturbed) ▪ Are ecologically fragile and have little resilience to imposed stresses (i.e., fragile)	**Low resilience**—low capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance. **Moderate resilience**—moderate capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance. **High resilience**—high capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance.
Likelihood of Residual Effects		
Likelihood	Whether or not a residual effect is likely to occur	**Low**—low likelihood that there will be a residual effect. **Medium**—moderate likelihood that there will be a residual effect. **High**—high likelihood that there will be a residual effect.

NOTES:

[a] DFO (2013a) defines “resilience” as “the capacity of a population or ecosystem to recover from a disturbance”, and states that a more diverse marine ecosystem tends to have higher overall productivity and to be more resilient to natural or human disturbances than a less diverse ecosystem. Marine ecosystems that are subject to frequent natural or human disturbances are typically adapted to recover quickly following a disturbance (Newell et al. 1998).

Five field studies were conducted (see Stantec Consulting Ltd. [2014a] for further details):

- Two intertidal surveys were conducted from August 30 through September 2, 2012 and from June 22 through June 27, 2013. The survey design included transect surveys and quadrat sampling to collect baseline data on marine fish and fish habitat in the intertidal zone. Eighteen transects were surveyed in the facility LSA.
- A salt marsh survey was conducted from August 30 through September 2, 2012 and on July 31, 2013 at the salt marsh located north of the Eurocan Basin (the small bay between the Methanex jetty and RTA Wharf "B"; see Figure 5.8-8). The survey design included transect surveys and quadrat sampling to collect baseline data on marine fish and fish habitat in the salt marsh. Three transects across the salt marsh were surveyed. Complementary estuarine fish and fish habitat surveys were conducted from April 2012 through June 2013 in the salt marsh (Triton Environmental Consultants Ltd. 2014).
- A subtidal survey was conducted from October 3 through October 6, 2012. A camera-mounted remotely operated vehicle (ROV) was used to record video along transects extending across the facility LSA, to collect baseline data on marine fish and fish habitat in the subtidal zone. Twelve underwater transects were completed in the LSA. Depth profiles of dissolved oxygen, temperature, salinity, and pH were taken at five stations in the LSA, at 1 m intervals from 1 m below the surface to the seabed (or to a maximum depth of 20 m).
- A second subtidal survey was conducted from May 24 through May 29, 2014 in the BSAs. A camera-mounted ROV was used to record video along transects within each of the BSAs, to collect baseline data on marine fish and fish habitat. Ten underwater transects were completed with the ROV in BSA 1, five transects were completed in BSA 2, and five transects were completed in BSA 3.
- Twelve marine mammal line-transect vessel surveys were conducted in the shipping RSA between January 28 and October 29, 2013. The surveys evaluated the high and low periods of marine mammal use of the shipping RSA and coincided with biologically important times for certain species in the region (e.g., peak foraging or migration periods). There were six survey periods, each of which involved two consecutive surveys: winter (Jan. 27–Feb. 20), spring (March 26–April 24), early summer (June 1-25), mid-summer (July 1–27), late summer (July 31–Aug. 28), and fall (Oct. 1-29). Each survey started in Kitimat Arm and travelled southwest to Caamaño Sound, then north towards Principe Channel and Triple Island. Distance sampling methods were used for data collection and density surface modelling was used to estimate the number of marine mammals in a given area (i.e., relative abundance) for commonly observed species. The shipping RSA was divided into six strata (i.e., Kitimat Arm/Douglas Channel, Whale Channel, Squally Channel, Caamaño Sound/Estevan Sound, Principe Channel, and Triple Island) to reflect boundaries for designated humpback whale critical habitat, potential northern resident killer whale critical habitat, and different waterbodies in the area. This allowed for estimates of relative marine mammal abundance in each stratum, allowing for a more fine-scale analysis than would be obtained from a single estimate for the entire RSA.



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MARINE RESOURCES ENVIRONMENTAL EFFECTS ASSESSMENT

MARINE TERMINAL AND MARINE FISH HABITAT

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
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DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
22-AUG-14	**5.8-8**

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5.8.3.2 Baseline Overview

The facility RSA and BSAs are located in the North Coast Fjords Ecodistrict, which is characterized by turbid low productivity surface layers, estuarine circulation, typically hypoxic deep waters, diverse attached invertebrate communities at sills, soft bottom benthic communities, and seasonal salmon migrations (Harding 1997). The facility LSA is situated in the Kitimat River estuary, in the Kitimat Arm of Douglas Channel. Since the 1950s, the LSA has been subject to a variety of human disturbances associated with past and present industrial operations, including an aluminum facility, a pulp and paper mill (discharges from the mill entered the facility LSA from the Kitimat River), a methanol plant, the municipal wastewater treatment plant, which discharges effluent into the lower Kitimat River, and log storage and handling facilities (Levings 1976; MacDonald and Shepherd 1983).

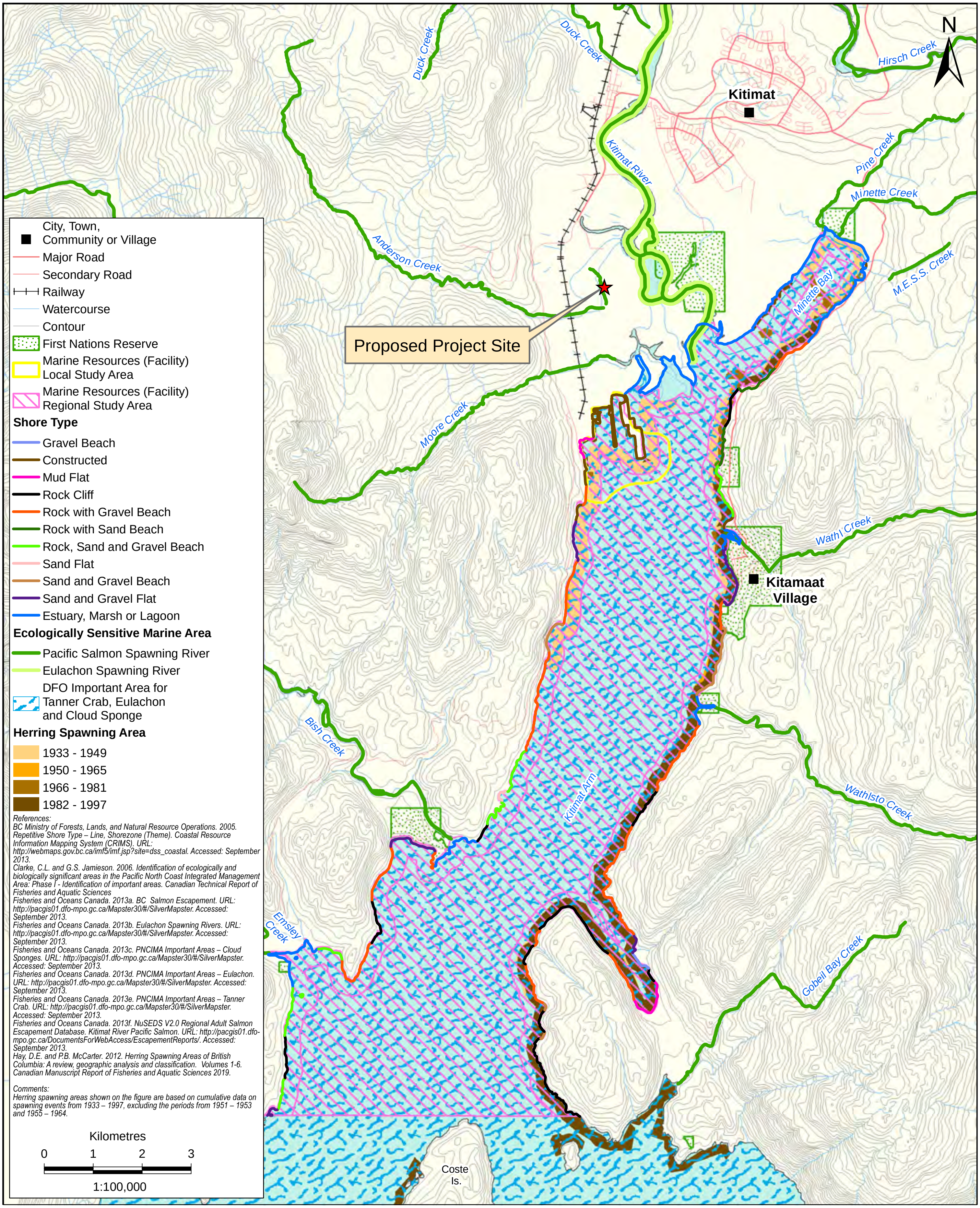
Water sampling conducted in the facility LSA in October 2012 indicated the upper 20 m of the water column had a weak halocline, with a gradual increase in salinity and decrease in temperature and dissolved oxygen with depth (Stantec Consulting Ltd. 2014a). Turbidity averaged 0.3 NTU (nephelometric turbidity unit), with little variation with depth or sampling location.

The shipping RSA overlaps with the North Coast Fjords, Hecate Strait, Queen Charlotte Sound, and Dixon Entrance Ecodistricts (Harding 1997):

- The Hecate Strait Ecodistrict is characterized by shallow waters, coarse bottom sediments, and strong tidal currents. It is a nursery area for Pacific salmon and herring, feeding grounds for marine mammals, and is characterized by abundant benthic invertebrate stocks.
- The Queen Charlotte Sound Ecodistrict is characterized by a wide shelf with water depths typically greater than 200 m.
- The Dixon Entrance Ecodistrict is characterized by deep waters, typically greater than 300 m, and strong freshwater influence from the mainland river runoff. It serves as a migration corridor for salmon, and nursery areas for juvenile fish and invertebrates.

5.8.3.2.1 Marine Fish and Fish Habitat

Marine riparian, intertidal, subtidal, eelgrass and kelp bed, estuary, and salt marsh habitats occur in the facility RSA. The RSA and BSAs overlap with DFO Important Areas (IAs) for eulachon (*Thaleichthys pacificus*), tanner crabs (*Chionoecetes bairdi*), and cloud sponges (*Aphrocallistes vastus*); and the RSA encompasses salmon (*Oncorhynchus* spp.) and eulachon spawning rivers and Pacific herring (*Clupea pallasii*) spawning areas (Figure 5.8-9) (Hay 2000; Clarke and Jamieson 2006a; Clarke and Jamieson 2006b; Hay 2012; DFO 2013e).



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MARINE RESOURCES ENVIRONMENTAL EFFECTS ASSESSMENT

MARINE FISH HABITAT FEATURES IN THE FACILITY RSA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION: UTM9	DRAWN BY: SS
DATUM: NAD 83	CHECKED BY: SW
DATE: 29-JUL-14	FIGURE NO. **5.8-9**

The facility RSA lies within the traditional territory of Haisla Nation, and the shipping RSA overlaps with the traditional territory of Haisla Nation, Gitga'at First Nation, Gitxaala Nation, Lax Kw'alaams First Nation, Metlakatla First Nation, Kitsumkalum First Nation, and Kitselas First Nation. These Aboriginal Groups use marine resources for food, social, and ceremonial purposes.

Marine fish species caught by Haisla Nation include salmonids, such as chum (*O. keta*), sockeye (O. *nerka*), coho (*O. kisutch*), chinook (*O. tshawytscha*), pink (*O. gorbuscha*), and steelhead trout (*O. mykiss*); small pelagic fish, such as eulachon and Pacific herring; demersal fish, such as Pacific halibut (*Hippoglossus stenolepis*), ling cod (*Ophiodon elongatus*), rock cod and snapper (*Sebastes* spp.), sablefish (*Anoplopoma fimbria*), and flounders (family Pleuronectidae); and invertebrates such as Dungeness crab (*Metacarcinus magister*), clams, cockles, mussels (*Mytilus* spp.), shrimps/prawns, octopus, sea cucumber, and sea anemone (Powell 2013). Marine fish are caught by Haisla Nation in many coastal areas within their traditional territory, particularly in the northern portion of Kitimat Arm and Minette Bay, and near Kitamaat Village (Powell 2013).

Salmon fishing season in Haisla Nation traditional territory generally runs from early spring to early fall (Powell 2013). Timing of fishing is species dependent because each species enters Kitimat Arm at different times of the year on their migration route towards the Kitimat River watershed to spawn. Demersal fish are targeted by Haisla Nation year round (Powell 2013).

Gitxaala Nation harvests marine fish such as Pacific herring and herring roe on kelp, halibut, black cod (sablefish), ling cod, rock cod, snapper, and salmonids; and invertebrates such as crab, prawns/shrimp, clams, cockles, mussels, chitons, northern abalone (*Haliotis kamtschatkana*), sea cucumbers, urchins, and octopus (Calliou Group 2014a,b; Firelight Group 2014). Metlakatla First Nation harvests seaweeds and herring roe from kelp beds, halibut, flounder, cod, salmon, abalone and other shellfish, octopus, sea urchins, sea prunes, and sea cucumbers (DM Cultural Services Ltd. 2014).

Salmon migration routes and general occurrence by species identified by Gitxaala Nation are listed and mapped in the Calliou Group (2014a) report. Gitxaala Nation identified that sockeye salmon spawn off Principe Channel and part of Petrel Channel, and salmon (non-species specific) are generally found throughout the shipping RSA. The locations where other marine resources are harvested were also identified by Calliou Group (2014a). Herring spawn around Gurd, Goschen, Dolphin, and Spicer islands, and around Ander Island; halibut is harvested throughout the shipping RSA; and crab is harvested around Kitkatla Inlet and the southwest tip of Pitt Island. In addition to fish and invertebrates, Gitxaała Nation harvests seaweed and kelp in various locations throughout the shipping RSA and at specific times during the year.

Marine resources within the shipping RSA have also traditionally been (and currently are) harvested by Kitsumkalum First Nation and Lax Kw'alaams First Nation. Kitsumkalum First Nation fished resources include cod, halibut, herring, octopus, dogfish, eel, flounder, rockfish, shrimp and prawn, bivalve, crab, sea cucumber, barnacle, and snail (Crossroads CRM 2014). Lax Kw'alaams First Nation reported they harvest the latter species as well as sea urchin, sea prunes, Chinese slippers, abalone, pilchard, all five salmon species, red snapper, Pollock, lingcod, sablefish, and squid (Lax Kw'alaams 2004). Kelp is also harvested. Restoring and reducing further loss of eulachon and eulachon habitat is of particular importance to both Kitsumkalum and Lax Kw'alaams First Nations (Lax Kw'alaams 2004; Crossroads CRM 2014). Kitsumkalum First Nation fish eulachon on the Skeena near tidal limits below Kwinitsa, and in other tributaries of the Skeena. Lax Kw'alaams First Nation noted what areas are ideal for fishing various species (Lax Kw'alaams 2004): for example, Big Bay is ideal for fishing seals, crabs, cod, halibut, and herring roe; Melville Island for kelp; Zayas Island for spring salmon, and Porcher Island for roe on kelp. In general, Dundas Island, Stephens Island, and the Hecate Strait are heavily used by Lax Kw'alaams First Nation to harvest seafood.

Table 5.8-3 lists marine fish species that are part of CRA fisheries and species at risk known to occur seasonally or year-round in the facility and shipping RSA and LSA, and BSAs, along with species observed during field surveys of the facility LSA and BSAs.

Table 5.8-3: Marine Fish Species Part of CRA Fisheries and Species at Risk Known to Occur in the Facility and Shipping LSA and RSA, and BSAs

Taxa	CRA Fishery Species	SARA-Listed	COSEWIC	BC *Wildlife Act*	Observed during Facility LSA Field Surveys	Observed during BSA Field Surveys
Chum salmon (*Oncorhynchus keta*)	✓				✓	
Coho salmon (*Oncorhynchus kisutch*)	✓					
Chinook salmon (*Oncorhynchus tshawytscha*)	✓					
Pink salmon (*Oncorhynchus gorbuscha*)	✓					
Sockeye salmon (*Oncorhynchus nerka*)	✓					
Steelhead trout (*Oncorhynchus mykiss*)	✓					
Cutthroat trout (*Salmo clarki clarki*)	✓					
Dolly Varden char (*Salvelinus malma*)	✓					
Pacific herring (*Clupea pallasii*)[a]	✓					
Eulachon (*Thaleichthys pacificus*)	✓		*endangered*	*blue*		✓
Surf smelt (*Hypomesus pretiosus*)	✓					
Cod (family Gadidae)	✓				✓	✓
Greenling (family Hexagrammidae)	✓				✓	

Taxa	**CRA Fishery Species**	**SARA-Listed**	**COSEWIC**	**BC *Wildlife Act***	**Observed during Facility LSA Field Surveys**	**Observed during BSA Field Surveys**
Bocaccio (*Sebastes paucispinis*)	✓		*endangered*			
Canary rockfish (*Sebastes pinniger*)	✓		*threatened*			
Darkblotched rockfish (*Sebastes crameri*)	✓		*special concern*			
Quillback rockfish (*Sebastes maliger*)	✓		*threatened*			
Rougheye rockfish (*Sebastes* sp. type I and type II)	✓	*special concern*	*special concern*			
Splitnose rockfish (*Sebastes diplorproa*)	✓					✓
Yelloweye rockfish (*Sebastes ruberrimus*)	✓	*special concern*	*special concern*			
Yellowmouth rockfish (*Sebastes reedi*)	✓		*threatened*			
Longspine thornyhead (*Sebastolobus altivelis)*		*special concern*	*special concern*			
Perch (family Emiotocidae)	✓				✓	
Pacific sand lance (*Ammodytes hexapterus*)	✓					
Sablefish (*Anoplopoma fimbria*)	✓					
Pacific halibut (*Hippoglossus stenolepis*)	✓					✓
Righteye flounder (family Pleuronectidae)	✓				✓	✓
Sculpin (family Cottidae)	✓				✓	✓
Green Sturgeon (*Acipenser medirostris*)	✓	*special concern*	*special concern*	*red*		
Bluntnose sixgill shark (*Hexanchus griseus*)		*special concern*	*special concern*			
Tope (*Galeorhinus galeus*)		*special concern*	*special concern*			
Salmon shark (*Lamna ditropis*)	✓					
North Pacific spiny dogfish (*Squalus suckleyi*)	✓		*special concern*			✓
Skate (family Rajidae)	✓				✓	✓
Dungeness crab (*Metacarcinus magister*)	✓				✓	✓
Alaska king crab (*Paralithodes camtschaticus*)	✓					
Red rock crab (*Cancer productus*)	✓					
Shore crab (*Hemigrapsus* spp.)	✓				✓	
Shrimp (family Pandalidae)	✓				✓	✓

Taxa	CRA Fishery Species	SARA-Listed	COSEWIC	BC *Wildlife Act*	Observed during Facility LSA Field Surveys	Observed during BSA Field Surveys
Giant Pacific octopus (*Octopus dofleini*)	✓					
Opal squid (*Loligo opalescens*)	✓					✓
Northern abalone (*Haliotis kamtschatkana*)	✓	*endangered*	*endangered*	*red*		
Bivalve molluscs (class Bivalvia)[b]	✓				✓	
Olympia oyster (*Ostrea conchaphila*)		*special concern*	*special concern*	*blue*		
Sea urchin (*Strongylocentrotus* spp.)	✓				✓	✓
Sea cucumber (class Holothuroidea)	✓				✓	✓
Sea stars (class Asteroidea)	✓				✓	✓
Sea anemones (order Actiniaria)	✓				✓	

NOTES:

CRA fishery species listed above include species reported in the facility and shipping RSA (see Sources below).

[a] Includes roe

[b] Includes: Baltic macoma clam (*Macoma balthica*), intertidal clams (*Protothaca staminea, Saxidomus giganteus*), soft shell clam (*Mya arenaria*), geoduck (*Panopea generosa*), cockle (family Cardiidae), blue mussels (*Mytilus* spp.), northern horse mussel (*Modiolus modiolus*), oyster (*Ostrea lurida*), and Olympia oyster (*Ostreola conchaphila*)

[c] Bivalve shellfish biotoxin closures and sanitary contamination closures are in effect for the entire facility RSA (DFO 2013d).

Sources: Species list compiled from: Levings (1976); MacDonald and Shepherd (1983); Lax Kw'alaams (2004); Jacques Whitford (2005); Clarke (2006a); Hyatt (2007); Schweigert (2007); Jacques Whitford Ltd. (2010); Powell (2011); Government of Canada (2012); DFO (2013h); DFO (2013i); DFO (2013g); Powell (2013); Calliou Group (2014a); Crossroads CRM (2014); DM Cultural Services Ltd.(2014); Stantec Consulting Ltd. (2014a). Conservation status compiled from: COSEWIC (2009); Government of Canada (2012); BCMOE (2013)

The total length and relative abundance of shore types in the facility RSA are listed in Table 5.8-4. Shore types classified as constructed are shoreline habitats previously altered or destroyed by human development or activity. At present, 8.7% (6.6 km) of shoreline in the facility RSA is classified as the constructed shore type (BC MFLNRO 2005). Constructed shores comprise approximately 81% of the shoreline in the facility LSA and 100% of the shoreline at the marine terminal (BC MFLNRO 2005; Stantec Consulting Ltd. 2014a).

Table 5.8-4: Length and Relative Abundance of Shore Types in the Facility RSA

Shore Type	RSA - Length (km)	RSA - % Total Length
Estuary, marsh or lagoon	26.1	34.5
Gravel beach	0.5	0.6
Constructed	6.6	8.7
Mud flat	1.9	2.5
Rock cliff	9.6	12.7
Rock with gravel beach	15.9	21.0
Rock, sand, and gravel beach	5.8	7.6
Rock with sand beach	1.9	2.5
Sand and gravel beach	2.8	3.7
Sand and gravel flat	4.3	5.7
Sand flat	0.4	0.5
Total	**75.7**	**100.0**

Source: Modified from BC MFLNRO (2005)

Intertidal habitat in the facility LSA consists of constructed riprap quay walls in the high intertidal zone and tidal flat with mixed sand and mud substrate in the mid and low intertidal zones. In the intertidal zone, 4 marine fish species, 15 invertebrate species, 1 seagrass species, 12 algae species, and 5 marsh plant species were observed (Stantec Consulting Ltd. 2014a). During intertidal surveys, a patchy eelgrass (*Zostera marina*) bed covering approximately 9,100 m^2 was observed in the southwest portion of the LSA (Figure 5.8-8). Within the bed, 12 small patches of eelgrass were identified ranging in size from 1 m^2 to 30 m^2 with densities of 10% to 95% cover, and covering a combined total area of approximately 83 m^2 (Stantec Consulting Ltd. 2014a). Subsequent surveys by Golder Associates Ltd. (2014a) suggest there is seasonal and inter-annual variation in the size of the eelgrass bed and that it covers an area of 31,815 m^2 with percent cover ranging from 5% to 50%. A second patchy eelgrass bed covering an area of 3,262 m^2 was observed in the Eurocan Basin with percent cover ranging from 25% to 50% (Golder Associates Ltd. 2014a). Riparian vegetation included small to medium size coniferous and deciduous trees, shrubs, sedge, and grasses (Stantec Consulting Ltd. 2014a). More detailed information on vegetation in the facility LSA is available in Stantec Consulting Ltd. (2014b).The backshore zone consists of a variety of constructed structures and materials, including graded construction and staging areas, jetties, wharves, gravel roads, concrete and rock riprap, culverts, and wood and metal debris.

The salt marsh habitat located north of the Eurocan Basin (see Figure 5.8-8) covers an area of approximately 84,000 m^2 and consists of marsh vegetation and a network of tidal channels (Stantec Consulting Ltd. 2014a). The marsh is bordered by constructed riprap quay walls in the high intertidal zone and riparian vegetation to the west, north, and east, and a rock dike partially open to Kitimat Arm to the south. Log debris is abundant in the northern area of the marsh in the high intertidal zone. The marsh substrate consists of mud and is covered by beds of unattached rockweed (*Fucus gardneri*) in many areas. Two marine algae species, six marsh plant species, two marine invertebrate species, and two marine fish species were observed in the salt marsh during the surveys. Lyngbye's sedge (*Carex lyngbyei*), rockweed, silverweed (*Potentilla anserina* ssp. *pacifica*), gammarid amphipods, and stubby isopods (*Gnorimosphaeroma oregonensis*) were the most common species observed. The marsh is subject to daily inundation at high tide and provides habitat for juvenile salmon and non-migratory fish species. Between April 2012 and June 2013, eight fish species were observed in the marsh: five species of Pacific salmon (*Oncorhynchus* spp.), three-spined stickleback (*Gasterosteus aculeatus*), Pacific staghorn sculpin (*Leptocottus armatus*), and starry flounder (*Platichthys stellatus*) (Triton Environmental Consultants Ltd. 2014).

Subtidal habitat in the facility LSA consists of mud flats (58% of LSA), mud depressions (15% of LSA), mud ridges (15% of LSA), and mud slopes (11% of LSA) with limited structural complexity (i.e., lacking rock substrates and biogenic habitats). Water depths in the facility LSA range from 0 m CD to greater than 100 m CD. During the survey, 51 marine fish and invertebrate species, 5 algae species and 1 seagrass species (common eelgrass) were observed at or near the seabed of the LSA (Stantec Consulting Ltd. 2014a). Overall, coverage of marine algae in the subtidal zone was sparse, with densest coverage in shallow areas of the LSA, typically at depths of less than 5 m, on rocky substrates. Patches of eelgrass were observed in shallow waters in the southwest portion of the LSA, which is consistent with the observations made during the intertidal survey.

The channels of the BSAs are characterized by steep bedrock walls and a gently sloping soft seabed comprised of mud and silt sediment (Figure 5.8-3; Bornhold 1983; Stantec Consulting Ltd. 2014a). Mud depressions are the dominant benthic class present in the BSAs, with smaller areas of mud ridges, and water depths in the BSAs range from 150 m to 350 m CD (Figure 5.8-3). The seabed of BSA 1 consists of complex undulated terrain, while the seabed of BSA 2 and BSA 3 is less complex with gentle slope grading downward from north to south (Stantec Consulting Ltd. 2014a). Areas of bedrock substrate with some pebble and cobble are present in BSA 3 at the base of the eastern rock wall of Amos Passage (Stantec Consulting Ltd. 2014a). During the survey, 42 marine fish and invertebrate species were observed in the BSAs with an additional 18 unconfirmed species present (Stantec Consulting Ltd. 2014a). The BSA substrates are located well below the photic zone, and therefore no marine vegetation was observed. No sponges were observed in the BSAs during the subtidal survey; however, two cloud sponge skeletons were collected in a single sediment grab in the southeast portion of BSA 3, which likely originated from higher up on the bedrock channel wall (Stantec Consulting Ltd. 2014a).

5.8.3.2.2 Marine Mammals

Marine mammals are abundant on the north coast of BC, and many species are found year-round and seasonally within the shipping RSA. Baleen whales commonly observed in the region include humpback (*Megaptera novaeangliae*), grey (*Eschrichtius robustus*), fin (*Balaenoptera physalus*) and minke whales (*Balaenoptera acutorostrata*). Toothed whales that frequent the shipping RSA include northern resident and Bigg's killer whales (*Orcinus orca*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Dall's porpoise (*Phocoenoides dalli*) and harbour porpoise (*Phocoena phocoena*). Harbour seals (*Phoca vitulina richardii*), Steller sea lions (*Eumetopias jubatus*) and sea otters (*Enhydra lutris*) are also found within the shipping RSA. For detailed quantitative information on marine mammal abundance and occurrence in the shipping RSA refer to the Marine Resources TDR (Stantec Consulting Ltd. 2014a). A high-level summary is provided below.

Of the baleen whales commonly observed, humpback whales are the most abundant. They have been seen year-round in the shipping RSA north of Browning Entrance, with numbers peaking in the late summer survey period (August) in Caamaño Sound and around Gil Island (Stantec Consulting Ltd. 2014a). The designated critical habitat for humpback whales, and a DFO Important Areas for humpback whales, overlap with portions of the shipping RSA around Gil Island (DFO 2013e; Clarke 2006a) (Figure 5.8-6 and Figure 5.8-7). Grey and fin whales exhibit more seasonal use of the area. Grey whale presence is more frequently associated with the open waters of the shipping RSA during their spring migration, and fin whale observations peak in the mid-summer survey period, particularly in the southern portion of Squally Channel and in Caamaño Sound. Minke whales have been observed year-round in BC waters in low numbers. The Kitsumkalum First Nation identified Hecate Strait as an area used by humpback whales (Kitsumkalum Band 2012). Gitxaala Nation reported the presence of humpback whales between Banks Island and McCauley Island, in Wright Sound, and in Otter Channel; and identified the north end of Principe Channel up through Edye Passage as a migration corridor for the species (Calliou Group 2014a).

Toothed whales are also abundant within the shipping RSA, with the potential for large groups (i.e., hundreds) of Pacific white-sided dolphins, primarily in the fall and winter, as well as year-round sightings of Dall's porpoise and harbour porpoise. Feedback from Gitga'at First Nation on timing of marine mammal surveys indicated that Pacific white-sided dolphin aggregations were largest (greater than 100 animals) in the shipping RSA during February (Picard 2013). Bigg's killer whales are present year-round and northern resident killer whale distribution, which is strongly associated with prey abundance, peaks in the early summer. DFO Important Areas and potential northern resident killer whale critical habitat have been identified in the shipping RSA (Ford, 2006; Clarke 2006a) (Figure 5.8-6 and Figure 5.8-7). Gitxaala Nation reported killer whale presence in Wright Sound and Otter Channel, and porpoises between McCauley Island and Goschen Island, north of Banks Island (Calliou Group 2014a).

Harbour seals and Steller sea lions are present within the shipping RSA throughout the year. Haisla Nation identified that seals are present in Minette Bay, the flats around Zagwis, and the Kitamaat Village area (Powell 2013; Powell 2011). Lax Kw'alaams First Nation (2004) noted that seals can also be found in the Pearl Harbour area. Seals and sea lions have additionally been reported in many areas throughout Douglas Channel and the islands along Hecate Strait (Marsden 2012; Satterfield et al. 2012). Gitxaala Nation reported seals breed along Ander Island (Calliou Group 2014a). No Steller sea lion rookeries are located within the RSA, but there is a year-round haulout at Warrior Rocks and a major winter haulout on Ashdown Island. Sea otters have been sighted within the shipping RSA, but infrequently; the area currently extends beyond what is considered their northern-most range. Metlakatla First Nation, Kitsumkalum First Nation, and Lax Kw'alaams First Nation have traditionally hunted sea lions and seals in their traditional territories (Lax Kw'alaams 2004; Crossroads CRM 2014; DM Cultural Services Ltd. 2014). Marine mammal species and species at risk that occur in the shipping RSA are listed in Table 5.8-5; all species listed in the table were observed during field surveys.

Table 5.8-5: Marine Mammal Species at Risk Known to Occur in the Facility RSA and in the Shipping RSA

Taxa	SARA-Listed	COSEWIC	BC *Wildlife Act*	Likely in Facility RSA	Likely in Shipping RSA
Humpback whale (*Megaptera novaeangliae*)	*threatened*	*special concern*	*red*	✓	✓
Fin whale (*Balaenoptera physalus*)	*threatened*	*threatened*	*red*		✓
Grey whale (*Eschrichtius robustus*)	*special concern*	*special concern*	*blue*		✓
Minke whale (*Balaenoptera acutorostrata*)		*not at risk*	*yellow*		✓
Northern resident killer whale (*Orcinus orca*)	*threatened*	*threatened*	*red*	✓	✓
Bigg's (transient) killer whale (*Orcinus orca*)	*threatened*	*threatened*	*red*	✓	✓
Dall's porpoise (*Phocoenoides dalli*)		*not at risk*	*yellow*	✓	✓
Harbour porpoise (*Phocoena phocoena*)	*special concern*	*special concern*	*blue*	✓	✓
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)		*not at risk*	*yellow*	✓	✓
Harbour seal (*Phoca vitulina richardii*)		*not at risk*	*yellow*	✓	✓
Steller sea lion (*Eumetopias jubatus*)	*special concern*	*special concern*	*blue*	✓	✓
Sea otter (*Enhydra lutris*)	*special concern*	*special concern*	*blue*		✓

SOURCES:

List compiled from field surveys, BC Cetacean Sightings Network (BCCSN) data (2013); BCMOE (2013); COSEWIC (2009); Government of Canada (2012)

Abundance estimates, based on field studies, for commonly sighted species provide a snapshot of seasonal changes in abundance throughout the shipping RSA. Figure 5.8-10 shows the estimated abundance and confidence intervals by stratum or area within the shipping RSA, based on results of density surface modelling. Detailed methods and results are described in the Marine Resources TDR (Stantec Consulting Ltd. 2014a).

5.8.3.2.3 Sediment and Water Chemistry

Elevated contaminant levels above natural background concentrations, particularly for polycyclic aromatic hydrocarbons (PAHs), have been recorded in waters of the facility RSA (Jacques Whitford Ltd. 2010). These concentrations originated from industrial, municipal and residential inputs over the past 60 years. PAHs are the contaminants of most concern due to their high concentrations and potential for toxicity, and are related to air emissions and effluent discharges from the RTA facility (Warrington 1987; NOAA 2009). These PAHs are considered to have low bioavailability and toxicity to marine organisms because they are present in large soot/coke particles (Paine et al. 1996; NOAA 2009).

Sediment sampling from 2012 to 2014 in the dredge area indicated that levels of individual PAHs were above CCME probable effects levels (PEL) at 43 locations (Stantec Consulting Ltd. 2014a). Concentrations above PELs are likely to result in adverse biological effects. Total parent PAH levels were higher than the disposal at sea Tier 1 screening criterion (2.5 mg/kg) in 75% of the locations, mainly in the top 3 m of sediment, but extending to 6 m depth in the area west of LNG Berth 2 (Figure 5.8-8). Some metal concentrations (copper, cadmium, zinc) were above CCME Interim Sediment Quality Guidelines (ISQG), which are values above which adverse biological effects are expected to occur occasionally. Copper levels were higher than the CCME ISQG throughout the area, reflecting natural conditions; however, two locations had copper levels higher than the PEL, one location had cadmium levels higher than the ISQG, and five locations had zinc concentrations higher than the ISQG or PEL, suggesting human activities as the source of these metals. Dioxin and furan values were above the ISQG in several locations but below the PEL (Golder Associates Ltd. 2013, 2014b). Sampling from previous studies reported that PAH concentrations were highest in the Alcan Harbour, but were also elevated in the facility LSA and, to a lesser extent, throughout Kitimat Arm, compared with reference sites (Paine et al. 1996; NOAA 2009).

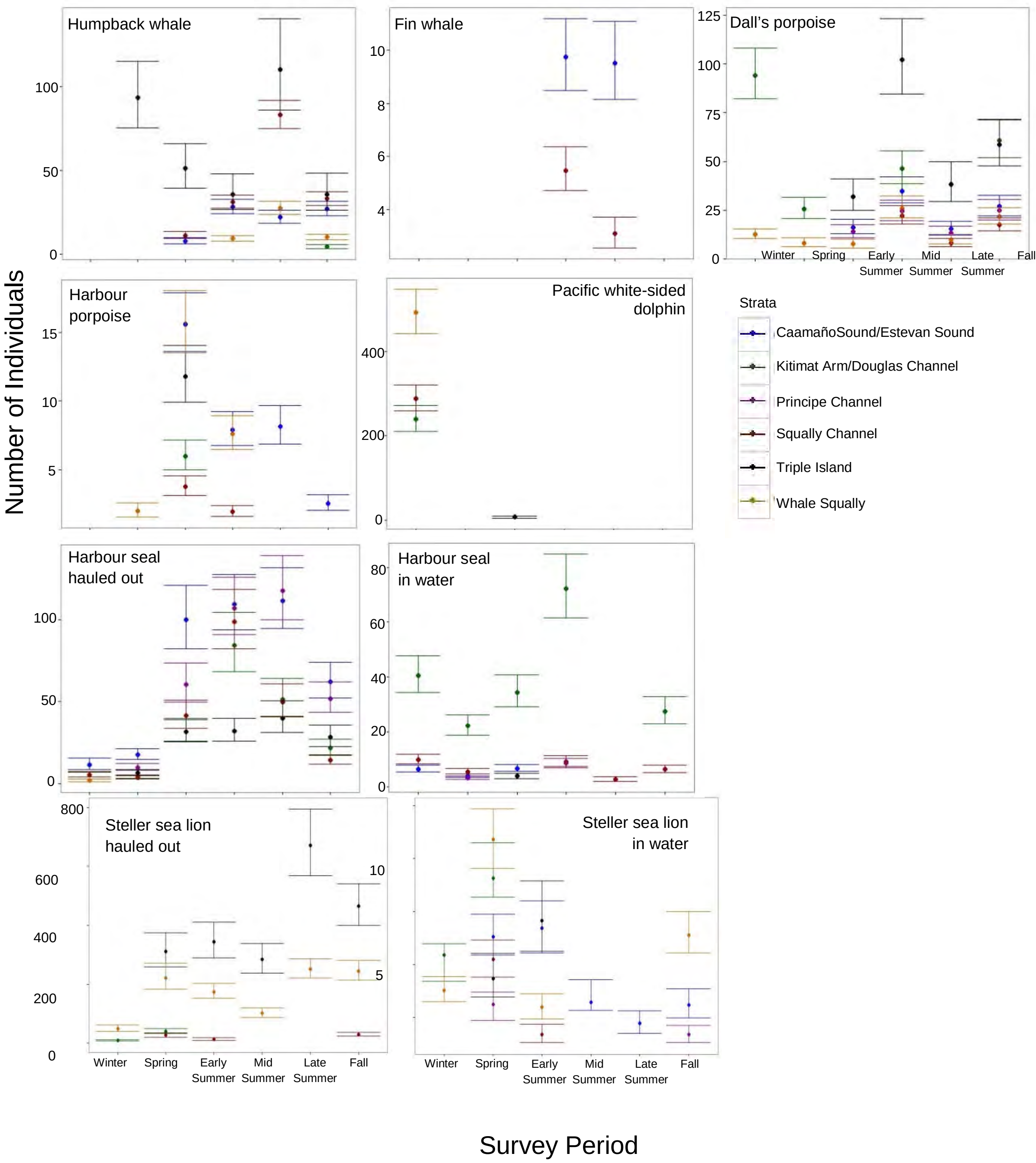

Figure 5.8-10: Density Surface Modelling Abundance Estimates in the Shipping RSA

5.8.3.2.4 Ambient Underwater Noise

Williams et al. (2013) evaluated the ambient noise levels (dB re: 1µPa @ 1 m) in marine mammal species-specific frequency bands at three locations within the shipping and facility RSAs (Kitimat, Kitkiata Inlet, Triple Island). Kitimat and Kitkiata Inlet currently experience relatively little large-ship traffic; therefore, these areas have lower noise levels (66 to 72 dB, 84 to 90 dB, and 78 to 78 dB at frequency bands within which fin whales, humpback whales, and killer whales, respectively, communicate) than other sites along the BC coast. Triple Island, being near to the port of Prince Rupert, has higher ambient noise levels (84 to 90 dB, 90 to 96 dB, and 84 to 90 dB at frequency bands within which fin whales, humpback whales, and killer whales, respectively, communicate). Under these higher ambient underwater noise levels, the distance over which marine mammals can communicate is reduced.

JASCO Applied Sciences Ltd. conducted field measurements of underwater ambient noise levels from the end of April 2013 through to the beginning of September 2013 at four locations along the marine access route: at the proposed LNG facility near Kitimat, Douglas Channel, Wright Sound, and Browning Entrance (Stantec Consulting Ltd. 2014a). The acoustic data reflected industrial noise (near Kitimat), vessel traffic, wind and wave noise, water flow from tidal currents, and marine mammal vocalizations, with shipping noise the dominant contributor to the current ambient conditions. The area near Kitimat had higher noise levels than Douglas Channel, primarily from shipping and local industrial activity. However, the highest mean and maximum daily sound exposure levels were recorded at Wright Sound, where there is regular vessel traffic.

5.8.4 Project Interactions

Table 4.4–1 (Section 4) identifies potential interactions of concern between Project activities and each of the selected VCs that are assessed. The potential effects identified in Section 5.8.2.4 that may result in an adverse effect as a result of interactions with Project activities are listed in Table 5.8-6.

A conservative approach is taken in assigning a Rank of 1, whereby interactions with a meaningful degree of uncertainty are assigned a Rank of 2 so that a detailed effects assessment is conducted.

LNG facility activities and works assigned a rank of 0 have no interactions with marine resources. These are the strictly land-based construction (i.e., site preparation, vehicle and rail traffic), operation (i.e., natural gas treatment and condensate extraction, and LNG production), and decommissioning (i.e., remediation and reclamation of the site; post-closure monitoring and follow-up) activities. For site preparation and onshore construction, all effects are ranked as 0. These interactions are not considered further in this assessment.

Table 5.8-6: Potential Project Effects on Marine Resources

Project Activities and Physical Works	Potential Effects					
	Change in Fish Habitat	Change in Fish Health as a Result of Toxicity	Harm to Fish or Marine Mammals		Change in Fish or Marine Mammal Behaviour due to Underwater Noise or Pressure Waves	
	Marine Fish	Marine Fish	Marine Fish	Marine Mammals	Marine Fish	Marine Mammals
Facility Activities and Works						
Construction						
Onshore construction (installation of LNG facility, utilities, ancillary support facilities, access roads, and includes hydrotesting)	1	1	0	0	0	0
Dredging (includes disposal)	2	2	2	0[a]	2	2
Marine terminal construction (modifications to existing wharf, installation of sheet piling, material offloading and laydown areas, transfer piping and electrical installations)	2	2	2	2	2	2
Waste management (waste collection and treatment)	1	1	0	0	0	0
Operation						
Waste management (solid and liquid waste collection and disposal, wastewater effluent collection and treatment, site stormwater management)	1	1	0	0	0	0
Decommissioning						
Dismantling of land-based and marine infrastructure	1	0	2	0	2	2
Waste management	1	1	0	0	0	0
Shipping						
Construction						
Shipping equipment and materials	1	1	0	0[a]	2	2
Operation						
LNG shipping	1	1	0	0[a]	2	2
Decommissioning						
Shipping equipment and materials	1	1	0	0[a]	2	2

KEY:

0 = No interaction.

1 = Potential adverse effect requiring mitigation, but further consideration determines that any residual adverse effects will be eliminated or reduced to negligible levels by existing codified practices, proven effective mitigation measures, or BMPs.

2= Interaction may occur and the resulting effect may exceed negligible or acceptable levels without implementation of Project-specific mitigation. Further assessment is warranted.

[a] Potential harm to marine mammals due to vessel strikes is considered to be an unplanned event and is assessed in Section 10, Accidents or Malfunctions.

NOTE: Only activities with an interaction of 1 or 2 for at least one effect are shown.

5.8.4.1 Justification of Interaction Rankings Ranked as 1

Activities ranked as 1 in Table 5.8-6 are considered to have a non-substantial interaction with marine resources, but are managed through use of standard operating procedures or mitigation. They are discussed below, briefly summarized in Sections 5.8.5 and 5.8.6, and considered in the cumulative effects assessment (Section 5.8.7).

5.8.4.1.1 Onshore Construction (Hydrostatic Testing) – Interactions with Fish Habitat and Fish Health

During construction, discharge of water used in hydrostatic testing has the potential to affect marine fish habitat and fish health. Seawater may be used for hydrostatic testing of the LNG storage tanks, followed by rinsing with freshwater. All water that may be used will be tested, and treated if necessary, before discharge into marine waters near the marine terminal. All hydrostatic testing will be conducted in accordance with the Canadian Association of Petroleum Producers *Hydrostatic Test Water Management Guidelines* (CAPP 1996), and all discharged water will meet *CCME Water Quality Guidelines for the Protection of Aquatic Life*. By complying with these regulatory requirements and industry guidelines, the discharged water will not contain contaminants or “deleterious substances” (as defined in section 36 of the *Fisheries Act*). In addition, the test water will be released in a controlled manner to limit changes in general chemistry (e.g., temperature, salinity, pH) of the receiving marine waters. Therefore, no change in fish habitat or fish health due to hydrostatic testing is expected and no further assessment is warranted.

5.8.4.1.2 Waste Management – Interaction with Fish Habitat and Fish Health

The release of treated sewage, stormwater, and blow down (cooled down bleed) water from the cooling towers into marine waters of the facility LSA during the construction, operation, and decommissioning phases has the potential to change water and sediment quality, and by extension, fish habitat and fish health. Fish habitat and fish health also has the potential to be affected by runoff from the salt marsh where the majority of sediment that does not meet disposal at sea screening criteria will be disposed of. These waste discharges will be managed to comply with applicable federal and provincial legislation, regulations, and guidelines including the *Fisheries Act*, CEPA, CSA 2001, BC *Environmental Management Act*, Waste Discharge Regulation, the Petroleum Storage and Distribution Facilities Storm Water Regulation, and the CCME Water Quality Guidelines for the Protection of Aquatic Life (see Section 5.8.1.1). Many of these statutes and regulations were developed specifically to protect fish habitat, marine environmental quality, and fish health. Because any discharge of waste into marine waters will be within regulatory limits, no further assessment is warranted.

5.8.4.1.3 Shipping (Propeller Wash) – Interactions with Fish Habitat and Fish Health

Propeller wash from LNG carriers, escort or harbour tugs and construction vessels arriving at or departing from the marine terminal during all Project phases have the potential to affect fish habitat. The effects of propeller wash on marine habitats are not well understood, but may include elevated levels of TSS, smothering of marine flora, and scouring of seabed sediments. Any contaminants (such as PAHs) present in the sediment also could be disturbed.

Water depth at the LNG berths will be approximately -14 m CD, while the draft of the LNG carriers and escort tugs are approximately 12 m and 4 m, respectively, resulting in under keel clearance of approximately 2 m for LNG carriers and 10 m for escort tugs at the lowest mean tides (i.e., 0 m CD). With this limited under-keel clearance, propeller wash from LNG carriers and the escort tugs during the operation phase has the potential to result in a change in fish habitat or fish health in the area immediately surrounding the MOF and LNG berths. Scour protection will be installed along the MOF and LNG berths and will reduce disturbance to sediments from propeller wash and the erosion of loose materials. Scour protection will involve placement of a rock apron/blanket on the seabed. Propeller wash from the variety of other support vessels used for construction and decommissioning is not expected to result in a measurable change in fish habitat.

Contaminants (mainly PAHs, but also dioxins and furans, cadmium, copper and zinc) are present in the upper 3 m of sediment (Golder Associates Ltd. 2013, 2014b). Dredging for berth construction will remove sediment from the top 10 m to 14 m, effectively removing contaminants from the majority of areas that could be disturbed by propeller wash. The only area where sediment with elevated contaminant levels may remain is southeast of the marine terminal area (Figure 5.8-7) where water is deeper and dredging will be less extensive. Generally, PAHs in the facility LSA and RSA have low toxicity and bioavailability, which is expected to limit the potential for adverse effects if sediment from that area is disturbed (NOAA 2009; Paine et al. 1996). Additional testing is being conducted on the sediments to better understand the various components.

Frequent natural and human disturbances occur within the facility LSA, such as heavy sediment loads carried by the Kitimat River into Kitimat Arm during spring freshet and periods of high precipitation (MacDonald and Shepherd 1983), as well as strong tidal currents, and vessel traffic from existing projects. As a result, it is reasonable to expect that marine fish and fish habitat in the LSA are well adapted and resilient to temporary fluctuations in TSS levels. Propeller wash is, therefore, not expected to change the total area or productive capacity of fish habitat, or sediment or water quality, and no further assessment of the effects of propeller wash on fish habitat or fish health is warranted. The temporary mobilization of contaminants of concern during dredging is addressed in Section 5.8.5.3, and potential for harm to fish from temporary increases in TSS levels due to other sources is assessed in Section 5.8.5.4.

Effects on marine mammals from temporary increases in TSS levels and mobilization of contaminants of concern during dredging are not expected to occur.

5.8.4.1.4 Shipping (Wake Waves) – Interaction with Fish Habitat

Wake generated by LNG carriers and escort tugs transiting the shipping RSA during the operation phase has the potential to affect fish habitat along the shoreline. The size and character (period, direction, number, duration) of wake waves at the shoreline in confined channels depends on a range of factors, including water depth beneath the vessel, channel width, vessel design (hull form), vessel size (length and draft), vessel speed, and distance between the vessel and the shoreline (Pullar and Single 2009; Sorensen 1997). LNG carriers and escort tugs are expected to generate larger wake waves than construction support vessels. Over the minimum 25-year lifespan of the LNG facility operation, between 170 and 350 LNG carriers are expected to call on the marine terminal per year, resulting in between 340 and 700 transits of the marine access route annually.

Shoreline habitats are regularly exposed to wave action from naturally occurring wind- and swell-generated waves and are thus already adapted to this natural disturbance. Additional anthropogenic effects to shoreline habitats are expected only if the size and/or frequency of vessel wake waves are sufficiently greater than naturally occurring waves to increase shoreline erosion and dislodge marine vegetation.

Table 5.8-7 shows monthly mean and maximum wave heights derived from buoy data provided by DFO at two stations along the marine access route: Nanakwa Shoal and South Hecate Strait (DFO 2014c). Nanakwa Shoal station is located in Kitimat Arm and is representative of confined channel environments, while South Hecate Strait station is located in south Hecate Strait between Haida Gwaii and the BC mainland and is representative of open ocean environments. The data show that average monthly wave heights are greater at both stations during winter months (November through March) than at other times of year. Average annual wave heights at Nanakwa Shoal (0.14 m) are one order of magnitude lower than at South Hecate Strait (1.80 m). Waves of up to 3.36 m and 13.70 m can be expected at Nanakwa Shoal and South Hecate Strait each year, respectively.

Table 5.8-7: Wave Heights at Buoy Stations Along the Marine Access Route

Buoy Station/ No.	Water Depth (m)	Latitude/ Longitude	Wave Height (m)													
			Mean/ Max.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Nanakwa Shoal 46181	22	53° 50.0' N 128° 49.9' W	Mean	0.24	0.18	0.15	0.09	0.10	0.11	0.11	0.09	0.09	0.11	0.16	0.22	0.14
			Max.	2.02	2.33	2.27	3.36	3.04	2.05	0.75	0.78	0.71	0.85	1.23	1.79	3.36
South Hecate Strait 46185	228	52° 24.4' N 129° 47.0' W	Mean	2.53	2.24	2.16	1.74	1.36	1.13	0.97	1.03	1.33	1.91	2.43	2.65	1.80
			Max.	12.80	12.00	10.20	7.96	7.87	5.84	6.89	7.09	8.20	11.00	12.50	13.70	13.70

Sources: DFO (2014c)

Studies regarding the effects of vessel wake typically focus on riverine environments (Nagrodski 2012; Kucera-Hirzinger et al. 2009; Pearson et al. 2006; Adams et al. 1999; Sorensen 1997); however, there is a lack of information and empirical studies on wake waves from large commercial shipping vessels in the marine environment. In general, rivers are characterized by much shallower water depths and narrower widths than the confined channels along the fjords of the BC north coast. Furthermore, river banks are not exposed to the same wind- and swell-generated waves that act naturally upon marine shorelines. Therefore, wake effects on shoreline habitats tend to be more of an issue in riverine than marine environments. Studies on wake waves in marine environments tend to be focused on vessels that transit at high speeds and are known to produce large wake waves, particularly high-speed ferries (Fonseca and Malhotra 2012; Kurennoy et al. 2009; Soomere et al. 2005; Parnell and Kofoed-Hansen 2001; Jonason 1993).

The few studies on wake waves generated by large commercial shipping vessels in confined marine channel regions suggest that heights of wake waves are typically less than or similar to wave heights of natural wind- and swell-generated waves in the region (Pullar and Single 2009; Ellis et al. 2005). This is consistent with modelling studies conducted on commercial shipping in the Douglas Channel (The Glosten Associates 2013; FORCE Technology and Danish Hydraulic Institute 2012).

Pullar and Single (2009) studied wake effects from large commercial vessels (container ships, cruise ships, LPG carriers, oil tankers) in Lower Otago Harbour in New Zealand using a field observation program and wake measurements using tide gauge tracing. The field program involved detailed observations of 22 vessels transiting at speeds of 7 to 13 knots. The average height of wake waves at the shoreline observed during the program was 0.18 m, and height ranged from 0.10 m to 0.50 m.

Pullar and Single (2009) also measured the height of wake waves from vessels transiting at speeds of 6 to 12 knots along the Lower Otago Harbour shipping channel over a six month period using a tide gauge. Wake events were classified based on the measured wake wave height. Of the 36 liquefied petroleum gas carriers transiting the route during the study period, wake events from 31 (86%) of the events were classified as “no discernable wake waves”, 4 (11%) were classified as “barely discernable wake waves,” and 1 (3%) was classified as “readily distinguished wake waves” (Pullar and Single 2009).

Pullar and Single (2009) concluded that wake effects from large commercial vessels in Lower Otago Harbour were only likely to occur at shorelines within 500 m of the vessel, were of limited duration (average of 5.5 minutes per vessel), comprised less than 1% of the total wave environment in the harbour, and did not result in measurable effects to shoreline habitats.

The Lower Otago Harbour is 183 m wide and 13 m deep (Pullar and Single 2009). In general, the height of wake waves at the shoreline will decrease as channel depth and distance from the vessel (channel width) increase. Water depths in the Douglas Channel along the marine access route can be greater than 250 m and the distance to shore from the marine access route in confined channel areas ranges from approximately 0.7 km in areas of Douglas and Principe Channels to 3.7 km in Nepean Sound. Therefore, the results of the studies in Pullar and Single (2009) are expected to be very conservative estimates of wake waves along the confined channels of the marine access route.

Given the deep waters and wide channels along the marine access route, the height of wake waves generated by LNG carriers and escort tugs is expected to decrease substantially before reaching the shoreline. Although estimates of the wake wave heights from the Project’s LNG carriers and escort tugs at shoreline areas along the marine access route have not been made, available studies suggest that the height and frequency of wake waves at the shoreline in the confined channels will be well within the range of naturally occurring wind- and swell-generated waves in the shipping RSA (see Table 5.8-7). It is reasonable to expect that shoreline habitats adjacent to the marine access route are adapted to this level of wave action, and any effects on marine fish and fish habitat from vessel wake waves will be negligible. Similarly, the natural erosive forces of wind- and swell-generated waves at the shoreline are expected to exceed any contribution to shoreline erosion from vessel wake. As a result, no further assessment of the effects of vessel wake on marine fish and fish habitat is warranted.

5.8.4.1.5 Shipping (Introduction of Marine Invasive Species through Release of Ballast Waters) – Interactions with Fish Habitat

Vessels travelling to and from the marine terminal have the potential to affect marine fish habitat through introduction of non-native species when ballast water is released (Canadian Council of Fisheries and Aquaculture Ministers Aquatic Invasive Species Task Group 2004). This interaction is most likely for LNG carriers during the operation phase. Ballast water is taken on in foreign ports for ship stability and discharged before cargo is taken on. Vessel ballast water is to be exchanged at least 200 nautical miles from shore as per the Ballast Water Regulations. Some of the introduced species become invasive in their new environment (Casas-Monroy et al. 2013) due to lack of natural population controls, which may lead to adverse effects on the host ecosystem, native species, or the economy.

This phenomenon has occurred in ports around the world and is now well understood and regulated to reduce the potential for introduction of new invasive species to Canadian waters.

Vessels arriving at the marine terminal will have the vessel logs randomly audited by LNG Canada for their compliance with legislation and regulations on the management of ballast water including the Ballast Water Regulations (see Section 5.8.1.1). No ballast will be discharged until compliance has been determined. Only clean ballast from segregated ballast tanks will be allowed to be discharged into the sea at the marine terminal. LNG Canada requires that a pre-operational meeting take place between a marine terminal representative and the master or officer in charge of cargo and ballast operations to discuss procedures before any ballast operations commence.

Although the possibility of introducing marine invasive species through the release of ballast waters cannot be completely eliminated, by adhering to the Ballast Water Regulations, verified through the LNG Canada audit system, the likelihood of introducing non-native species will be managed. Therefore, no further assessment of change in fish habitat due to the introduction of marine invasive species through the release of ballast waters is warranted.

5.8.4.1.6 Shipping (Bilge Water Release) – Interaction with Fish Health

Bilge water is a well-known historical source of contaminants (e.g., oil, detergents, sediment) that could pose toxicity risks to marine organisms. However, release of bilge water is regulated through the Vessel Pollution and Dangerous Chemicals Regulations and the Ballast Water Regulations under the CSA 2001, which are aligned with MARPOL and ratified by Canada. The regulations require that bilge water be treated by filtration or oily water separating equipment prior to release to remove hydrocarbons (e.g., oils, grease, fuel) to a concentration not more than 15 mg/L for marine waters. The release must occur when vessels are underway, not while berthed. The provisions were developed specifically to protect marine environmental quality and fish health. Bilge water will be contained on the LNG carriers until it can be offloaded at adequate and regulated shore facilities or treated and released when carriers are underway. The marine terminal will have adequate bilge water facilities on site or through a licensed contractor if the need arises for bilge water offloading. Since any discharge of waste into marine waters will be within regulatory limits, this activity is not expected to result in changes to marine environmental quality or fish health and no further assessment is warranted.

5.8.4.1.7 Shipping (Physical Presence) – Interaction with Behaviour of Fish

During operation, the presence of LNG carriers along the marine access route or at the marine terminal has the potential to result in change in behaviour of fish. Fish near berthed or transiting LNG carriers are expected to respond by temporarily avoiding the vessel, and possibly the surface waters immediately surrounding the carrier. Once the LNG carrier has moved through the area and surface waters have settled, fish are expected to return to pre-disturbance behaviour. Assuming a length of 345 m, a beam width of 55 m, and a loaded draft of 12 m, the underwater volume of a LNG carrier at any given time is approximately 227,700 m^3. This is a negligible volume relative to the total volume of pelagic habitat available to fish in the shipping RSA. Combined with the temporary nature of the interaction, the negligible water volume disturbed indicates no further assessment of change in fish behaviour due to the physical presence of LNG carriers is warranted.

5.8.5 Assessment of Residual Effects from the LNG Facility

5.8.5.1 Analytical Methods

5.8.5.1.1 Analytical Assessment Techniques

The methods used to assess change in fish habitat, change in fish health as a result of toxicity, harm to fish or marine mammals and change in behavior of fish and marine mammals vary with the effect and are described in individual sections (Section 5.8.5.2 through Section 5.8.5.5)

5.8.5.1.2 Assumptions and the Conservative Approach

The uncertainties associated with this assessment of effects on marine resources include population dynamics of individual species, limiting factors in the productivity of fish populations and habitats, the influence of natural and human stressors on marine species, abundance estimates and habitat use for marine mammals, and the structure and function of marine ecosystems and food webs. In general, more information is available about fish species that are part of CRA fisheries than for non-fishery species. There is also uncertainty around the spatial and temporal scales to which effects on marine mammals extend.

These uncertainties are addressed by the following conservative assumptions used in this assessment (in addition to the stated mitigation measures for each effect, which are more than adequate for reducing an effect to acceptable levels):

- Effects on fish populations are given greater consideration if they persist for a period greater than one generation or if they occur during sensitive life stages.
- Certain fish species and populations are recognized as being more vulnerable to effects than others. These include species at risk, species with a K-selected life history traits (i.e., long-lived, slow-growing, low natural rate of mortality, and few offspring), species that have highly-specialized habitat needs, and sessile species that are unable to avoid affected areas.
- Effects on species at risk or ecologically important fish and marine mammal species (e.g., key prey species, structure-forming species, keystone species) are given greater consideration.
- Acoustic modelling of underwater noise is based on winter water temperature conditions, which create a conducive environment for propagation of underwater noise.
- Contaminant levels in water and sediment are compared to generic guidelines for protection of aquatic life, which are intentionally conservative because they combine toxicity test results and endpoints from a wide range of aquatic species and typically apply ten-fold safety factors.

- When there are uncertainties regarding magnitude, extent or duration of Project activities, the most conservative scenario is assumed. For example, LNG Canada has estimated that up to 350 LNG carriers will visit the marine terminal annually at full build-out; this assessment of potential Project effects assumes the maximum number of 350.
- The model of altered sediment transport, erosion, and deposition patterns in the facility LSA caused by the marine terminal footprint and dredging assumed an instantaneous change from existing conditions. However, in reality, these changes will occur over an extended period during the construction phase. Therefore, the actual changes in erosion and deposition rates in the facility LSA are expected to be more gradual than forecasted by the modelling.

5.8.5.2 Assessment of Change in Fish Habitat

Measurable parameters for assessing change in fish habitat are total area of fish habitat permanently altered or destroyed (quantitative) and productive capacity of fish habitat permanently altered or destroyed (qualitative). The following Project activities and works, ranked as 2 in Table 5.8-6, are assessed: dredging and marine construction associated with the marine terminal.

5.8.5.2.1 Analytical Assessment Techniques

Change in fish habitat is assessed by identifying the location, area (m^2), and type of habitat that will be lost or altered as a result of Project activities in marine riparian, intertidal and subtidal zones. Habitat types are defined in Table 5.8-8. Total area of habitat affected is determined using GIS analyses and engineering design information. Once total area affected is quantified, potential for the affected habitat to be considered *serious harm to fish* under the *Fisheries Act* are identified. DFO (2013a) interprets *serious harm to fish* as “a permanent alteration or destruction of fish habitat of a spatial scale, duration or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes”.

Productivity is complex to measure directly, given that it reflects numerous functions and processes in a variety of habitat types, involving a wide range of species; therefore, area (m^2) and a qualitative classification of productive capacity provide surrogate measures of habitat productivity. Productive capacity is described qualitatively considering baseline information collected from literature review and field studies. DFO defines productive capacity as “the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend” (DFO 1986). Table 5.8-9 provides the qualitative classifications of critical, important, and marginal fish habitat described by DFO (1998). Critical fish habitat, as defined by DFO (1998), is not the same as critical habitat designated for species at risk under SARA.

Table 5.8-8: Marine Habitat Types

Habitat Type	Definition
Marine riparian	Fish habitat between the higher high water large tide (HHWLT), which is approximately + 6.5 m CD in Kitimat Arm, and 30 m horizontal distance inshore
Intertidal mudflat	Fish habitat between 0 m CD and HHWLT; dominated by sediment ≤ 2 mm diameter and gradual slope
Constructed intertidal	Fish habitat between 0 m CD and HHWLT; dominated by artificial structures (e.g., rock riprap)
Salt marsh	Fish habitat between 0 m CD and HHWLT; dominated by marsh vegetation (e.g., sedge) and tidal channels
Eelgrass bed	Fish habitat consisting of eelgrass (*Zostera* spp.); grows in intertidal and shallow subtidal in soft sediment
Subtidal mudflat	Fish habitat below 0 m CD; dominated by sediment ≤ 2 mm diameter and gradual slope
Subtidal deep-water basin	Fish habitat below 175 m CD; dominated by sediment ≤ 2 mm diameter and low slope

Table 5.8-9: DFO (1998) Classifications for Productive Capacity

Qualitative Descriptor	Definition
Critical fish habitat	Habitats considered to be rare, to have high productive capacity, and to support fish during sensitive life stages.
Important fish habitat	Habitats used by fish for feeding, growth, and migration that, while important to the fish stock, are not considered critical. This may be because there is a relatively large amount of similar habitat that is readily available to the stock, or because the habitat has been disrupted by past human activity.
Marginal fish habitat	Habitat considered to have low productive capacity and to contribute only marginally to fish production

SOURCE:
Summarized from DFO (1998)

Sediment transport modelling is used to predict changes in sediment transport, erosion, and deposition in the facility LSA from the marine terminal footprint and changes in water depth from dredging (Stantec Consulting Ltd. 2014a). The model compares sediment transport under existing conditions and under the altered conditions following construction, during both freshet (maximum river discharge) and non-freshet conditions in Kitimat Arm. The changes in sediment transport are compared to baseline conditions to determine whether alteration or destruction of marine fish habitat is likely.

5.8.5.2.2 Description of Project Effect Mechanisms for Change in Fish Habitat

Marine Construction

Marine construction will result in alteration or destruction of marine riparian, intertidal, and subtidal habitats. The marine terminal, consisting of two LNG berths and a materials offloading facility (MOF), and a temporary early offloading facility (EOF) will be built in the Eurocan Basin (the small bay between the Methanex jetty and RTA Wharf “B”), shown in Figure 5.8-8. In-water construction for this infrastructure will involve dredging, excavation, placement of scour protection, soil improvements, and pile installation.

The two LNG berths have been designed for the safe approach, berthing, loading, and departure of LNG carriers with lengths of up to 345 m. At RTA Wharf “B”, sheet piled wall and slope protection consisting of riprap will be installed to provide protection from wave action. Each LNG berth will contain a soil retaining wall, central LNG loading platform, gangway tower, and berthing and mooring structures. The approximately 750 m^2 deck area of the loading platform will be concrete and the marine loading facilities are expected to be founded on individual vertical steel cylinder piles or pre-cast concrete pile foundations to approximately 55 m below the seabed. The MOF will be built at the northern end of the Eurocan Basin to load and unload equipment and materials (e.g., plant modules) during construction and future expansion (train 3 and train 4) of the LNG facility. The MOF will consist of a heavy lift/roll-on, roll-off (RoRo) berth (referred to as “module berth”), a second RoRo berth, construction berth, and heavy haul road. The module berth will be located directly east of the Methanex jetty and will be designed to suit RoRo vessels used for off-loading equipment and modules, and heavy lift ships used for offloading large and or long equipment items. The second RoRo berth will be located at LNG Berth 2 and will be suitable for receiving smaller modules. The construction berth, at the northern end of the Eurocan Basin, will accommodate small and large barges for off-loading construction supplies and equipment. The existing haul road between the LNG facility and the RTA Wharf “B” will require widening for transport of equipment, including heavy and oversize equipment, materials, and modules, from the MOF to the LNG facility during construction.

The EOF will be built at the southern end of the Methanex jetty to load and unload equipment and materials during construction, prior to completion of the MOF. The EOF will be designed and implemented as temporary structures, and will be removed following the construction phase.

Areas of RTA Wharf “B” and Methanex jetty, consisting of concrete structures and rock riprap (see Figure 5.8-8), will be excavated prior to dredging and the material reused wherever possible. This work is required to accommodate the LNG, MOF, and EOF berths and provide a navigation basin of sufficient width.

Site investigations identified the need for soil improvements along the RTA Wharf "B" and Methanex jetty following dredging. Current engineering design indicates soil improvements will involve vibro-densification and installation of stone columns in the subtidal mudflat. Tops of the stone columns will be approximately 30 cm below the seabed after installation, and this space will be naturally backfilled with sediment from the area. Scour protection at the RTA Wharf "B" and Methanex jetty will involve placement of a rock apron/blanket on the seabed.

Dredging and Disposal

The Eurocan Basin will be dredged during the construction phase to accommodate LNG carriers and support vessels, to depths of -5 m CD at the EOF, -10 m CD at the module berth, and -14 m CD in all other areas (Figure 5.8-8). The total dredge area will be approximately 248,600 m^2 and the total dredge volume will be an estimated 2.5 to 3.5 million m^3. During the construction phase, dredging will occur over a period of up to four years during specified working windows. Dredging involves physical removal of sediment (and associated benthic organisms) from the seabed. LNG Canada is reviewing dredging methods and selection of the preferred methods will be part of ongoing planning and detailed engineering design. Given existing sediment characteristics, wave and current conditions in the Eurocan Basin, maintenance dredging is expected to be required approximately every ten years during the operation phase. Change in fish health as a result of toxicity from contaminants released during dredging is assessed in Section 5.8.5.3, and harm to fish (i.e., burial, smothering, elevated TSS levels) from dredging is assessed in Section 5.8.5.4.

Baseline contaminant conditions in the Eurocan Basin indicate approximately 504,000 m^3 to 824,000 m^3 of sediment will not be suitable for disposal at sea. Some of those sediments will be suitable for placement on land zoned for industrial use (Golder Associates Ltd. 2013, 2014b) and some will need to be transported to a permitted landfill. The material proposed for on land disposal will be dredged and placed directly in the salt marsh immediately north of the MOF following its isolation (Figure 5.8-8). The dredge method for the contaminated materials may include a backhoe dredger (BHD) and special closed bucket.

Deeper dredge sediments are expected to meet the screening criteria for disposal at sea and LNG Canada is investigating the option of a Disposal at Sea Permit to dispose of up to 3 million m^3 of this sediment. The dredge method for this material may include a cutter suction dredge (CSD) or trailing suction hopper dredge (TSHD) combined with a backhoe dredge. Disposal at sea involves transportation of the dredged material to a designated disposal site where it is released and settles on the seabed. LNG Canada is reviewing methods for transporting and depositing the dredged material to the disposal at sea site, and selection of the preferred method will be part of ongoing planning and detailed engineering design. Methods under consideration include pumping the material directly from the dredge vessel to the designated disposal site via a pipeline system, and transporting the material by barge and depositing it either at the surface, or at specified water depths via a submerged discharge pipe.

The disposal of dredged material at sea will result in the release and re-suspension of sediment into the water column, which could potentially result in a change in habitat structure and cover.

Altered Sediment Transportation

Sediment resuspension, transportation, and deposition in the facility LSA are influenced by discharges from Kitimat River, inputs from Kildala Arm, tides, wind, water depth, temperature and salinity, and current speeds and direction, among other factors. Project activities and works, including dredging and the marine terminal footprint and changes in water depth following dredging, have the potential to change sediment transport, erosion, and deposition patterns within the facility LSA. Increased erosion or deposition of sediment may alter or destroy fish habitat by smothering marine vegetation or removing the substrate that supports its growth.

5.8.5.2.3 Mitigation for Change in Fish Habitat

Change in fish habitat resulting from Project activities and works cannot be completely avoided through redesign. However, given that construction of the marine terminal mainly requires modifications to existing structures (RTA Wharf "B" and Methanex jetty), the total area altered or destroyed is less than if a new terminal was constructed in an undisturbed area.

The following mitigation and offsetting measures will be used to reduce adverse effects of marine construction and dredging on marine fish and fish habitat:

- A Fish Habitat Offsetting Plan will be developed and implemented to offset unavoidable permanent alteration or destruction of fish habitat from Project activities and works. The Plan will be developed in consultation with DFO, Haisla Nation, and key stakeholders (Mitigation 5.7-8).
- If and where quay walls/slopes are required, use materials that promote post-construction colonization of marine algae and invertebrate communities (Mitigation 5.8-1).
- Develop and implement a Marine Activities Plan (MAP) in accordance with applicable federal and provincial legislation and regulations. The MAP will include measures to address potential effects from dredge activities, pile installation (including marine mammal exclusion zone, soft start procedures and consideration of sound dampening technologies) and shipping (Mitigation 5.8-2).
- Construction of the marine terminal does not currently plan for blasting in the marine environment. If blasting is determined to be required, it will comply with all regulatory requirements (Mitigation 5.8-3).

- A Disposal at Sea Permit will be obtained prior to any sediment disposal in the marine environment. A disposal site will be selected in consultation with Environment Canada, DFO, affected Aboriginal Groups, and key stakeholders (Mitigation 5.8-4).
- Vessels arriving at the marine terminal will comply with legislation and regulations on the management of ballast water. LNG Canada may conduct random audits of vessel logs. No ballast will be discharged until compliance has been determined. Only clean ballast from segregated ballast tanks will be allowed to be discharged into the sea at the marine terminal (Mitigation 5.8-5).

5.8.5.2.4 Characterization of Change in Fish Habitat

Marine riparian habitat affected by the Project was determined to contribute relatively little to the overall productive capacity of adjacent marine fisheries and to be marginal fish habitat (Table 5.8-8; DFO 1998) because it is not an important factor in temperature regulation (i.e., shade) or food and nutrients, though coarse debris inputs may contribute to cover.

Intertidal/subtidal mudflat and intertidal constructed habitats affected by the Project were determined to have low productive capacity and to be marginal fish habitat (Table 5.8-8; DFO 1998). Freshwater input and heavy sediment loads from Kitimat River appear to be a limiting factor in the establishment of certain species of marine algae and invertebrates. The large amount of similar habitat available in Kitimat Arm, human disturbance from past and present industrial activities, and the limited structural complexity of the mudflat habitat are additional factors contributing to the low productive capacity classification of these habitats.

Salt marsh habitat affected by the Project has high productive capacity and is considered important fish habitat (Table 5.8-8; DFO 1998) because it provides habitat for juvenile salmon and non-migratory species such as Pacific staghorn sculpin and threespine stickleback (Stantec Consulting Ltd. 2014a; Triton Environmental Consultants Ltd. 2014). It is not considered critical fish habitat because the habitat has been disrupted by past human activity and there is a relatively large amount of similar or more productive salt marsh habitat in the facility RSA (Stantec Consulting Ltd. 2014a; Triton Environmental Consultants Ltd. 2014).

The two eelgrass beds in the facility LSA have high productive capacity and are considered important fish habitat (Table 5.8-8; DFO 1998) because they provide rearing habitat and refuge for juvenile fish and invertebrates, and support a variety of CRA fishery species including Dungeness crab, salmon, and herring. They are not considered critical fish habitat because of their relatively small size and patchiness.

The deep-water basin habitat in the BSAs has moderate productive capacity and is considered important fish habitat (Table 5.8-8; DFO 1998) because it provides habitat for a variety of demersal fish and benthic invertebrates, including eulachon, flounders, and Pacific halibut. It is not considered critical fish habitat because there is large amount of similar habitat in Kitimat Arm and Douglas Channel.

Change in Fish Habitat Due to Marine Construction

Construction of the MOF and connection to the heavy haul road across the intertidal mudflat will permanently isolate the salt marsh immediately to the north from marine waters (Figure 5.8-8). This will cause the permanent alteration and/or destruction of marine riparian habitat, salt marsh habitat, intertidal mudflat habitat, and constructed intertidal habitat (Figure 5.8-8). Installation of sheet piled wall and piles at the LNG berths, MOF, and EOF will result in destruction of subtidal mudflat habitat. Vibro-densification, installation of stone columns, and scour protection along RTA Wharf “B” and the Methanex jetty will result in the destruction of subtidal mudflat. Marine riparian, intertidal mudflat, and constructed intertidal habitat (i.e., rock riprap/boulder) along RTA Wharf “B” and the Methanex jetty will be destroyed during excavation (Figure 5.8-8).

Marine riparian habitat destroyed during marine construction does not meet the DFO (2013a) criteria for *serious harm to fish* because loss of this marginal habitat type is not expected to impede the ability of any CRA fishery species in the facility RSA to carry out one or more of their life processes.

Approximately 4,970 m^2 of new constructed intertidal habitat (i.e., rock riprap/boulder) will be installed along RTA Wharf “B” and the Methanex jetty to provide slope protection. Marine algae, fish, and invertebrate communities are expected to become established in the newly created habitat within six months to two years of disturbance (Sousa 1979; Dethier 1984; Newell et al. 1998; Bilkovic 2011).

The new rock riprap/boulder habitat in the intertidal zone at the LNG berths will provide fish with structural habitat and interstitial spaces for refuge and spawning, and invertebrates and algae with substrate for attachment (Beauchamp et al. 1994; Gratwicke and Speight 2005; Pister 2009; Pondella et al. 2002; Toft et al. 2007). Species that colonize habitats exposed to unpredictable short-term variations in environmental conditions, such as shallow subtidal, intertidal, and estuarine habitats, are subject to frequent catastrophic mortality; therefore, they are naturally selected for maximum rates of population increase and are well suited for the rapid invasion and colonization of recently created empty habitats (Newell et al. 1998). Algae, fish, and invertebrates are expected to become established in the constructed intertidal habitat within one to two years following disturbance (Dethier 1984; Sousa 1979; Newell et al. 1998).

Change in Fish Habitat Due to Dredging and Disposal

Dredging of the mudflat in the dredge pocket to depths of -10 m to -14 m CD will affect an estimated area of 248,600 m^2, including approximately 43,600 m^2 of intertidal mudflat habitat, 3,300 m^2 of eelgrass, and 190,800 m^2 of subtidal mudflat habitat (the remaining area represents the excavated areas of RTA Wharf "B" that do not provide fish habitat at present).

Dredging is usually followed by a short-term decline in species richness, density, and biomass of benthic organisms (Newell et al. 1998; Gilkinson et al. 2005). The recovery rate of benthic communities following cessation of dredging varies, depending on the type of community affected and extent to which it is naturally adapted to sediment disturbance and suspended particle load (Newell et al. 1998). The facility LSA is characterized by estuarine mud and sand substrate and frequent natural disturbance from variations in river outflow, TSS, and tidal currents (Bell and Kallman 1976; Stantec Consulting Ltd. 2014a). For similar habitats, recovery time for benthic communities and fish assemblages typically ranges from six months to two years following dredging (Newell et al. 1998; Bilkovic 2011). It is anticipated that maintenance dredging will be required approximately every 10 years, resulting in the intermittent disturbance and subsequent recovery of benthic communities in the subtidal mudflat habitat. It is anticipated that changes in water depth from dredging will prevent recolonization of eelgrass on the mudflat, resulting in the destruction of 3,262 m^2 of eelgrass habitat. With the exception of the loss of eelgrass in the dredge area, dredging is anticipated to result in a temporary disturbance of fish habitat, and not a permanent alteration.

Following isolation from marine waters, the salt marsh immediately north of the dredge area will be used for on land disposal of the majority of the dredged material that does not meet screening criteria for disposal at sea but does meet the BC contaminated site regulations (Figure 5.8-8). Prior to disposal, the salt marsh area will be permanently isolated from marine waters during construction of the MOF and connection to the heavy haul road (see Change in Fish Habitat Due to Marine Construction above). The remaining dredge material that does not meet screening criteria for disposal at sea or BC contaminated sites regulations will be transported to a permitted landfill.

Disposal at sea involves deposition of dredged material at a designated disposal site. Up to 3 million m^3 of dredged material from the marine terminal will be deposited at a designated disposal site in upper Kitimat Arm (Figure 5.8-3). Based on sediment samples from the vibracores, the grain size of the dredged material is primarily sands (between 0.063 mm and 2 mm diameter) and fines (less than 0.063 mm), with some gravels (greater than 2 mm) (Golder Associates Ltd. 2013, 2014b). The degree to which habitat structure and cover at the disposal site is altered by deposition of the dredged material depends on the characteristics of the existing sediment at the designated disposal site. Sediment in the BSAs under investigation for the disposal at sea site has similar grain size distribution to the dredged material

(Figure 5.8-3; Stantec Consulting Ltd. 2014a). In addition, deep-water habitat in the BSAs is characterized by relatively uniform topography and low slope, making large-scale sediment movements following disposal unlikely. Therefore, the alteration of habitat structure or cover following deposition is expected to be minimal. Substrate at the designated disposal site will be located well below the photic zone at depths greater than 175 m. Therefore, no marine vegetation is expected to be smothered or buried during disposal. The designated disposal at sea site will not be located in an area with high structural complexity and sensitive habitats, and will have high resilience. Benthic communities and fish assemblages in the soft bottom habitat at the disposal site are expected to recover within two years following disposal (Newell et al. 1998). Therefore, disposal of dredged material at sea is not expected to result in the permanent alteration or destruction of fish habitat, or changes in fish habitat that affect the population viability of any fish species (including species at risk). A comprehensive assessment and characterization of change in fish habitat at the selected disposal site will be conducted as part of the Disposal at Sea Permit process.

Change in Fish Habitat Due to Altered Sediment Transportation

The effects of jetty modifications and dredging on currents and sediment transport patterns were modelled for two 12-day periods reflecting freshet and non-freshet conditions (Stantec Consulting Ltd. 2014a). Model outputs indicate the change in sediment erosion or deposition predicted to occur in the marine terminal area. The marine terminal footprint and the changes in water depth from dredging have the potential to alter sediment transport, erosion, and deposition patterns as the area adjusts to the new conditions and moves toward stability. No change or very small change (less than 0.2 m) in depth, as a result of erosion or deposition, is predicted for the majority of the modelling domain. Spatial trends are similar for freshet and non-freshet conditions, with the exception of a wider area of deposition (extending about 300 m east of the footprint) modelled during freshet. Along the seaward slope and step of the dredge footprint, at 10 or 14 m water depth, a narrow band of deposition (less than 1 m change) interspersed with small areas of erosion (less than 1 m change) is predicted to occur (Figure 5.8-8). A narrow band of erosion is also predicted to occur along the western edge of the berth area (less than 0.5 m change) and also along the western shore of Kitimat Arm directly west of the southern extent of the berth area (less than 1.0 m change in an area 100 m by 200 m in size). There is a patchy eelgrass bed about 100 to 200 m to the south of the predicted erosion area on the western shore (Figure 5.8-8), which has the potential to be affected by that erosion. However, the construction and dredging will occur over an extended period and the predicted erosion and deposition will occur gradually (the model assumes instantaneous change). Adverse effects on the eelgrass area are considered unlikely, given the gradual change in sediment transport patterns and the distance between the erosion area and eelgrass bed.

Increased sediment deposition associated with dredging has the potential to smother or bury eelgrass in the patchy area on the western shore of Kitimat Arm, which is about 450 m from the dredging area (Figure 5.8-8). The amount and extent of sediment plumes and deposition is being modelled in preparation for the Disposal at Sea Permit application and the data will be used to further assess potential effects to eelgrass in the facility LSA. Mills and Fonseca (2003) reported that eelgrass experienced greater than 50% mortality when buried in 4 cm of sediment (25% of plant height) for 24 days, and 100% mortality when buried in 8 cm of sediment (75% of plant height). Erftemeijer and Lewis III (2006) reported critical sedimentation thresholds for eelgrass ranging from 2 cm to 13 cm per year and effects of dredging on eelgrass beds ranging from zero loss to complete loss of eelgrass beds; use of TSS monitoring, sediment containment, and timing windows were effective in preventing or reducing loss of eelgrass. With use of proposed monitoring and mitigation measures, it is expected that smothering or burial of eelgrass from sediment deposition during Project dredging will be minimal.

Combined Changes in Fish Habitat

The total area of permanent alteration or destruction of marine fish habitat resulting from Project activities is summarized in Table 5.8-10 by habitat type. These estimates will be finalized in the application for an authorization under paragraph 35(2)(b) of the *Fisheries Act*. Marine fish habitat for CRA fishery species permanently altered or destroyed as a result of the Project will be offset through creation, restoration and/or enhancement of fish habitat.

There is a high likelihood that dredging and marine construction will result in a temporary change in fish habitat, taking into account construction of the habitat offsetting measures. Adverse residual effects will occur in the facility LSA and positive residual effects (from implementation of offsetting measures) will occur within the facility RSA. The residual effects of all Project activities, except dredging and disposal at sea, will be short-term in duration and occur as multiple regular events during the construction phase. Residual effects of dredging and disposal at sea will be long-term and will occur as multiple irregular events during the construction and operation phases. All the affected habitat types, except the salt marsh and eelgrass habitats, have high resilience because they are already adapted to frequent natural and human disturbances and are expected to be recolonized after construction. However, the salt marsh habitat has low resilience because it will be destroyed by construction of the heavy haul road and MOF, and eelgrass habitat has low resilience because it may be permanently altered or destroyed by increased sediment erosion and/or deposition rates.

Table 5.8-10: Total Area of Marine Fish Habitat Types Permanently Altered or Destroyed

Habitat Type[a]	Effect Type	Productive Capacity[b]	Habitat Description	Project Activity	Potential Area of Serious Harm[c] (m^2)
Salt marsh	Permanent alteration or destruction	Moderate; important fish habitat	Marsh vegetation and tidal channels	▪ Construction of heavy haul road and MOF	84,000
Intertidal mudflat	Destruction	Low; marginal fish habitat	Mud and tidal flat	▪ Construction of heavy haul road ▪ Installation sheet piled wall	8,068
Eelgrass bed	Permanent alteration or destruction	Moderate; important fish habitat	Patchy eelgrass bed	▪ Dredging ▪ Altered sediment transport	≥ 3,262
Constructed intertidal	Permanent alteration	Low; marginal fish habitat	Rock riprap	▪ Excavation of RTA Wharf "B" and Methanex jetty ▪ Construction of EOF and MOF	14,193
Subtidal mudflat	Destruction	Low; marginal fish habitat	Mud seabed	▪ Soil improvements and scour protection ▪ Installation of piles and sheet pile wall	55,707
Total:					**165,230**

NOTES:

[a] See Table 5.8-8 for definitions

[b] See Table 5.8-9 for definitions

[c] "Serious harm" includes the destruction of fish habitat or an alteration of fish habitat of a spatial scale, duration and intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes (DFO 2013a).

Habitat creation, restoration, and enhancement measures are expected to completely offset serious harm to marine habitat of CRA fishery species. With implementation of the Fish Habitat Offset Plan, the total area and productive capacity of habitat for marine fish species that support or are part of CRA fisheries, such as salmon and Dungeness crab, will be maintained or increased. Consequently, the change in fish habitat is expected to be negligible and reversible.

The objectives of the Fish Habitat Offsetting Plan will be to avoid and mitigate effects to fish, and to counterbalance unavoidable *serious harm to fish* and support and enhance the sustainability and ongoing productivity of affected CRA fishery species. Every effort will be made to implement habitat offsetting measures prior to or concurrently with the Project construction phase to prevent a temporary decrease in the total area and productive capacity of fish habitat for CRA fishery species. If this is not possible, additional measures will be implemented to offset any temporary decrease in the productive capacity of fish habitat during construction.

A Conceptual Fish Habitat Offsetting Plan, developed using the best available information on Project activities, describes potential marine habitat creation, restoration, and enhancement measures (Stantec Consulting Ltd. and Triton Environmental Consultants Ltd. 2014). The conceptual offsetting measures for loss of habitat types outlined in Table 5.8-10 focus on creation of salt marsh habitat, subtidal rock reefs, the expansion or creation of eelgrass beds, and the restoration of degraded habitats. These offsetting measures are expected to increase the productivity of local Pacific salmon populations, which are the CRA fishery species most likely to be affected by dredging and marine construction, as well as species such as Pacific herring, Dungeness crab, and rockfish. The offsetting measures are expected to increase the overall area and productive capacity of marine habitat for CRA fishery species.

The final Fish Habitat Offsetting Plan will be developed during the permitting phase and in consultation with DFO, Aboriginal Groups, and key stakeholders (e.g., property owners) and considering local fisheries management objectives and restoration priorities. The plan will draw upon scientific literature about the habitat creation, restoration, or enhancement methods, and the habitat requirements of CRA fishery species. Based on the professional judgment and past experience of the assessment team, the offsetting measures will have a high likelihood of enhancing productive capacity of marine fish habitat for CRA fishery species.

Project activities and works with interactions ranked as 1 in Table 5.8-6 for change in fish habitat are discussed in Section 5.8.4.1 and are summarized as follows:

- Release of TSS during decommissioning (dismantling of marine infrastructure) will be managed through implementation of standard mitigation measures and BMPs, and will result in minimal change in fish habitat.
- Wastewater discharged from the LNG facility during all Project phases must meet regulatory standards designed to protect aquatic life; therefore, no residual effect on fish habitat is anticipated for this activity.
- Discharge of hydrostatic test waters into marine waters will be done in a controlled manner to reduce changes in temperature, salinity, and pH and comply with federal and provincial regulations for release into marine waters.
- Propeller wash from escort tugs and support vessels arriving at or departing from the marine terminal during all Project phases will result in minimal effects on fish habitat (elevated TSS levels, smothering of marine flora, and scouring of seabed sediments) because the marine berth area and organisms in that area are adapted to frequent natural and human disturbances. These include the heavy sediment loads carried by the Kitimat River into Kitimat Arm during spring freshet and periods of high precipitation, strong tidal currents, and vessel traffic from existing projects.

- Wake generated by vessels transiting the shipping RSA would have a negligible effect on fish habitat along the shoreline, because studies on large commercial vessels indicate that wake waves dissipate quickly and the height and frequency of wake-induced waves will be similar to that from swell- and wind-generated waves. Marine organisms and habitats along the shoreline are adapted to this level of wave action.
- Modern ballast water regulations and mandatory management procedures outlined in CSA 2001 limit or eliminate the potential for introduction of non-native species when ballast water is released.

5.8.5.2.5 Determination of Significance of Change in Fish Habitat

There is a high likelihood that marine construction will result in permanent alteration or destruction of marine fish habitat and that dredging and disposal at sea will result in temporary disturbance of fish habitat. With implementation of the Fish Habitat Offset Plan, there will be no net loss in total area or productive capacity of fish habitat. Consequently, the change in fish habitat is expected to be negligible and reversible, and there is a low likelihood that the anticipated change in fish habitat will affect viability of fish populations that support or are part of CRA fisheries, or fish species at risk. With mitigation and offsetting measures, change in fish habitat as a result of Project activities is assessed as not significant.

5.8.5.3 Assessment of Change in Fish Health at the LNG Facility as a Result of Toxicity

Chemical composition of sediment and water is the measurable parameter for change in fish health as a result of toxicity. The Project activities and works ranked as 2 in Table 5.8-6 and assessed here are dredging and marine construction.

5.8.5.3.1 Analytical Assessment Techniques

Change in fish health as a result of toxicity is assessed by comparing baseline levels of contaminants in sediment or water (see Section 5.8.3) with estimated Project-related chemical concentrations to CCME (CCME 1999) and BC (Nagpal et al. 2006) water and sediment quality guidelines for protection of marine life and to Environment Canada screening criteria for disposal of sediment at sea (Government of Canada 2001). For certain substances listed under the Disposal At Sea Regulations, Lower Level concentrations provide the basis of the Tier 1 screening criteria and an initial assessment of whether the material is suitable for disposal at sea; if the prescribed Lower Level concentrations are exceeded, the regulations further describe the requirements for biological testing for conducting a Tier 2 screening criteria assessment (see Section 5.8.2.1.5). Sediment and water quality guidelines indicate levels below which adverse effects on marine life are not expected. Due to the conservative methods by which these concentrations are derived (use of large safety factors, mix of toxicity endpoints in laboratory tests) and their generic nature, the guidelines do not define levels at which adverse effects could occur. As a result, site-specific factors and toxicological literature are also used to identify levels at which adverse effects could occur.

5.8.5.3.2 Description of Project Effect Mechanisms for Change in Fish Health at the LNG Facility as a Result of Toxicity

Sediment within the Project footprint contains contaminants, primarily PAHs, but also metals, dioxins, and furans (see Section 5.8.3.2). Dredging and marine construction have the potential to change fish health when sediment is disturbed and existing contaminants are released into the water column. The greatest amount of sediment disturbance will be associated with dredging (the dredge area described in Section 5.8.5.2 and shown in Figure 5.8-8).

The sediment surface layer will be disturbed when a dredge bucket contacts the ocean floor and sediment will be released as the loaded bucket moves through the water column. Loss of sediment from a dredge bucket is estimated at 1% of the total volume dredged (Schroeder and Ziegler 2004). Disturbed contaminants and sediment will be re-suspended in the water column and may settle in areas with lower contaminant levels. Uptake of contaminants may lead to toxicity in fish.

Deeper sediments are expected to meet the disposal at sea screening criteria for levels of contaminants (i.e., metals and organic constituents) (based on recent testing) and LNG Canada is investigating permitting for disposal at sea of up to 3 million m^3 of this sediment.

5.8.5.3.3 Mitigation for Change in Fish Health at the LNG Facility as a Result of Toxicity

The following mitigation measures will be implemented to limit the disturbance and subsequent dispersion of contaminants from sediment:

- Develop and implement a Marine Activities Plan (MAP) in accordance with applicable federal and provincial legislation and regulations. The MAP will include measures to address potential effects from dredge activities, pile installation (including marine mammal exclusion zone, soft start procedures and consideration of sound dampening technologies) and shipping (Mitigation 5.8-2).
- In-water marine construction, dredging, and sediment disposal activities will be conducted throughout the year. For the periods outside the timing windows of least risk, additional mitigation measures will be implemented to protect sensitive species and life stages as appropriate. Timing windows and mitigations will be developed in consultation with DFO at the permitting stage and will consider the location and timing of sensitive life stages specific to CRA fishery species (Mitigation 5.8-6).
- Optimization of sediment containment will be considered when selecting dredging and sediment disposal methods/equipment (Mitigation 5.8-7).

- Full assessment of effects of the selected sediment disposal methods and use of mitigation measures, with details to be provided in the Disposal at Sea Permit application (Mitigation 5.8-8).
- Movement of barge anchors will be minimized to limit sediment disturbance (Mitigation 5.8-9).
- A Disposal at Sea Permit will be obtained prior to any sediment disposal in the marine environment. A disposal site will be selected in consultation with Environment Canada, DFO, affected Aboriginal Groups, and key stakeholders (Mitigation 5.8-4).

5.8.5.3.4 Characterization of Change in Fish Health at the LNG Facility as a Result of Toxicity

Changes in fish health as a result of toxicity related to dredging are discussed in this section because these effects are expected to be more substantial than for other marine construction activities, given the larger volume of sediment disturbed. Sediment disturbed due to dredging will be re-suspended in the water column before re-settling in the surrounding area. Use of silt curtains can limit the dispersal of sediment and contaminants; however, they are most effective in shallow areas with slow currents, so may not be effective for the entire dredge footprint. As a result, some dispersal of sediment and contaminants is expected outside the dredge area (Figure 5.8-8).

The distance re-suspended sediment travels depends on particle size and currents. Sediment in the dredge area consists mainly of silt and clay, so is expected to travel some distance before settling. The dredge area and facility LSA are sheltered by the RTA Wharf “B” and Methanex jetty, and lower wave action is expected here than in Kitimat Arm. Surface current speeds in the facility LSA are low (mean current speed of 0.24 m/s) compared to elsewhere in the facility RSA (up to 0.5 m/s) (Bell and Kallman 1976). Preliminary desktop analysis and numerical modelling by LNG Canada predict that maximum currents in the dredge area would be 0.25 m/s in a 100 year event. Disturbed sediment tends to settle out of the water column within days after dredging ceases (Fissel et al. 2006).

Contaminants (primarily PAHs) at levels higher than ISQG and Disposal at Sea Tier 1 screening criteria are present mainly in the upper 3 m of sediment in the dredge area, although elevated PAH levels extend to 6 m depth in the area west of LNG Berth 2 (Golder Associates Ltd. 2013, 2014b). Uptake of contaminants from sediment, through either direct ingestion or consumption of contaminated prey, is the likely pathway for inducing toxicity in fish. PAHs, the main contaminants of concern, are relatively high in concentration (ranging from less than 0.05 mg/kg to 208 mg/kg total parent PAH, compared to the Disposal at Sea Tier 1 screening criterion of 2.5 mg/kg), but have been generally found to have low bioavailability and toxicity through Tier 2 screening as described in Section 5.8.2.1.5. Hence, disturbance of these sediments is expected to have limited effects on biota. PAHs are hydrophobic, with low solubility in water (Simpson et al. 1996; United States Environmental Protection Agency 2008), further limiting their bioavailability and toxicity. Dioxins and furans levels are higher than the CCME ISQG in 9 of 18 samples tested (up to 12.64 pg/g TEQ, above the ISQG of 0.85 pg/g but below the PEL of 21.5 pg/g TEQ). Dioxins and furans are also hydrophobic and unlikely to be taken up directly from water when re-suspended. The elevated cadmium, zinc and copper concentrations reflect naturally elevated levels of copper (to which organisms in the area are adapted) and isolated areas of high concentrations that likely reflect human activities.

Disturbance of PAHs represents the highest potential for a change in fish health as a result of toxicity. However, several studies have shown that PAHs in Kitimat Arm generally have low bioavailability and that effects on fish and other marine biota are limited. Paine (1996) reported that sediment from the Alcan Harbour did not cause toxicity in sand dollars (*Dendraster excentricus*) and amphipods (*Rhepoxynius abronius*), despite total PAH concentrations up to 9,890 mg/kg (in comparison, the highest total PAH value recorded in Golder Associates Ltd.'s 2012 to 2014 program was 208 mg/kg). Paine et al. (1996) found minimal differences in the health of crabs from the Alcan Harbour and a reference site. Using lower analytical detection limits, Eickhoff et al. (2003) reported higher PAH concentrations in Dungeness crabs from near the RTA facility than in crabs from the rest of Douglas Channel, but the differences in concentrations were small. A study of PAH accumulation in soft-shell clams, sampled from 1995 to 2000, found that RTA facility–derived PAHs were not bioavailable, but PAHs associated with effluent from the pulp mill on the Kitimat River (closed in 2010) were bioavailable (Yunker et al. 2011). Low uptake and associated low bioavailability of PAHs has been attributed to PAHs being associated with large particle sizes (Paine et al. 1996) and presence of the PAHs in pitch or soot particles (Yunker et al. 2011). Previous studies found no evidence of metal bio-accumulation in fish from the area (NOAA 2009).

Some evidence of PAH bioavailability has been found in fish in the facility LSA. A study conducted from 2000 to 2004 found elevated total PAH concentrations in the stomachs and bile of flatfish and juvenile chinook salmon caught in the facility LSA (NOAA 2009). However, only flatfish showed evidence of toxicity (increased incidence of DNA damage and liver lesions compared to reference sites). Juvenile chinook salmon were relatively unaffected, likely due to their wider range and their use of pelagic rather than benthic habitat. No effect on reproduction was found for either species. The NOAA study concluded that adverse effects associated with the elevated PAH levels in Kitimat Arm were notably lower than reported for other areas with similar concentrations but different sources of PAHs (e.g., Puget Sound, with urban and industrial sources, rather than the RTA facility sources in Kitimat).

Dredging will release and disperse sediment and PAHs, which may cause localized short-term effects on benthic fish such as flatfish, similar to those already experienced in the area. Effects could occur during dredging of the top 1 m to 3 m of sediment (6 m in area west of LNG Berth 2), where contaminant levels are higher than disposal at sea screening criteria, but are not expected during dredging of the deeper sediment, which comprises the majority of the dredge volume. The net effect of dredging will be an improvement in sediment quality within the Eurocan Basin area because sediment containing elevated contaminants will be removed from the harbour.

Disposal at sea will release and disperse sediment at the designated disposal site. Only sediment that meets disposal at sea screening criteria will be deposited at the designated disposal site. The disposal at sea screening criteria were developed specifically to protect fish habitat, marine environmental quality, and fish health. Since disposal at sea will only be conducted in accordance with a Disposal at Sea Permit, and all sediment will meet screening criteria, this activity is not expected to result in changes in fish health that affect the population viability of any fish species (including species at risk), or harm *threatened* or *endangered* fish species. A comprehensive assessment and characterization of change in fish health as a result of toxicity at the designated disposal site will be conducted as part of the Disposal at Sea Permit process.

The effect of dredging on fish health due to toxicity will be low magnitude (small increase in PAH levels compared to background, low bioavailability, and studies show no evidence of toxicity to fish in the facility LSA, at sites where PAH levels were higher than currently). The residual effect will occur within the facility LSA, in an area with a similar contaminant history, during dredging, over the short-term (during construction phase), and will be reversible (ending within days after dredging ceases). Fish populations in the facility LSA have high resilience, due to a history of exposure to contaminants, and are likely to recover from residual effects in the short term. The net effect of dredging will be an improvement in sediment quality within the dredged areas because contaminated sediment will be removed from the marine environment. Also, any dispersed contaminants will be covered by clean sediment from subsequent dredging of deeper sediment and from the Kitimat River**.** The effects of marine construction activities on fish health will be lower in magnitude and geographic extent than from dredging, given the smaller amounts of sediment disturbance and the mitigation measures used to limit sediment dispersal.

Project activities and works with interactions ranked as 1 in Table 5.8-6 for change in fish health as a result of toxicity are discussed in Section 5.8.4.1 and are as follows:

- Wastewater discharged from the LNG facility during all phases must meet regulatory standards designed to protect aquatic life; therefore, no residual effect on fish health is anticipated for this activity.
- Discharge of hydrostatic test waters into marine waters will be done in a controlled manner to limit changes in temperature, salinity, and pH and comply with federal and provincial regulations; this activity will not introduce contaminants to marine waters or have an adverse effect on fish health.

- Sediment disturbance due to shipping (propeller wash) and decommissioning (dismantling of marine based infrastructure) will occur after dredging has removed contaminants from sediment at the marine berths; this activity is not anticipated to have a residual effect on fish health.
- Bilge water release is regulated through the Vessel Pollution and Dangerous Chemicals Regulations under CSA 2001, which require that bilge water be treated by filtration or oily water separating equipment prior to release to remove hydrocarbons (e.g., oils, grease, fuel) to a concentration not more than 15 mg/L for marine waters; this activity is not expected to result in changes to fish health.

5.8.5.3.5 Determination of Significance for Change in Fish Health at the LNG Facility as a Result of Toxicity

There is a high likelihood that contaminants will be released during dredging of the upper sediment layer; however, there is a low likelihood that these levels will result in a change in fish health as a result of toxicity. Any adverse change in fish health will be short term and low in magnitude, and will not affect the population viability of any fish species (including species at risk), and no *endangered* or *threatened* fish species are likely to be harmed as a result of toxicity. Effects will be limited to the facility LSA and will be reversible. The natural deposition of clean material over any dispersed contaminants following dredging, combined with removal of sediment containing high PAH levels from the dredge area, will result in a net improvement in fish health due to reduced exposure to contamination. Therefore, change in fish health as a result of toxicity related to the LNG facility is assessed as not significant.

5.8.5.4 Assessment of Harm to Fish or Marine Mammals

The measurable parameter for harm to fish or marine mammals is likelihood of harm to fish that support or are part of CRA fisheries, marine mammals, and species at risk. Project activities and works, ranked as 2 in Table 5.8-6, that have the potential to result in harm to fish or marine mammals include: dredging (construction and operation phase), marine construction (construction phase), and dismantling of marine infrastructure (decommissioning phase).

5.8.5.4.1 Analytical Assessment Techniques

Likelihood of harm (following mitigation) is determined by using the likely distribution and abundance of fish, marine mammals, and species at risk in the facility and shipping RSAs (identified from baseline data and information gathered from TK/TU, literature review, and field studies) and their potential vulnerability to harm from Project activities and works.

Harm to fish from crushing or burial is assessed considering the likelihood that an organism will be present in the affected area and the ability of organisms to move away and avoid harm from these activities. Harm to fish from increased TSS levels is assessed by comparing TSS predictions to CCME WQG for protection of aquatic life (CCME 2013) and BC Approved WQG (BCMOE 2006), which are the same, and a review of published literature. For continuous activities (24 hours to 30 days), the WQG is an increase in TSS of no more than 5 mg/L above background. For short-term activities of 24 hours or less, the WQG is an increase of no more than 25 mg/L above background. A further allowance is made for conditions of naturally high TSS levels, such as during spring freshet. The continuous activity WQG is more appropriate to ongoing dredging activities and disposal events. The WQG represent levels at which chronic (non-lethal) effects to marine aquatic life may occur.

Sediment plume modelling is used to assess the potential for dispersal of sediment within upper Kitimat Arm in the BSAs when dredged material is disposal of (Figure 5.8-3; Stantec Consulting Ltd. 2014a). The modelling simulates potential disposal methods for the dredged material, including surface release from a split-hull hopper barge, and the discharge of pumped slurry from a submerged pipe connected to a barge at water depths of 60 m and 120 m (Stantec Consulting Ltd. 2014a). The estimated TSS levels from disposal at sea activities are compared with the continuous activity WQG to assess the potential for harm to fish.

Harm to fish or marine mammals also addresses pressure-related injuries caused by noise impulses from pile driving, which are determined by established underwater noise thresholds, where possible. For marine mammals, estimates of modelled distribution and relative abundance for species within the facility LSA and RSA are used to estimate the likelihood of a species occurring near construction activities or within the facility RSA. A qualitative assessment of likelihood of harm from underwater noise due to pile installation is used to make a significance determination.

The potential for harm to fish and marine mammals depends on the level of underwater noise produced. Auditory injury thresholds from impulsive noise (such as pile driving) are expressed using two common metrics: sound pressure level (SPL), measured in dB re: 1 μPa, and sound exposure level (SEL), a measure of energy in dB re: 1 $\mu Pa^2 s$. SPL can be an instantaneous value, whereas SEL is the total noise energy to which the organism is exposed over a given time period, typically one second for pulse sources (Theobald et al. 2009). SPL and SEL are further categorized into the following metrics:

- Peak SPL (SPL_{peak}): the maximum sound pressure at any given moment produced by a particular activity, which is the maximum mechanical force that will be experienced by sound receivers
- Root mean square SPL (SPL_{RMS}): average root mean square pressure level over a given amount of time
- Cumulative SEL (SEL_{cum}): cumulative energy exposure over multiple pulses for a given period of time.

There are few peer-reviewed studies on harm to fish from exposure to pile driving. Hastings and Popper (2005), Popper and Hastings (2009a), and Popper (2009b) concluded there is evidence that exposure to pile driving sounds causes physical injury and mortality to marine fish but there are insufficient data to indicate percentage of fish killed or injured, distances at which fish are killed or injured, and whether some species are more susceptible than others.

Popper and Hastings (2009a) noted that, given the current state of knowledge, it is not possible to develop sound-exposure metrics and thresholds for predicting potential effects of noise on fish. Despite this, the Fisheries Hydroacoustic Working Group (FHWG) thresholds for injury to fish from pile driving activities include a peak SPL of 206 dB re 1 µPa, a cumulative SEL (SEL_{cum}) of 187 dB re 1 $µPa^2$·s for fish weighing two grams or greater, and a SEL_{cum} of 183 dB re 1 $µPa^2$·s for fish weighing less than two grams (FHWG 2008).

The potential for harm to marine mammals from underwater noise associated with pile installation depends on both the sound levels produced and the ability of marine mammals to hear the noise. The hearing frequency ranges and sensitivity to sound differ among species. Southall et al. (2007) identified four functional hearing groups and their associated hearing frequency ranges:

- low-frequency cetaceans (hearing frequencies of 7 Hz to 22 kHz for baleen whales, including humpback whales, grey whales, and fin whales)
- mid-frequency cetaceans (hearing frequencies of 150 Hz to 160 kHz for various odontocetes, including killer whales and Pacific white-sided dolphins)
- high-frequency cetaceans (hearing frequencies of 200 Hz to 180 kHz for various odontocetes, including harbour porpoise and Dall’s porpoise), and
- pinnipeds in water (hearing frequencies of 75 Hz to 75 kHz for pinnipeds, including Steller sea lions and harbour seals).

Marine mammal sound thresholds have been established for received levels predicted to cause permanent auditory damage (i.e., permanent threshold shifts [PTS]) or temporary changes in hearing abilities (i.e., temporary threshold shifts [TTS]). The onset level of TTS has been measured for some species (Southall et al. 2007), but no data exist on exposure levels that could cause PTS, and it has never been experimentally tested. As a result, PTS-onset thresholds are based on extrapolations from TTS-onset levels.

Southall et al. (2007) and NOAA provide separate guidance on estimated sound level thresholds that may induce PTS or TTS. The thresholds have been estimated using different metrics, and some have been weighted by marine mammal functional hearing group to emphasize frequencies of greatest sensitivity. NOAA released interim thresholds (NOAA 2013a) while revising the threshold to incorporate new scientific information. The draft revised thresholds (NOAA 2013b), are not directly comparable to the

Southall et al. (2007) thresholds because they were developed using different weighting criteria. Table 5.8-11 summarizes thresholds for PTS onset (i.e., auditory injury levels) as suggested by Southall et al. (2007) and both previous and current NOAA guidance.

Table 5.8-11: Permanent Auditory Injury Thresholds (Received Level) for Marine Mammals

Functional Hearing Group (hearing range)	NOAA Draft Acoustic Threshold[a]		NOAA Interim Threshold[b]	Southall et al. 2007 Threshold[c]	
	Pulse	Non-pulse		Pulse	Non-pulse
Phocid Pinnipeds (75 Hz to 100 kHz)	235 dB_{peak} and 192 dB SEL_{cum}	235 dB_{peak} and 197 dB SEL_{cum}	190 dB_{RMS}	218 dB_{peak} and 186 SEL_{cum}	218 dB_{peak} and 203 SEL_{cum}
Otariid Pinnipeds (100 Hz to 40 kHz)	235 dB_{peak} and 215 dB SEL_{cum}	235 dB_{peak} and 220 dB SEL_{cum}			
Low- Frequency Cetaceans (7 Hz to 30 kHz)	230 dB_{peak} and 187 dB SEL_{cum}	230 dB_{peak} and 198 dB SEL_{cum}	180 dB_{RMS}	230 dB_{peak} and 198 SEL_{cum}	230 dB_{peak} and 215 SEL_{cum}
Mid- Frequency Cetaceans (150 Hz to 160 kHz)	230 dB_{peak} and 187 dB SEL_{cum}	230 dB_{peak} and 198 dB SEL_{cum}			
High-Frequency Cetaceans (200 Hz to 180 kHz)	201 dB_{peak} and 161 dB SEL_{cum}	201 dB_{peak} and 180 dB SEL_{cum}			

NOTES:
NOAA's Interim Thresholds were replaced by the NOAA Draft Criteria released in December 2013 but as this document is still in draft; both sets of thresholds are shown here for comparison. NOAA Interim Thresholds do not distinguish between different types of sound sources.
SEL_{cum} acoustic threshold levels are weighted by functional hearing group.
Sources: [a] NOAA (2013b), [b] NOAA (2013a), [c] Southall et al. (2007)

Currently, DFO has not adopted regulatory thresholds for assessing effects of underwater noise on marine mammals.

5.8.5.4.2 Description of Project Effect Mechanisms for Harm to Fish or Marine Mammals

Marine fish, marine mammals, and species at risk that inhabit the facility LSA and RSA either seasonally or year-round are listed in Table 5.8-3 and Table 5.8-5. These species could be present within the facility LSA and could be harmed by Project activities and works. Pile installation may cause harm to both fish and marine mammals; dredging, disposal at sea, and other marine construction activities only have the potential to cause harm to fish.

Underwater Noise and Pressure Levels from Pile Installation

Pile installation can generate high-intensity impulse sounds and changes in underwater pressure levels that can injure fish and marine mammals and potentially kill fish (Hastings and Popper 2005; Southall et al. 2007). The exact number of piles and total length of sheet piled wall required for the Project will depend on results of ongoing planning and detailed engineering design.

Underwater sound levels generated by pile installation depend on factors such as pile type (e.g., creosote, concrete, steel), diameter, method of installation (i.e., impact hammer or vibratory driver), and water depth (Illinworth and Rodkin 2007). The sounds from pile driving with an impact hammer result from a rapid release of energy when the hammer strikes the pile, as described by (Popper and Hastings 2009b; Hastings and Popper 2005). The sound causes a transient stress wave, or pulse, to propagate down the length of the pile and transverse stress waves in the wall of the pile that radiate into the water. The pulse propagating down the length of the pile may also cause transient waves to propagate outward through the seabed, which can be transmitted into the water at some distance from the pile to create localized areas of very low and/or very high sound pressure. Underwater sounds from pile driving are characterized by multiple rapid increases and decreases in sound pressure over a very short period of time.

Measured source levels from previous unmitigated pile-driving operations suggest the FHWG thresholds are seldom exceeded during installation of steel cylinder piles, or sheet piles, and recent monitoring studies conducted on use of FHWG interim thresholds suggest they may overestimate the likelihood of injury to fish (Rodkin et al. 2012; Illinworth and Rodkin 2007).

Burial or Crushing during Dredging, Marine Construction, and Dismantling of Land-based and Marine Infrastructure

Direct physical injury or mortality to marine fish and invertebrate species may occur due to burial or crushing during dredging, disposal at sea, soil improvements, installation of scour protection, excavation of areas of the RTA Wharf “B” and Methanex jetty, installation of piles and sheet piled wall, construction of the heavy haul road and MOF across the intertidal mudflat (marine construction), and dismantling of marine infrastructure.

Elevated TSS Levels from Dredging, Disposal at Sea, and Marine Construction

Dredging, disposal at sea, installation of scour protection, soil improvements and pile installation will result in re-suspension, dispersal and resettling of sediment. The associated increase in TSS levels above background levels may harm fish through gill or egg abrasion, reduced pumping rates in bivalve molluscs, and direct mortality (Clarke and Wilber 2000; Wilber and Clarke 2001). Effects on marine mammals are not expected as these organisms are not known to be sensitive to elevated TSS levels. The likelihood of harm to fish depends on factors such as species, life stage, TSS concentration, and duration of exposure. The CCME and BC WQG recommend an increase in TSS of no more than 5 mg/L above background levels for continuous activities (i.e., 24 hours to 30 days).

Isolation of Salt Marsh from Marine Construction

The MOF and heavy haul road will be built across the intertidal mudflat at the northern end of the Eurocan Basin. As a result, all tidal influx of marine waters into the salt marsh will cease and the area will be reclaimed.

5.8.5.4.3 Mitigation for Harm to Fish or Marine Mammals

The following mitigation measures will be used to reduce the potential and likelihood for harm:

- Develop and implement a Marine Activities Plan (MAP) in accordance with applicable federal and provincial legislation and regulations. The MAP will include measures to address potential effects from dredge activities, pile installation (including marine mammal exclusion zone, soft start procedures and consideration of sound dampening technologies) and shipping (Mitigation 5.8-2).
- For marine pile installation, LNG Canada will proactively manage pile installation with noise measurement and active monitoring of marine mammal exclusion zones (see MAP for more detail). Additional sound dampening methods and/or alternative pile installation methods will be investigated and applied if necessary, to prevent the exposure of marine mammals to underwater noise exceeding defined thresholds. These methods and the defined thresholds will be described in the MAP (Mitigation 5.8-10).
- In-water marine construction, dredging, and sediment disposal activities will be conducted throughout the year. For the periods outside the timing windows of least risk, additional mitigation measures will be implemented to protect sensitive species and life stages as appropriate. Timing windows and mitigations will be developed in consultation with DFO at the permitting stage and will consider the location and timing of sensitive life stages specific to CRA fishery species (Mitigation 5.8-6).
- Prior to isolation of the salt marsh habitat immediately north of the dredge area, fish using the area will be captured with a beach seine net strung across tidal channels. Fish will be relocated to more suitable areas in the marine resources facility RSA that will not be affected by Project activities (Mitigation 5.8-11).
- A Disposal at Sea Permit will be obtained prior to any sediment disposal in the marine environment. A disposal site will be selected in consultation with Environment Canada, DFO, affected Aboriginal Groups, and key stakeholders (Mitigation 5.8-4).
- Full assessment of effects of the selected sediment disposal methods and use of mitigation measures, with details to be provided in the Disposal at Sea Permit application (Mitigation 5.8-8).

- Optimization of sediment containment will be considered when selecting dredging and sediment disposal methods/equipment (Mitigation 5.8-7).
- Construction of the marine terminal does not currently plan for blasting in the marine environment. If blasting is determined to be required, it will comply with all regulatory requirements (Mitigation 5.8-3).

As outlined in Mitigation 5.8-10, LNG Canada will measure the underwater sound levels produced during pile installation. Based on these measurements, marine mammal exclusion zones will be defined and monitored for marine mammals to prevent them from being exposed to underwater noise above thresholds. LNG Canada will also investigate the use of alternative pile installation methods, such as vibratory pile installation, which has been shown to reduce pile installation noise by up to 25 dB (SELs of 10 to 15 dB lower) (Illingworth and Rodkin Inc. 2007; McCauley and Salgado Kent 2008). The suitability of additional sound dampening methods will also be considered (Mitigation 5.8-10). For example, hydro sound dampeners (Mitigation 5.8-10), which are a relatively new technology, may be used to reduce sound levels from pile installation (SEL of 23 dB between 100 Hz and approximately 600 Hz) (Elmer et al. 2012).

5.8.5.4.4 Characterization of Harm to Fish or Marine Mammals

Pile installation may cause harm to both fish and marine mammals. Dredging and disposal of the dredged material, soil improvements, installation of scour protection, and construction of the heavy haul road and MOF have the potential to cause harm to fish but not marine mammals.

Underwater Noise or Pressure Waves from Pile Installation

Pile installation will temporarily add underwater noise above baseline levels in the facility LSA and RSA. With implementation of mitigation measures, the number of fish within any given species (including species at risk) expected to be harmed by underwater noise or high pressure levels from pile installation is anticipated to be negligible relative to their total population size in the facility RSA (i.e., fish stocks managed in DFO FMA 6-1). Given the efficacy of mitigation measures and low likelihood of fish species at risk being present in the facility LSA (Stantec Consulting Ltd. 2014a), no individuals of *endangered* or *threatened* fish species are expected to be injured or killed due to underwater noise or pressure waves from pile installation.

Marine mammals could also be exposed to underwater noise produced during pile installation that could result in harm. To estimate the number of marine mammals potentially exposed to underwater noise above injury thresholds, the estimated relative abundance for available species and their distribution maps are used to determine species likely to be within the facility RSA.

Mitigation measures, such as marine mammal exclusion zones (Mitigation 5.8-2 and 5.8-10), will reduce the potential for marine mammals to be exposed to underwater noise above the injury threshold during pile installation. The use of sound dampening methods and alternate methods of installation will also be investigated and applied if necessary to reduce the areal extent of that noise, and subsequently the number of marine mammals exposed to that noise (Mitigation 5.8-2 and 5.8-10). Vibratory pile installation can potentially reduce noise by approximately 25 dB (Illingworth and Rodkin Inc. 2007; McCauley and Salgado Kent 2008). Testing of hydro sound dampeners indicated reductions in SEL of 23 dB between 100 Hz and approximately 600 Hz (Elmer et al. 2012).

The expected number of marine mammals that could potentially be exposed to noise capable of causing PTS is likely to be low relative to modelled abundance estimates for Kitimat Arm and Douglas Channel and for BC waters. This is largely due to the low numbers of marine mammals modelled to be near construction activities. For example, the facility RSA and waters within Kitimat Arm and Douglas Channel are not expected to be areas of high use by Steller sea lions compared to other areas within the shipping RSA such as Whale Channel, which has a haulout at Ashdown Island (Stantec Consulting Ltd. 2014a). *Endangered* and *threatened* species (e.g., humpback whales, fin whales, Bigg's and northern resident killer whales) are expected to be present in low numbers within the facility RSA. The known distribution of these species relative to the facility RSA is as follows:

- Four humpback whales were sighted within the facility RSA during field studies, with additional sightings reported to the BC Cetacean Sightings Network (BCCSN) (Stantec Consulting Ltd. 2014a). Based on modelling results, humpback whales are expected to have low abundance in Kitimat Arm/Douglas Channel, peaking at an average of five individuals in the fall (Stantec Consulting Ltd. 2014a).
- Estimates for fin whales could not be modelled in the facility RSA or in Kitimat Arm/Douglas Channel because there were no sightings within the area during field studies (Stantec Consulting Ltd. 2014a).
- No abundance estimates were modelled for Bigg's or northern resident killer whales, due to data limitations; i.e., they were not sighted in the facility RSA during field studies and the closest sighting was 40 km south of the facility RSA boundary (Stantec Consulting Ltd. 2014a).
- Killer whales (not specified by ecotype) have been reported in the facility RSA, with five sightings recorded by BCCSN.

With mitigation, there is a low likelihood of harm to marine mammals (including species at risk) from pile installation. The residual effect is predicted to be short-term and limited to the construction phase, with underwater noise levels returning to pre-existing conditions following construction. The effect is expected to be moderate in magnitude because underwater noise levels are expected to be above suggested thresholds, but is anticipated to have no ongoing effect on marine mammal population viability. With mitigation measures such as definition of marine mammal exclusion zones (using measurement of underwater noise levels) and use of marine mammal observers plus consideration of additional measures if required and determined to be feasible (such as vibratory pile installation, use of screw piles, or hydro sound dampeners), the potential to expose marine mammals to noise above the injury threshold is reduced and the noise levels and spatial extent of noise levels that could induce PTS may also be reduced. With the definition of exclusion zones and the estimated low abundance of marine mammals within the facility LSA, the mitigation measures are anticipated to result in low numbers of marine mammals exposed to noise above thresholds, and even fewer numbers for *threatened* and *endangered* species, such as Bigg's and northern resident killer whales.

Burial or Crushing during Soil Improvements and Scour Protection

Soil improvements (vibro-densification and installation of stone columns) and scour protection measures are required in the subtidal mudflat along the RTA Wharf "B" and Methanex jetty. These activities are unlikely to result in harm to fish and mobile invertebrates because these organisms are typically able to avoid burial or crushing by leaving the affected area. In contrast, slow-moving and sessile invertebrates (e.g., orange sea pens) are vulnerable to harm during soil improvements because they are unable to relocate. Fish species most likely to be present in this habitat type are flounders, pricklebacks (family Stichaeidae), eelpouts (family Zoarcidae), Dungeness crabs, pandalid shrimp, orange sea pens (*Ptilosarcus gurneyi*), and benthic infauna (Stantec Consulting Ltd. 2014a). These species are common and widely distributed throughout the BC north coast. With mitigation (e.g., use of timing windows), the number of fish harmed within any given species (including species at risk) is expected to be negligible relative to their total population size in the facility RSA. Given the efficacy of the mitigation measures and the low likelihood of fish species at risk being present in the subtidal mudflat habitat (Stantec Consulting Ltd. 2014a), there is a low likelihood that individuals of *endangered* or *threatened* fish species will be injured or killed.

Burial or Crushing during Excavation

Excavation of constructed rock riprap habitats in the existing RTA Wharf "B" is expected to result in physical injury or mortality to marine invertebrates, including amphipods, stubby isopods, and common acorn barnacles, the species most likely to be present (Stantec Consulting Ltd. 2014a). All of these species are common and widely distributed throughout the BC north coast. Given the extremely low likelihood of SARA-listed fish species being present in the constructed habitats (Stantec Consulting Ltd. 2014a), no individuals of *endangered* or *threatened* fish species are anticipated to be injured or killed during excavation.

Burial or Crushing during Dredging and Disposal

Methods of dredging are under review and selection of the preferred method will be part of ongoing planning and detailed engineering design. The dredge methods are likely to include a BHD with bucket clamp or clamshell, and a CSD or TSHD with barge. The likelihood of harm to fish and invertebrates from mechanical dredges (e.g., BHD with bucket clamp or clamshell) is lower than for hydraulic dredges (e.g., CSD, TSHD) (Reine and Clarke 1998; Stevens 1981), presumably because mechanical dredges move slowly, resulting in limited damage to organisms and because fish and mobile invertebrates avoid increased TSS, and low-frequency vibrations generated during mechanical dredging (Stevens 1981; Wainwright et al. 1992).

The species most likely to be present in the dredge area are flounders, pricklebacks, eelpouts, Dungeness crabs, pandalid shrimp, orange sea pens, and benthic infauna (Stantec Consulting Ltd. 2014a), all of which are common and widely distributed throughout the BC north coast. Fish and mobile invertebrates are unlikely to be harmed during dredging because they are typically able to avoid burial or crushing by leaving the dredge area once activities are underway. In contrast, slow-moving and sessile invertebrates are most vulnerable because they are unable to relocate. Literature on susceptibility to entrainment during dredging indicates the following:

- Invertebrate species susceptible to entrainment by dredging include Dungeness crab, sand and mud shrimp, bivalve molluscs, annelid worms, and amphipods (Reine and Clarke 1998; Stevens 1981).
- Entrainment and mortality of fish species by mechanical dredges is uncommon (Stevens 1981; Wainwright et al. 1992). For hydraulic dredges, overall entrainment rates of marine fish are low but certain species, including Pacific staghorn sculpin (*Leptocottus armatus*), Pacific sand lance (*Ammodytes hexapterus*), and flatfish (family Pleuronectidae) appear to be more susceptible (Reine and Clarke 1998).
- Anadromous fish species, including juvenile salmon and eulachon, are susceptible to entrainment by hydraulic dredges in constricted river environments, but are unlikely to be entrained in large numbers outside of these environments (Reine and Clarke 1998).
- The mortality rate of Dungeness crab from entrainment in mechanical dredges is approximately 10%, suggesting this activity has a negligible effect on Dungeness crab populations (Stevens 1981; Wainwright et al. 1992). For hydraulic dredges, mortality rates from entrainment range from 5 to 100%,
- The mortality rate for bivalve shellfish larvae from hydraulic dredges is expected to be near 100% (Reine and Clarke 1998; Stevens 1981; Wainwright et al. 1992).

Disposal at sea will involve the deposition of up to 3 million m^3 of sediment at the designated disposal site. Disposal of this volume of sediment is expected to result in the burial or crushing of fish and invertebrates at the designated disposal site. Depending on the deposition rate, fish and mobile invertebrates are able to avoid burial or crushing by leaving the area. Less mobile organisms, such as benthic invertebrates, are more vulnerable to burial or crushing, but are expected to recover within two years following disposal (Bilkovic 2011; Newell et al. 1998).

The fish and invertebrate species most likely to be present at the designated disposal site in the BSAs are eelpouts, tom cod (*Microgadus proximus*), flounders, pandalid shrimp, tritons, anemones, white sea pens, and tube worms (Stantec Consulting Ltd. 2014a). Eulachon were observed in the northern portion of BSA 3 (five individuals). A small number of unidentified smelts (three or fewer individuals) were also observed in the northern portion of BSA 2 (Stantec Consulting Ltd. 2014a).

With mitigation (including use of timing windows to avoid sensitive life stages of CRA fishery species, and relocation of fish from the salt marsh prior to isolation), the number of fish harmed by dredging, disposal of dredged material in the salt marsh, and disposal of dredged material at sea, for any given species (including species at risk), is anticipated to be negligible relative to their total population size in the facility RSA and BSAs. Given the efficacy of the mitigation measures and the low likelihood of *endangered* or *threatened* fish species being present in the dredge area, salt marsh, or selected disposal at sea site (Stantec Consulting Ltd. 2014a; Triton Environmental Consultants Ltd. 2014) during dredging and disposal of the dredged material, no individuals of *endangered* or *threatened* fish species are expected to be harmed.

Elevated TSS Levels from Dredging, Disposal at Sea, and Marine Construction

In preparation for the Disposal at Sea Permit application, LNG Canada is conducting sediment plume modelling to predict the extent, duration, and TSS levels of the sediment plume associated with dredging at the marine terminal and disposal of dredged material at the selected disposal site in upper Kitimat Arm. Preliminary TSS modelling was done to evaluate various methods for sediment disposal (surface disposal from a split-hull barge, depth disposal from a submerged pipe at either 60 or 120 m depth) at a generic 300 m deep location in Kitimat Arm (Appendix I in Stantec Consulting Ltd. 2014a). The influence of particle size, sediment density (ranging from 1,300 kg/m^3 to 1,800 kg/m^3), seasonal conditions (winter and summer), and cumulative disposal events was examined. There was little appreciable difference in the predicted TSS levels for the surface discharge and the 120 m deep pipe discharge; however, with surface disposal, there would be measurable TSS elevation in surface waters and potential cumulative increases with consecutive disposal events. Disposal at 60 m depth could result in neutral buoyancy of sediment before it reaches the bottom, resulting in more extensive dispersal of sediment in deep water, as would release of less dense sediment with higher water content. The modelling exercise was not designed to quantitatively predict TSS levels, given the number of options modelled; however, TSS ranges were provided for the various modelling scenarios.

- Surface disposal would result in sediment plumes of 1 to 10 mg/L TSS in the entire water column (localized peak of 10 to 100 mg/L one hour after disposal), with TSS levels diluted to background levels within twelve hours.
- Deepwater disposal from a submerged pipe at 60 m depth could result in neutral buoyancy at depth, with TSS levels of up to 1400 mg/L in deep water one hour after disposal; TSS of 1 to 100 mg/L would persist at mid depths (150 to 250 m) even at twelve hours after disposal, which would be more pronounced for summer than for winter disposal events.
- Deepwater disposal from a submerged pipe at 120 m depth would result in rapid settling of most of the sediment, with TSS levels of 1 to 10 mg/L at depths below 120 m (localized peak of 10 to 100 mg/L after one hour), decreasing to background or isolated peaks of 1 to 10 mg/L within twelve hours. Consecutive disposal events six hours apart are predicted to result in areas of TSS up to 10 mg/L in waters below 120 m depth.
- TSS plumes (in the range of 1 to 50 mg/L) could extend up to 3 km, decreasing with distance from the disposal site.

Responses of marine organisms to elevated TSS levels are species-specific, with lethal effects observed at concentrations as low as several hundred mg/L for 24 hours, or no effect at concentrations above 10,000 mg/L for one week (Clarke and Wilber 2000; Wilber and Clarke 2001). Adult fish and highly mobile invertebrates typically avoid areas with elevated TSS levels and exposure durations are generally limited to minutes or hours (Johnson and Wildish 1981; Newcombe and Jensen 1996; Clarke and Wilber 2000; Wilber and Clarke 2001). Egg and larval stages of fish appear to be the most sensitive to suspended sediment (Clarke and Wilber 2000). Studies on the effects of TSS on Pacific herring suggest there is low likelihood of harm at TSS levels typically associated with dredging and disposal at sea (Ogle 2004; Connor et al. n.d.). Species of bivalve molluscs have varying tolerances to TSS, with filter-feeders more sensitive than deposit feeders, and larval forms more sensitive than adults (Newell et al. 1998). Harm to crustaceans and bivalve molluscs from typical TSS levels associated with dredging projects is considered unlikely (Clarke and Wilber 2000). Overall, dredging does not appear to have an important effect on the density and species composition of benthic invertebrates outside the dredge area (Newell et al. 1998).

The TSS levels generated during dredging and disposal of sediment are unlikely to cause harm to marine fish and invertebrates (Clarke and Wilber 2000; Newell et al. 1998; Wilber and Clarke 2001). Modelling suggests that disposal of dredged material at sea has the potential to result in an exceedance of WQGs for TSS (Stantec Consulting Ltd. 2014a), which would result in temporary effects to some species of marine fish and invertebrates at or near the designated disposal site. With mitigation, the number of fish within any given species (including species at risk) harmed by elevated TSS levels from dredging, disposal at sea, and marine construction is anticipated to be negligible relative to the total population size in the facility RSA and BSAs. Given the efficacy of the mitigation measures and the low likelihood of fish species at risk being present in the facility LSA during dredging and pile installation, or at the designated disposal site during disposal at sea (Stantec Consulting Ltd. 2014a), no individuals of *endangered* or *threatened* fish species are expected to be harmed by elevated levels of TSS.

Burial or Crushing during Construction of the Heavy Haul Road and MOF

Construction of the heavy haul road and MOF across the intertidal mudflat in the Eurocan Basin is expected to result in physical injury or mortality to fish. The species most likely to be present in this habitat and most vulnerable to harm from construction activities include stubby isopods, crangonid shrimp, and Baltic macoma clam (*Macoma balthica*) (Stantec Consulting Ltd. 2014a), all of which are common and widely distributed throughout the BC north coast. Therefore, the number of fish and invertebrates within any given species harmed during this construction is anticipated to be negligible relative to their total population size in the facility RSA. Given the low likelihood of *endangered* or *threatened* fish species being present in the intertidal mudflat (Stantec Consulting Ltd. 2014a), no individuals of *endangered* or *threatened* fish species are anticipated to be injured or killed during construction of the heavy haul road and MOF.

Isolation of the Salt Marsh from Marine Construction

Once the heavy haul road and MOF are situated in the intertidal mudflat, all tidal influx of marine waters into the marsh will cease and the habitat will be lost. With mitigation (including use of timing windows to avoid sensitive life stages of CRA fishery species and relocation of fish from the marsh), the number of fish harmed within any given species (including species at risk) is estimated to be negligible relative to their total population size in the facility RSA. Given efficacy of the mitigation measures and the low likelihood of SARA-listed fish species being present in the salt marsh (Stantec Consulting Ltd. 2014a; Triton Environmental Consultants Ltd. 2014), no individuals of *endangered* or *threatened* fish species are expected to be injured or killed as a result of isolation of the salt marsh.

Dismantling of Marine Infrastructure

Dismantling of marine infrastructure during decommissioning may result in physical injury or mortality to marine invertebrates, particularly those that inhabit constructed intertidal habitats. The species most likely to be present in this habitat type and most vulnerable to harm include amphipods, stubby isopods, and common acorn barnacles (Stantec Consulting Ltd. 2014a), all of which are common and widely distributed throughout the BC north coast. Given the extremely low likelihood of SARA-listed fish species being present in the intertidal constructed habitats (Stantec Consulting Ltd. 2014a), and that decommissioning will be conducted based on applicable statutes and regulations, no individuals of *endangered* or *threatened* fish species are anticipated to be injured or killed as a result of dismantling of infrastructure.

Combined Harm to Fish or Marine Mammals from All Project Activities and Works

The mitigation measures will reduce the likelihood of harm to fish, marine mammals, and species at risk during dredging, disposal at sea, and marine construction; however, there is a high likelihood that Project activities and works will result in harm to a limited number of individuals of fish species that support or are part of CRA fisheries, and a low likelihood that Project activities will result in harm to individuals of *endangered* or *threatened* fish species. Any harm to CRA fishery species is not anticipated to be sufficient to affect their population viability.

Harm to fish from dredging and marine construction will be limited to the facility LSA, and harm to fish from disposal at sea will be limited to the designated disposal site. Fish and invertebrate populations are expected to have high resilience because the populations are relatively healthy in the facility RSA and BSAs and many already experience and recover from frequent human and natural disturbances (industrial activities, variations in river outflow and TSS, and tidal currents). The duration of harm to fish from the various Project activities, except dredging and disposal at sea, will be short-term and will occur repeatedly as a multiple regular event during the construction phase. Effects of dredging and disposal at sea will be limited to the Project footprint (i.e., dredge area), and long-term because they will occur as multiple irregular events during construction and operation (including periodic maintenance dredging). With mitigation, it is anticipated that only a limited number of individual fish relative to the total population size in the facility RSA will be harmed. The combined harm to fish from dredging, disposal at sea, and marine construction is anticipated to be negligible. Although harm to individual fish is irreversible, the effects of harm to fish populations in the facility RSA and at the designated disposal site are reversible.

Low numbers of marine mammals are estimated to be present in areas where acoustic harm could occur during pile installation. With mitigation measures that reduce the potential for marine mammals to be exposed to noise about injury thresholds and potentially reduce the extent of noise above injury thresholds (i.e., use of underwater noise defined exclusion zones and marine mammal observers, consideration of additional measures such as vibratory pile installation, or hydro sound dampening), there will be a low likelihood of harm to marine mammals during construction, and only a few marine mammals, and even fewer *threatened* or *endangered* species, are anticipated to be affected. The magnitude of the effect is considered moderate because underwater noise will be temporarily above thresholds, but the viability of marine mammals populations is not expected be negatively affected (i.e., a reversible effect). Effects will occur within the facility RSA, and be short-term and a multiple regular event. The context is low resilience (due to conservation status for killer whales).

5.8.5.4.5 Determination of Significance for Harm to Fish or Marine Mammals

With mitigation, there is a high likelihood that Project activities will result in harm to a limited number of individual fish that support or are part of CRA fishery species, and a low likelihood that they will result in harm to individuals of fish species at risk. The number of individual fish of CRA fishery species potentially harmed is anticipated to be only a small proportion of the total population sizes in the facility RSA (i.e., fish stocks managed in DFO FMA 6-1). Harm to a limited number of individual fish will not affect population viability of species that support or are part of CRA fisheries, and no harm to *endangered* or *threatened* fish species is anticipated. Consequently, harm to fish that support or are part of CRA fisheries, and to fish species at risk, is assessed as negligible and not significant.

Residual effects on marine mammals are considered short term in duration and reversible because residual effects will be limited to the construction phase of the Project, underwater noise will return to baseline conditions, and population level residual effects on marine mammals are not expected. Implementation of mitigation measures will reduce the potential for marine mammals to be exposed to noise above the injury threshold and the extent of noise and, combined with the low estimated abundance of marine mammals in the facility LSA, the number of individuals anticipated to be exposed to noise above injury thresholds is low. There is a lower likelihood of affecting *threatened* or *endangered* marine mammal species, given their estimated low abundance near the facility LSA. With mitigation, there is a low likelihood of harm, of affecting the viability of marine mammal populations, and of causing harm to *threatened* or *endangered* species. Therefore, harm to marine mammals is assessed as not significant.

5.8.5.5 Assessment of Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressures Waves

The measurable parameter is likelihood of exposure to underwater noise, relative to recommended acoustic thresholds, for assessing change in behaviour of fish or marine mammals due to underwater noise or pressure waves. Project activities and works at the LNG facility that have the potential to result in a change in behaviour of fish or marine mammals ranked as 2 in Table 5.8-6 are dredging, pile installation (marine construction), and dismantling of marine infrastructure. Underwater noise from vessel berthing and movement at the marine terminal is assessed in Section 5.8.6, Assessment of Residual Effects from Shipping.

5.8.5.5.1 Analytical Assessment Techniques

The likelihood of underwater noise levels causing change in behaviour of fish or marine mammals is assessed by determining the exceedance of recommended sound level thresholds associated with noise produced from Project activities and the potential for species to hear the noise and be present within the facility LSA and RSA. There are no acoustic thresholds available for change in behaviour of fish, so a qualitative assessment considering timing (seasonal) and duration is conducted using scientific literature and professional judgment.

Effects of underwater noise on marine mammal behaviour are determined considering established underwater noise thresholds for behavioural disruption, which are different for continuous (non-pulse) and impulsive (pulse) sounds.

Exposure to sound is typically described using a measure of the received sound level and duration of the sound signal (Popper and Hastings 2009b; Hastings and Popper 2005). Broadly speaking, there are two types of anthropogenic noise: short pulses of high-intensity sounds such as those from impact pile driving and non-pulse or continuous sounds such as those from dredging or vessel traffic (Popper and Hastings 2009b).

New thresholds for onset of behavioural effects for marine mammals are being developed (NOAA 2013b) but are not publicly available. Hence, this assessment relies on NOAA's interim behavioural disruption thresholds for marine mammals (NOAA 2013a), which provide a means to evaluate potential effects associated with modelled underwater noise levels. The NOAA interim behavioural disruption thresholds are 160 dB_{RMS} re 1 µPa for pulsed noise and 120 dB_{RMS} re 1 µPa for non-pulse noise for both pinnipeds and cetaceans; these values are not weighted by functional hearing group. Southall et al. (2007) noise thresholds do not include a threshold for behavioural disruption, although they do indicate behavioural response criteria.

Underwater noise levels are modelled for dredging with a TSHD (Stantec Consulting Ltd. 2014a). The modelling results are assumed to be a conservative estimate of the underwater noise created by the Project from dredging activities as other methods may be employed that produce lower levels of underwater noise. Predicted sound levels are compared to the NOAA behavioural disruption thresholds to determine the area within which marine mammals might be exposed to noise levels capable of causing behavioural change. Predictive models of marine mammal density and abundance (based on results of field studies) are then used to assess the number of individuals likely to occur in these areas and, thus, potentially exposed to sound levels that exceed the NOAA behavioural disruption threshold.

5.8.5.5.2 Description of Project Effect Mechanisms for Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressures Waves

A number of fish species have the basic acoustic abilities of other vertebrates, including the ability to discriminate between sounds of different magnitudes or frequencies, detect a sound in the presence of other signals, and determine the direction of a sound source (Hastings and Popper 2005). Fish are categorized as hearing specialists (e.g., herrings, shads, menhaden, anchovies) or generalists (e.g., salmonids). Hearing specialists have anatomical specializations that make them better able to detect lower levels of sound pressure and thus perceive wider bandwidths than hearing generalists (Hastings and Popper 2005; Popper and Hastings 2009b). The majority of fish species do not have these anatomical specializations and are considered hearing generalists (Hastings and Popper 2005). However, there is a general lack of empirical data on effects of underwater noise on these species groups (Hastings and Popper 2005; Popper and Hastings 2009a; Popper and Hastings 2009b; Moriyasu 2004).

Marine mammals exhibit a variety of responses to underwater noise, but predicting the magnitude of effect, long-term outcomes or population level effects can be difficult. Responses vary from increased stress (Rolland et al. 2012; Southall et al. 2007) and disrupted communications (e.g., Castellote et al. 2012; Merchant et al. 2014; Risch et al. 2012; Williams et al. 2013a) to disrupted migration and foraging patterns (e.g., Southall et al. 2007; Sundermeyer et al. 2012; Tougaard et al. 2012) and changes in surfacing and diving behaviour (Nowacek et al. 2007). Several factors affect how and if an animal responds, including the species and activity state of the animal in question, as well as novelty, intensity and duration of the noise (Ellison et al. 2012; Popper and Hawkins 2012; Richardson et al. 1995; Southall et al. 2007). There is also often large variation in behavioural response within a species, with some individuals responding differently to different intensities and frequencies of sound (e.g., Kastelein et al. 2012). Tyack (2008) noted the intensity of behavioural response may not always be an accurate predictor of population-level effects of noise.

Project activities that have the potential to cause change in behaviour of fish or marine mammals are dredging (including periodic maintenance dredging during operations), disposal at sea, installation of piles and sheet piled walls (marine construction), and dismantling of land-based and marine infrastructure.

The intensity of noise from dredging can vary greatly depending on equipment used and substrate being dredged. Generally, poorly maintained equipment and firmer sediments generate more intense noise (Dickerson et al. 2001). Information about the type of dredging equipment to be used for the Project is not available at the time of assessment, but equipment will be selected to optimize sediment containment. Underwater noise sources from mechanical dredging methods are generated by the barge-installed power plant and scraping of the dredger against hard sediment. Hydraulic dredges create underwater noise through the vessel’s propulsion system and suction of material using a high-power pump, and are typically louder than mechanical dredging (Stantec Consulting Ltd. 2014a).

5.8.5.5.3 Mitigation for Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressures Waves

The mitigation measures used to reduce the likelihood of harm to fish and marine mammals (Section 5.8.5.4) will also be effective in reducing the intensity and areal extent of underwater noise as a result of Project activities at the LNG facility and the number of marine fish and marine mammals whose behaviour may be affected by exposure to noise. These measures include:

- Develop and implement a Marine Activities Plan (MAP) in accordance with applicable federal and provincial legislation and regulations. The MAP will include measures to address potential effects from dredge activities, pile installation (including marine mammal exclusion zone, soft start procedures and consideration of sound dampening technologies) and shipping (Mitigation 5.8-2).
- For marine pile installation, LNG Canada will proactively manage pile installation with noise measurement and active monitoring of marine mammal exclusion zones (see MAP for more detail). Additional sound dampening methods and/or alternative pile installation methods will be investigated and applied if necessary, to prevent the exposure of marine mammals to underwater noise exceeding defined thresholds. These methods and the defined thresholds will be described in the MAP (Mitigation 5.8-10).
- In-water marine construction, dredging, and sediment disposal activities will be conducted throughout the year. For the periods outside the timing windows of least risk, additional mitigation measures will be implemented to protect sensitive species and life stages as appropriate. Timing windows and mitigations will be developed in consultation with DFO at the permitting stage and will consider the location and timing of sensitive life stages specific to CRA fishery species (Mitigation 5.8-6).
- Construction of the marine terminal does not currently plan for blasting in the marine environment. If blasting is determined to be required, it will comply with all regulatory requirements (Mitigation 5.8-3).

5.8.5.5.4 Characterization of Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressures Waves

The effects of short-term and long-term exposure to underwater noise on fish and invertebrate behaviour are largely unknown and, at present, there are no standard criteria or thresholds for assessing sound levels that are likely to affect fish behaviour. According to Popper and Hastings (2009b), potential behavioural changes range from no change to small temporary movements for the duration of the sound, large movements that displace fish from their normal locations, and large-scale changes in habitat use. In theory, large-scale displacement of fish from important foraging, spawning, rearing, or migration habitat could affect long-term survival of a population. However, published literature does not suggest that underwater noise from short term activities such as dredging, disposal at sea, pile installation, and dismantling of marine infrastructure will result in a large-scale displacement of fish populations (including species at risk) that would affect their viability.

Studies on effects of anthropogenic noise on fish have mostly focused on disturbances associated with impulsive sounds such as explosives (e.g., blasting), impact pile driving, and seismic air guns (Popper and Hastings 2009a; Popper and Hastings 2009b; Moriyasu et al. 2004). Most studies were conducted in a laboratory setting, which does not necessarily provide accurate insight into how fish behave in their natural habitat (Popper and Hastings 2009a; Popper and Hastings 2009b). Popper and Hastings (2009b) also note that it is difficult to extrapolate data on the effects of sound among different fish species and sound sources. For continuous or intermittent low-intensity underwater noise, there is limited scientific literature regarding behavioural changes, especially for the fish and invertebrate species that occur in the facility RSA. Thomson (2012) reported that noise from pile driving can trigger a temporary change in behaviour in fish, but that fish may become habituated to the noise over relatively short periods of exposure time (i.e., weeks).

There is a medium likelihood of a low magnitude change in behaviour of fish (including species at risk) due to underwater noise or pressure waves from marine construction, dredging, and decommissioning (measurable change from existing conditions but will not affect ongoing viability of populations). The geographic extent of this effect is the facility RSA, with noise expected to dissipate with distance from the marine terminal. Because the activities will occur in an area already subject to noise from vessels using existing infrastructure, the affected fish populations are expected to have high resilience to underwater noise and are likely to recover from effects in the short-term (i.e., within a few minutes following cessation of noise), although activities will be long term with maintenance dredging occurring during operations. Change in behaviour of fish due to underwater noise is anticipated to be a multiple irregular event, occurring during construction and operations, and to be reversible, lasting a few weeks for continuous sound sources (e.g., dredging, pile installation).

Marine mammal species that could be exposed to noise levels above the NOAA behavioural disruption threshold (NOAA 2013a) include Pacific white-sided dolphins, Dall’s porpoise, harbour porpoise, harbour seals and Steller sea lions within the facility LSA, with the addition of Bigg’s and northern resident killer whales and humpback whales within the facility RSA. Underwater noise from dredging above the behavioural disruption threshold is predicted to extend 9.3 km from the dredging site (Stantec Consulting Ltd. 2014a).

Underwater noise from pile installation and dredging is anticipated to affect the behaviour of few marine mammals, relative to abundance in Kitimat Arm/Douglas Channel and in BC waters. Pacific white sided-dolphins and harbour seals are expected to have the highest numbers of individuals that could experience changes in behaviour from underwater noise. For Pacific white-sided dolphins, an average of less than 43 individuals are predicted to be exposed to noise above the behavioural disruption threshold, compared to modelled average abundance of 238 individuals in Kitimat Arm and Douglas Channel and 32,637 individuals in BC (Best and Halpin 2011; Stantec Consulting Ltd. 2014a). For harbor seals, an average of less than 44 individuals are predicted to be exposed to noise above the behavioural disruption threshold, compared to modelled average abundance of 156 individuals in Kitimat Arm and Douglas Channel and 105,000 individuals in BC (DFO 2010a; Stantec Consulting Ltd. 2014a). It is not expected that these potential changes in behaviour will have an adverse effect on their population viability. Similarly, the highest number of Steller sea lions estimated to be exposed to noise above the behavioural disruption threshold is an average of 13 individuals, with no rookeries or major haulouts located in Kitimat Arm or Douglas Channel. This is not expected to have negative effects on population viability because there are 20,000 to 28,000 individuals estimated for BC waters (DFO 2010b) and an average of 50 individuals estimated for Kitimat Arm and Douglas Channel (Stantec Consulting Ltd. 2014a). The overall low relative abundance for Kitimat Arm and Douglas Channel for humpback whales (average of five individuals in October) (Figure 5.8-10; Stantec Consulting Ltd. 2014a) results in an estimated maximum average of one individual exposed to noise above the behavioural disruption threshold. Abundance estimates could not be estimated for all species, due to low numbers of sightings during field surveys, so the number of animals that could potentially be disturbed cannot be estimated. The distribution of these species is as follows:

- Bigg's and northern resident killer whales have been sighted within the area where sound levels are potentially above the behavioural disruption threshold but abundance could not be estimated due to the low numbers of sightings during the field surveys.
- Fin whales are not expected to be within the area because there were no sightings during field surveys and none have been recorded by the BCCSN near the facility RSA (Stantec Consulting Ltd. 2014a).

With mitigation measures (e.g., sound dampening methods) (Mitigation 5.8-2 and 5.8-10) which will reduce sound levels produced and the spatial extent of noise above the behavioural disruption threshold, combined with the estimated low abundance of marine mammals within the facility RSA, few *endangered* or *threatened* species are anticipated to be exposed to sound levels above the behavioural disruption threshold.

Dismantling of land-based and marine infrastructure (decommissioning) is not expected to exceed the noise levels predicted for pile installations or dredging. Therefore, estimates of individuals exposed to sound from decommissioning activity are similar.

The estimated number of marine mammals (including species at risk) that could be exposed to underwater noise above the behavioural disruption threshold from Project activities is expected to be low, relative to abundance of the species in BC waters. The residual effect is long-term (occurring during construction and operations) and reversible, with underwater noise conditions returning to baseline after Project activities are completed. Acoustic modelling suggests the effect may extend into the facility RSA. With mitigation, it is expected the extent of underwater noise will decrease and, subsequently, few marine mammals will be exposed to underwater noise that could result in changes in behaviour. While there is a high likelihood of change in marine mammal behaviour due to underwater noise or pressure waves, the residual effect is expected to be moderate in magnitude because although underwater noise will exceed recommended thresholds, it is not expected to adversely affect marine mammal population viability. The context for change in behaviour is moderate because of the uncertainty in the relationship between behavioural change and population level effects and the time frame needed for recovery from behavioural effects.

5.8.5.5.5 Determination of Significance of Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressures Waves

With mitigation, there is a medium likelihood that Project activities and works during the construction and operation phase will result in change in behaviour of fish that support or are part of CRA fishery species, and fish species at risk. The change in behaviour of fish is anticipated to be low magnitude, long term, and reversible. Temporary changes in behaviour of a limited number of individual fish in the facility RSA will not affect population viability of fish that support or are part of CRA fisheries, or fish species at risk. Consequently, change in behaviour of fish is assessed as not significant.

Change in behaviour of marine mammals in response to noise and pressure waves produced during dredging and marine construction could occur over long distances. Even with mitigation, pile installation and dredging will increase underwater noise levels above baseline conditions and may exceed the NOAA marine mammal behavioural disruption threshold, leading to a high likelihood of a moderate magnitude residual effect, but in a smaller area than for unmitigated effects. There is a low likelihood that changes in behaviour will affect the population viability of marine mammals (including species at risk). With mitigation, change in behaviour from underwater noise and pressure waves from the LNG facility is assessed as not significant.

5.8.5.6 Summary of Project Residual Effects from the LNG Facility

With implementation of mitigation and offsetting measures, residual effects are not expected to affect the ongoing viability of marine fish and marine mammal populations (including species at risk), or to cause harm to *endangered* or *threatened* species. With implementation of the Fish Habitat Offset Plan, there will be no net loss in the total area or productive capacity of marine fish habitat. Mitigation measures will reduce effects on fish habitat, fish health, harm to fish and marine mammals, and behaviour of fish and marine mammals. Overall, residual effects from the LNG facility are expected to be negligible to moderate in magnitude, short to long-term in duration, and extend into the facility RSA, depending on the effect.

Change in fish habitat, fish health, and behaviour of fish and marine mammals due to underwater noise or pressure waves is reversible; while harm to fish and marine mammals is irreversible at the individual level; however, it is reversible at the population level. Residual effects on marine resources from the LNG facility for all four effects are assessed as not significant.

5.8.6 Assessment of Residual Effects from Shipping

5.8.6.1 Analytical Methods

5.8.6.1.1 Analytical Assessment Techniques

This assessment of residual effects from shipping assesses the potential change in behaviour on marine fish and marine mammals within the shipping RSA. For marine mammals, predicted sound levels from shipping that exceed the NOAA behavioural disruption threshold (120 dB_{RMS} re 1 µPa; NOAA 2013a) are compared to their potential presence based on density surface modelling. For change in behaviour of fish, a qualitative assessment is conducted using information in published scientific literature and professional judgment.

Acoustic modelling is used to estimate the underwater sound pressure levels (SPLs) produced by shipping activities for five scenarios (Stantec Consulting Ltd. 2014a):

- LNG carrier berthing assisted by three harbour tugs
- LNG carrier and one accompanying escort tug at transiting speeds of 12 knots and 10 knots in Douglas Channel
- LNG carrier and one accompanying escort tug at transiting speeds of 12 knots and 10 knots in Wright Sound
- LNG carrier and one accompanying escort tug at transiting speeds of 12 knots and 10 knots in Nepean Sound, and
- LNG carrier and one accompanying escort tug at transiting speeds of 12 knots and 10 knots in Browning Entrance.

Acoustic modelling did not assess additional scenarios for shipping activities associated with construction and decommissioning as the five modelled scenarios are likely to represent the maximum inputs of underwater noise from Project shipping activities. Project shipping activities associated with construction or decommissioning are anticipated to be completed by smaller vessels, which are expected to make less noise than the larger LNG carriers and accompanying escort tugs (Richardson et al. 1995). The exact sound level and frequency of underwater noise produced depends on vessel size and speed, with noise primarily produced from propeller cavitation (Richardson et al. 1995a).

The NOAA interim threshold for behavioural disruption from non-pulse (e.g., shipping) noise (NOAA 2013a) is used to determine potential for residual effects on marine mammal behavior. An additional threshold for killer whales (MacGillivray et al. 2012) is used; this threshold is based on a review of scientific literature on killer whale responses to whale watching vessels (Williams et al. 2002a; Williams et al. 2002b). The resulting noise thresholds for behavioural response by killer whales is approximately 64 dB above their hearing threshold (HT) for overt avoidance of whale watching vessels and approximately 57 dB above HT for subtle responses. Modelled underwater noise from LNG carrier activity during berthing and along the marine access route is compared to the NOAA and MacGillivray behavioural disruption thresholds to determine the potential spatial area over which sound produced by shipping exceeds the thresholds for the five scenarios modelled.

To estimate the number of individual exposures to noise above the behavioural disruption thresholds for marine mammals along the marine access route, the most conservative extent (i.e., the largest extent) of underwater noise was applied to the marine access route and a zone of influence is calculated. This is done separately for the marine access route in the confined channels and the open waters between Browning Entrance and Triple Island. When possible, these areas are then compared with the estimated relative abundance of marine mammals in the shipping RSA. Relative abundance of commonly sighted marine mammal species within the shipping RSA is estimated by using density surface models, based on results of the field studies (see Stantec Consulting Ltd. [2014a] for detailed methods and results).

5.8.6.1.2 Assumptions and the Conservative Approach

For fish and marine mammals, uncertainties are associated with population dynamics, abundance estimates, habitat use, and individual and population-level responses. To address these uncertainties, the following conservative assumptions are used:

- Effects on fish populations are given greater consideration if they persist for more than one generation or if they occur during sensitive life stages.
- Certain fish species and populations are recognized as being more vulnerable to effects than others. These include species at risk, species with a K-selected life history traits (i.e., long-lived, slow-growing, low natural rate of mortality, and few offspring), species that have highly-specialized habitat needs, and sessile species that are unable to avoid affected areas.
- Effects on species at risk or ecologically important fish and marine mammal species (e.g., key prey species, structure-forming species, keystone species) are given greater consideration.

- The most conservative behavioural disruption threshold is used to determine the extent of underwater noise that could result in changes in marine mammal behaviour.
- Acoustic modelling of underwater noise is based on winter water temperature conditions, which create a conducive environment for propagation of underwater noise.

Whenever there are uncertainties regarding magnitude, extent or duration of Project activities, the most conservative scenario is assumed. For example, LNG Canada estimates that between 170 and 350 LNG carriers will visit the marine terminal annually at full build-out; therefore, this assessment assumes the maximum number.

5.8.6.2 Assessment of Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressure Waves

5.8.6.2.1 Description of Project Effect Mechanisms for Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressure Waves

Shipping activities and works with potential to result in a change in behaviour of fish or marine mammals are identified in Table 5.8-6 and may occur in any Project phase. Shipping operations and berthing of LNG carriers at the LNG facility will produce underwater noise that may change the behaviour of marine fish or marine mammals, including species at risk. Over the minimum 25-year lifespan of the LNG facility operation, up to 350 LNG carriers are expected to call on the marine terminal per year, resulting in up to 700 transits of the marine access route annually. LNG carriers will be accompanied by one escort tug between the Triple Island pilotage station and the marine terminal and by as many as four harbour tugs as necessary when at the marine terminal to assist with berthing and departure within harbor confines or as per pilots' instructions. Two BC Coast Pilots will accompany all LNG carriers when travelling between Triple Island and the port of Kitimat, greatly enhancing the expertise and local knowledge on watch during all transits. The enhanced bridge will therefore consist of the vessel captain, two BC Coast Pilots, office of the watch, and a dedicated crew member acting as lookout. During construction and decommissioning, shipping of materials will also occur, likely using barges. The noise produced from these activities is expected to be quieter than from LNG carriers and tugs along the marine access route and during berthing and, therefore, is not discussed explicitly in this assessment.

5.8.6.2.2 Mitigation for Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressure Waves

Underwater noise from vessels is largely produced by propeller cavitation (Ross 1976), with larger vessels creating louder and lower frequency sound than smaller vessels. The main mitigation measure is reduction in vessel travel speeds; acoustic modelling indicated a substantial decrease in noise levels and areal extent of sound for LNG carriers travelling at 10 knots compared to 12 knots (Stantec Consulting

Ltd. 2014a). The following mitigation measure will reduce the likelihood of change in behaviour of fish and marine mammals from shipping activities by decreasing the amount of underwater noise produced:

- LNG carriers will travel at speeds of 8 knots to14 knots. Speeds will vary depending on navigational safety, weather conditions, location, and marine mammal presence, and will be determined based on the judgment of the ship's master who receives advice from the BC Coast Pilots on board. Subject to navigational safety needs, in areas of high whale density between the northern end of Campania Island and the southern end of Hawkesbury Island, LNG carriers will travel at speeds of 8 knots to10 knots from July through October (recognizing periods of high use by marine mammals) (Mitigation 5.8-12).

This mitigation measure is based primarily on acoustic modelling and expert opinion and will reduce the likelihood of changes in behaviour by fish or marine mammals from shipping.

5.8.6.2.3 Characterization of Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressure Waves

Underwater noise from shipping may result in change in behaviour of marine fish and invertebrates by creating temporary increases in stress, behavioural disturbances (i.e., a deviation from foraging behaviours), and avoidance of noisy areas (Wale et al. 2013a; Wale et al. 2013b; Spiga et al. 2012a,b; Schwarz and Greer 1984). Behavioural changes in response to underwater noise depend on a number of variables including magnitude and duration of noise, distance from the sound source, the species exposed to noise, and activity of the animal at the time (Popper and Hawkins 2012; Richardson et al. 1995; Southall et al. 2007). Scientific information on underwater noise from shipping activities suggests these acoustic disturbances have the potential to trigger a change in fish behaviour (Popper and Hastings 2009b).

The residual effects of short- and long-term exposure to underwater noise on fish and invertebrate behaviour are largely unknown (Section 5.8.5.5), for both continuous and intermittent low-intensity underwater noise, especially for the species that occur in the shipping RSA. Schwarz (1984) found that Pacific herring exhibited a “mildly negative” behavioural change in response to the sound of approaching large fishing vessels by slowly moving away from the sound source. Atlantic herring (*Clupea harengus*) are known to exhibit avoidance reactions to the sound of approaching vessels during wintering and spawning migration (Olsen et al. 1983; Vabø et al. 2002). However, Skaret et al. (2005) showed that spawning herring do not exhibit avoidance reactions to approaching vessels and postulated that they prioritize reproductive activities over avoiding a perceived threat. Spiga et al. (2012a) found short-term exposure to boat noise can potentially cause temporary stress and changes in behaviour in juvenile fish. In the same study, juvenile fish exposed long-term to boat noise showed increased stress and behavioural changes at the onset of noise, but this response diminished within one week. Wale (2013b) found evidence of changes in foraging and predator avoidance behaviours in shore crabs exposed to ship noise. Recent studies noted that fish and invertebrates may become habituated to noise from vessel traffic over relatively short periods of time, i.e., weeks (Spiga et al. 2012a; Wale et al. 2013a) and that long-term exposure to boat noise did not influence fish growth and survival (Spiga et al. 2012b).

Published literature suggests marine fish may temporarily change their behaviour in response to underwater noise associated with shipping, but these activities are unlikely to result in large-scale displacement of populations from foraging, spawning, rearing, or migration habitat or otherwise affect population viability. Change in behaviour of fish due to underwater noise from shipping is expected to be low magnitude. The effect will be limited to the shipping LSA (sound will dissipate with distance from the vessels), long-term in duration (construction, operation, and decommissioning phases), a multiple regular event, and reversible (i.e., within a few minutes of the vessel passing), with fish populations having a high resilience to underwater noise.

Marine mammals exhibit a variety of responses to underwater noise (Nowacek et al. 2007), such as stress-induced physiological changes (e.g., Rolland et al. 2012; Southall et al. 2007); altered sound perception and impaired communication (e.g., Castellote et al. 2012; Merchant et al. 2014; Risch et al. 2012; Williams et al. 2013a); and avoidance behaviours, which may disrupt migration (Southall et al. 2007) or foraging patterns (e.g., Sundermeyer et al. 2012; Tougaard et al. 2012).

The occurrence and extent of behavioural changes also vary widely because species and individuals show different sensitivities to sounds across varying frequency ranges (Kastelein et al. 2012; Richardson et al. 1995; Southall et al. 2007). Borggaard et al. (1999) found humpback and minke whales distance themselves from the noise of shipping vessels and Tyack (2008) discussed a case where grey whales appeared to abandon an area where they were exposed to chronic shipping noise and returned several years after activity stopped. In contrast, Croll et al. (2001) found that foraging fin and blue whales off the coast of California had no responses to loud anthropogenic noise at the scales examined. Consequently, behavioural reactions to anthropogenic sounds are more difficult to predict than thresholds for auditory damage (Southall et al. 2007).

Based on a literature review, field studies and modelling results, several marine mammal species are expected to be present along the marine access route and in the northern end of Kitimat Arm near the marine terminal. Humpback whales, Bigg’s and northern resident killer whales, Dall’s porpoise, harbour porpoise, Pacific white-sided dolphins, harbour seals and Steller sea lions are most likely to be exposed to underwater noise from either berthing or shipping. Fin whales, grey whales, and minke whales are less likely to be exposed to underwater noise from berthing, but are expected to be present along the marine access route.

A stationary animal next to the marine access route would be exposed to underwater noise above the behavioural disruption threshold from the vessel for approximately 40 minutes to 108 minutes if the vessel were travelling at 12 knots; and between 28 minutes and 62 minutes if the vessel were travelling at 10 knots (exact exposure times vary by location)[1]. At 10 knots, the spatial extent over which sounds from the LNG carriers exceed the behavioural disruption threshold would be reduced, in certain areas by as much as 60% (Stantec Consulting Ltd. 2014a). Table 5.8-12 summarizes acoustic modelling results of the spatial extent of underwater noise for berthing and transiting vessels (including tugs), using the radius that includes 95% of all values above the behavioural disruption thresholds for LNG carriers travelling at 12 knots and 10 knots. Modelled results also predict that noise above the Southall et al. (2007) injury thresholds would not be produced by vessels travelling at either speed (Stantec Consulting Ltd. 2014a). These estimates assume stationary mammals; because marine mammals will be moving, the values are likely overestimates of conditions that would occur.

Table 5.8-12: Estimated Radius Exceeding Behavioural Disruption Thresholds for Marine Mammals during Berthing and Transiting of LNG Carriers

Behavioural Disruption Threshold	Vessel Speed	Radius (R95%) of Threshold Exceedance (in km) by Modelling Scenario				
		Douglas Channel	Wright Sound	Nepean Sound	Browning Entrance	LNG Carrier Berthing with 3 Tugs
120 dB re 1 µPa[a]	12 knots	10.7	10.3	7.5	19.9	14.2
	10 knots	4.3	4.3	4.3	9.5	
	Difference (% reduction)	6.4 (60%)	6.0 (58%)	3.2 (43%)	10.4 (52%)	
57 dB re $HT_{killer\ whale}$[b]	12 knots	4.9	5.0	4.9	4.2	4.0
	10 knots	3.3	3.3	3.6	2.9	
	Difference (% reduction)	1.6 (33%)	1.7 (34%)	1.3 (27%)	1.3 (31%)	

NOTES:
$R_{95\%}$ (the radius that includes 95% of the sound produced above the behavioural disruption threshold) values from Stantec Consulting Ltd. (2014a)
Sources: [a]NOAA (2013a), [b]MacGillivray et al. (2012)

[1] Time of exposure calculated using: $R_{95\%}$ * 2/vessel speed in m/s.

To assess potential changes in behaviour of marine mammals, the most conservative results of acoustic modelling are used:

- Conclusions are based on the NOAA (2013a) behavioural disruption threshold for all species, including killer whales, because these result in the more conservative radii (larger radii) of potential effects
- The most conservative radius estimated for the confined channels (i.e., Douglas Channel, Wright Sound, and Nepean Sound) is used to determine the zone of influence and applied to the whole marine access route south of Browning Entrance (i.e., 10.7 km and 4.3 km for LNG carriers travelling at 12 and 10 knots, respectively)
- The zone of influence in the area north of Browning Entrance is considered separately: noise above the behavioural disruption threshold is assumed to extend 19.9 km from the vessel at 12 knots and 9.4 km at 10 knots. Because both radii extend beyond the edge of the shipping RSA in this area, the number of animals potentially exposed to noise above the NOAA behavioural disruption threshold is considered to be the total modelled estimate of abundance for each species.

Table 5.8-13 presents modelling results for the estimated average number of marine mammals (by species) occurring within the area that exceeds the behavioural disruption threshold, either near the marine terminal during berthing or within the zone of influence along the marine access route. Only those species with sufficient sightings (Buckland et al. 2001) during field studies could be modelled and compared to areas exceeding the behavioural disruption threshold. Species that could not be modelled are still considered in this assessment by using available data. The abundance of each species in BC is also listed, as reported in DFO Management Plans or COSEWIC reports where available, or from average abundance estimates from Best and Halpin (2011).

Table 5.8-13: Estimated Average Number of Individuals Potentially Exposed to Sound above the Behavioural Disruption Threshold during Berthing and Transiting of LNG Carriers

Scenario		Winter	Spring	Early Summer	Mid-summer	Late Summer	Fall	BC Abundance
Humpback Whale								
Berthing	–	–	–	–	–	–	1	1,428–3,856[1]
Shipping (Confined Channels)	12 knots	–	–	10	31	79	37	
	10 knots	–	–	6	17	47	22	
Shipping (Triple Island/Browning Entrance)	12 or 10 knots	–	94	52	36	111	36	

Scenario		Winter	Spring	Early Summer	Mid-summer	Late Summer	Fall	BC Abundance
Fin Whale								
Berthing	–	–	–	–	–	–	–	274–395[2]
Shipping (Confined Channels)	12 knots	–	–	–	4	3	–	
	10 knots	–	–	–	2	2	–	
Shipping (Triple Island/Browning Entrance)	12 or 10 knots	–	–	–	–	–	–	
Pacific white-sided dolphin								
Berthing	–	57	–	–	–	–	–	16,522–29,721[2]
Shipping (Confined Channels)	12 knots	589	–	–	–	–	–	
	10 knots	386	–	–	–	–	–	
Shipping (Triple Island/Browning Entrance)	12 or 10 knots	–	–	7	–	–	–	
Dall's porpoise								
Berthing	–	3	1	–	3	–	3	4,638–6,064[2]
Shipping (Confined Channels)	12 knots	98	29	61	106	26	112	
	10 knots	96	28	57	86	19	98	
Shipping (Triple Island/Browning Entrance)	12 or 10 knots	–	–	33	103	39	59	
Harbour porpoise								
Berthing	–	–	–	1	–	–	–	4,885–13,401[2]
Shipping (Confined Channels)	12 knots	–	–	18	6	4	1	
	10 knots	–	–	12	3	2	1	
Shipping (Triple Island/Browning Entrance)	12 or 10 knots	–	–	12	–	–	–	
Harbour seal[a]								
Berthing	–	22	13	29	63	21	24	105,000[3]
Shipping (Confined Channels)	12 knots	74	60	219	416	260	145	
	10 knots	63	47	158	326	195	116	
Shipping (Triple Island/Browning Entrance)	12 or 10 knots	–	7	36	33	40	29	

Scenario		Winter	Spring	Early Summer	Mid-summer	Late Summer	Fall	BC Abundance
Steller sea lion[a]								
Berthing	–	5	14	–	–	–	–	20,000–28,000[4]
Shipping (Confined Channels)	12 knots	16	64	3	3	4	7	
	10 knots	15	56	2	2	2	3	
Shipping (Triple Island/Browning Entrance)	12 or 10 knots	–	317	352	283	671	464	

NOTES:

– modelled relative abundance not calculated due to less than three sightings during the time period

Values are rounded up to the nearest whole number.

Time periods coincide with marine mammal field surveys. Winter: Jan. 28 – Feb. 20, Spring: March 26 – April 24, Early summer: June 1 – June 25, Mid-summer: July 2 – July 27, Late summer: Aug. 2 – Aug. 27, Fall: Oct. 2 – Oct. 29.

[a] Includes in water and hauled out relative abundance

Minke whales, grey whales, Bigg's and northern resident killer whales and sea otters are not modelled due to too few sightings during field studies.

Sources: [1] DFO (2013e), [2]Best and Halpin (2011), [3]DFO (2010a), [4]DFO (2010b), marine mammal abundance estimates from modelled results and acoustic modelling in Stantec Consulting Ltd. (2014a).

LNG carrier berthing at the marine terminal could result in changes in behaviour of relatively few marine mammals (including species at risk) when compared to BC abundances. Estimates for harbour seals and Pacific white-sided dolphins show the highest number of individuals potentially exposed (63 and 57 individuals, respectively) (Table 5.8-13). This is largely due to modelled distributions, which indicate there are lower numbers of marine mammals in Kitimat Arm and the facility RSA than in other areas of the shipping RSA (Stantec Consulting Ltd. 2014a). As previously noted, killer whale abundance within the facility or shipping RSA could not be modelled due to the low number of sightings during the field season. *Threatened* or *endangered* species (i.e., humpback whales, Bigg's and northern resident killer whales, and fin whales) are also not as likely to be within the areal extent of noise above the behavioural disruption threshold from LNG carrier berthing. October is the peak time for humpback whales in Kitimat Arm and Douglas Channel (Stantec Consulting Ltd. 2014a), with an average of five individuals, one of which is modelled to be exposed to underwater noise above the behavioural disruption threshold during LNG carrier berthing. The 2010 (most recent) publicly available annual census estimates there are 261 northern resident killer whales in BC waters (Ellis et al. 2011). Relative to other nearby areas, the area where the behavioural disruption threshold is expected to be exceeded during berthing is not considered an area of particularly high use by killer whales; DFO has identified an Important Area for killer whales beginning at the base of Douglas Channel and extending around Gil Island and potential northern resident killer whale critical habitat located around Gil Island (Figures 5.8-6 and 5.8-7) (Ford 2006; Clarke and Jamieson 2006a). It is not known how many Bigg's and northern resident killer whales could be exposed to noise above the threshold but, given the location and low number of reported sightings in this area, it is likely that, at most, a few individuals would be in or near areas where the sound would exceed 120 dB re µPa during any particular berthing event. Based on their known distribution and sightings records, fin whales are not expected to be within the facility RSA or in the area where noise exceeds the behavioural disruption threshold from berthing.

A reduction in vessel speed (Mitigation 5.8-12) limits the spatial extent over which noise exceeds the behavioural disruption thresholds; this reduces the number of marine mammals that could experience noise that potentially results in behavioural changes and the amount of time the animals are exposed. While some marine mammals are likely to experience temporary behaviour change as a result of transiting LNG carriers and tugs, these numbers are low compared to estimates of total population size in BC for species listed in Table 5.8-13 and for *threatened* humpback whales and fin whales. Marine mammal abundance varies by species, area, and season, and some species will occur outside the zone of influence along the marine access route. For example, modelled fin whale distributions in the shipping RSA suggest areas of high use in Caamaño Sound and the southern portion of Squally Channel (Stantec Consulting Ltd. 2014a), which do not fall along the marine access route. Given that underwater noise dissipates with distance from the source, it is estimated that few individual fin whales are expected to be exposed to noise that could cause changes in behaviour (Table 5.8-12). Other species, such as humpback whales, will have higher abundance in areas along the marine access route, primarily in Squally Channel. With reduced speeds (e.g., to 10 knots), the estimated number of humpback whales exposed to noise above the NOAA behavioural disruption threshold in the confined channels (including in humpback whale critical habitat) decreases by approximately 40% compared to LNG carriers travelling at 12 knots (Table 5.8-13). Best and Halpin (2011) predicted areas of higher killer whale abundance in Estevan Sound and Caamaño Sound than in the rest of the shipping RSA. The area above the behavioural disruption threshold overlaps with potential northern resident killer whale critical habitat (Figure 5.8-6) through Otter Channel and the northern end of Squally Channel. The zone of influence, with LNG carriers travelling at 10 knots, overlaps with potential northern resident critical habitat for 192 km^2. However, as previously discussed, it was not possible to estimate the number of killer whales that might occur within the area above the behavioural disruption threshold from shipping.

Even with mitigation, there is a high likelihood that marine mammals will be exposed to noise above behavioural disruption thresholds from vessel berthing and shipping. Recovery strategies for humpback whales (DFO 2013d) and northern resident killer whales list increased underwater noise from vessel traffic as a concern within critical habitat, with unknown potential effects (DFO 2011). Acoustic disturbance is also listed as a threat for fin whales (COSEWIC 2005). There are few studies of behavioural effects on humpback whales from underwater noise; however, Frankel and Clark (1998) and Baker and Herman (1989) reported subtle responses. Williams et al. (2013b) reported subtle responses in northern resident killer whales to large vessel presence and also found the whales can spend less time feeding in the presence of vessels. Currently, these studies cannot make a clear link between behavioural disruptions from underwater noise and subsequent effects on populations, although Lusseau and Bejder (2007) reported long-term consequences on marine mammal populations from whale watching vessels.

Communication space has also been studied for humpback whales, fin whales and killer whales in areas that overlap with the shipping RSA (Williams et al. 2013a). Ambient noise was much quieter in the shipping RSA than in other areas of the BC coast (e.g., Haro Strait), with current underwater noise conditions in Kitimat Arm having no effect on communication space for humpback whale, fin whale and killer whale. In ambient conditions, humpback whales have a 50% loss in expected communication space in Kitkiata Inlet and Triple Island and killer whales have a 0% to 25% loss of expected communication space near Triple Island, as a result of current underwater noise conditions in the area. The increase in underwater noise due to shipping could contribute to loss in communication space for these species because sound produced by vessels transitingand berthing would be audible over large distances.

Research suggests that marine mammals exposed to sound that could disturb behaviour do recover or return to normal behaviour once the noise ceases (Southall et al. 2007). Therefore, it is anticipated that individuals exposed to underwater noise above the threshold may be disturbed on a regular frequency (twice per day from LNG carriers, once during each vessel transit) while the animals are present in the shipping RSA. The residual effect is considered to be long-term in duration (throughout operation), reversible, and moderate in magnitude for most marine mammal species (measurable change above baseline and recommended thresholds but with no likely effect on viability of populations). This is largely due to the effectiveness of decreasing speeds, which decreases the extent of noise above recommended thresholds, as well as the potential for animals to be exposed to that noise for short periods (28 minutes to 62 minutes, twice daily). For most marine mammals present within the shipping RSA, the estimated number of individual exposures within a species is low compared to abundance along the BC coast. The potential for residual effects on Bigg's and northern resident killer whales is more difficult to assess due to the higher uncertainty about the number of individuals that could experience change in behaviour from underwater noise, combined with their small population size, although it is expected that few individuals will be affected. Therefore, a low confidence in the moderate magnitude of the effects on killer whales is appropriate, given that potential high magnitude effect that could affect population viability cannot be ruled out.

The context for change in behaviour is moderate resiliency because of the uncertainty in the relationship between behavioural change and population level effects and the time frame needed for recovery from behavioural effects.

5.8.6.2.4 Determination of Significance for Change in Behaviour of Fish or Marine Mammals

With mitigation, there is a moderate likelihood that underwater noise from shipping activities will result in a change in behaviour of fish that support or are part of CRA fishery species and fish species at risk. The change in behaviour of fish is anticipated to be low magnitude (measurable change from existing baseline conditions, but will not affect viability of populations); long-term (will continue through all phases); and reversible (fish behaviour is expected to recover to existing baseline conditions following vessel transit). Temporary changes in behaviour of a limited number of individual fish in locations in the shipping LSA will not affect the viability of fish populations that support or are part of CRA fisheries, or fish species at risk. Consequently, change in behaviour of fish from shipping activities is assessed as not significant.

Shipping activities have a high likelihood of residual effects on behaviour in marine mammals. With mitigation, the areal extent of noise that could cause changes in behaviour will be reduced, but could still extend 4.3 km to 9.5 km from an LNG carrier during transit along the marine access route, and up to 14.2 km from LNG carriers during berthing activities. The effects are expected to be long term (i.e., will continue through all phases) in the shipping RSA. The magnitude is moderate for most species because behavioural thresholds will be exceeded within the shipping RSA, but behavioural changes are not expected to affect the ongoing viability of the populations (including species at risk). There is low confidence in the magnitude for change in behaviour for Bigg's and northern resident killer whales due to the lack of information on how many animals would be exposed to noise above the behavioural disruption threshold and how this could affect the population. Considering the number of individual animals potentially exposed to noise levels high enough to induce behaviour change, the BC population estimates and SARA status, and the transient nature of the exposure, effects of shipping are estimated as unlikely to affect population viability of marine mammals in the facility or shipping RSA (including species at risk). With the mitigation measures, the overall degree and extent of effects from underwater noise will be reduced; therefore, change in behaviour from underwater noise and pressure waves from shipping is assessed as not significant.

Project activities and works ranked as 1 in Table 5.8-6 in Section 5.8.4.1 are summarized as follows:

- During operation, the presence of LNG carriers along the marine access route or at the marine terminal on behaviour of fish is expected to be a temporary avoidance of the vessel and possibly the surface waters immediately surrounding the vessel.
- The area disturbed by an LNG carrier will be small at any time compared to total volume of pelagic habitat available to fish in the shipping RSA.

5.8.6.3 Summary of Project Residual Effects from Shipping

With implementation of mitigation measures, residual effects from shipping are not anticipated to affect the ongoing viability of marine fish or marine mammal populations (including species at risk), or to cause harm to *endangered* or *threatened* species. Mitigation measures will reduce the change in behaviour of fish and marine mammals due to underwater noise or pressure waves. Overall, residual effects from shipping are expected to be low to moderate in magnitude, long-term in duration, extend through the shipping RSA, and to be reversible. Residual effects on marine resources from shipping are assessed as not significant.

5.8.7 Summary of Project Residual Effects

The residual effects of the Project on the marine resources from the LNG facility and from shipping are summarized in Table 5.8-14. Due to differences in the way Project activities interact with the key components of the marine resources (i.e., marine fish and fish habitat, marine mammals), some residual effects are characterized differently for marine fish and for marine mammals. In such instances, Table 5.8-14 shows the range of characterizations.

Project residual effects on Schedule 1 SARA listed species from the LNG facility and shipping are summarized in Table 5.8-15. Section 79 of SARA requires assessment of the adverse effects of a proposed project on any species listed in Schedule 1, and for measures to be taken to avoid or lessen those effects, and to monitor them. All measures must be consistent with any recovery strategies or action plans in place for the species. Table 5.8-15 specifically identifies all species that are identified under Schedule 1 of SARA and provides a summary of the predicted residual effects for these species. In all cases the residual effects of the Project are predicted to be not significant.

Table 5.8-14: Summary of Project Residual Effects: Marine Resources

Project Phase	Mitigation Measures	Residual Effects Rating Criteria						Likelihood of Residual Effects	Significance	Prediction Confidence	Follow-up and Monitoring
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context				
Facility Works and Activities											
Change in Fish Habitat: Construction (dredging and installation of marine infrastructure) and decommissioning activities will affect the amount and quality of fish habitat.											
Construction	Mitigation 5.7-8 Mitigation 5.8-1 Mitigation 5.8-2 Mitigation 5.8-3 Mitigation 5.8-4 Mitigation 5.8-5	N	RSA	ST	MR	R	L–H	H	N	H	No follow-up programs are proposed for marine resources.
Operation		N	PF	LT	MI	R	H	H	N	H	
Decommissioning		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Residual effects for all phases		N	RSA	ST–LT	MI–MR	R	L–H	H	N	H	
Change in Fish Health at the LNG Facility as a Result of Toxicity: During construction, dredging will disturb sediment that contains existing contaminants (PAHs).											
Construction	Mitigation 5.8-2 Mitigation 5.8-6 Mitigation 5.8-7 Mitigation 5.8.-8 Mitigation 5.8-9 Mitigation 5.8-4	L	LSA	ST	S	R	H	H	N	H	No follow-up programs are proposed for marine resources.
Operation		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Decommissioning		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Residual effects for all phases		L	LSA	ST	S	R	H	H	N	H	
Harm to Fish or Marine Mammals: Construction, dredging and other activities could result in burial, crushing or desiccation of fish and pile installation could create noise or pressure waves that injure or kill fish or marine mammals.											
Construction	Mitigation 5.8-2 Mitigation 5.8-10	N–M	LSA–RSA[a]	ST	MR	R	L–H	M–H	N	M-H	No follow-up programs are proposed for marine resources.
Operation	Mitigation 5.8-6	N	PF	LT	MI	R	H	H	N	H	
Decommissioning	Mitigation 5.8-11	N	LSA	ST	MR	R	L–H	H	N	H	

Project Phase	Mitigation Measures	Residual Effects Rating Criteria: Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context	Likelihood of Residual Effects	Significance	Prediction Confidence	Follow-up and Monitoring
Residual effects for all phases	Mitigation 5.8-4 Mitigation 5.8-8 Mitigation 5.8-7 Mitigation 5.8-3	N–M	LSA–RSA	S–L	I–R	R	L–H	M–H	N	M–H	
Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressure Waves: Construction-related noise may affect behaviour.											
Construction	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-3	L–M	RSA	LT	MI	R	M–H	M–H	N	M–H	No follow-up programs are proposed for marine resources.
Operation		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Decommissioning		L–M	RSA	ST	MR	R	M–H	M–H	N	M–H	
Residual effects for all phases		L–M	RSA	ST-LT	MI-MR	R	M–H	M–H	N	M–H	
Shipping Activities											
Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressure Waves: Vessel noise during berthing and transit may affect behaviour of fish or marine mammals.											
Construction	Mitigation 5.8-12	L-M	LSA–RSA	ST	MR	R	M–H	M–H	N	M	No follow-up programs are proposed for marine resources.
Operation		L–M	LSA–RSA	LT	MR	R	M–H	M–H	N	L–M	
Decommissioning		L	LSA–RSA	ST	MR	R	H	M	N	M	
Residual effects for all phases		L–M	LSA–RSA	ST–LT	MR	R	M–H	M–H	N	L–M	

KEY

MAGNITUDE:

N = Negligible—no detectable or measurable change from existing baseline conditions

L = Low—a measurable change from existing baseline conditions but is below environmental and/or regulatory thresholds and does not affect the ongoing viability of fish or marine mammal populations

M = Moderate—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds but does not affect the ongoing viability of fish or marine mammal populations

H = High—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds and adversely affects the ongoing viability of fish and marine mammal populations

GEOGRAPHIC EXTENT:

PF = Project footprint—residual effects are restricted to the marine terminal footprint

LSA—residual effects extend into the LSA

RSA—residual effects extend into the RSA

DURATION:

ST = Short-term—residual effect restricted to Project construction and/or decommissioning phases and is predicted to return to existing baseline conditions with no lasting effect

MT = Medium-term—residual effect continues for up to two years following Project construction phase before returning to existing baseline conditions

LT = Long-term—residual effect continues for more than two years after the Project construction phase, or continues during Project operation and decommissioning phases, before returning to existing baseline conditions

P = Permanent—residual effect is unlikely to return to existing baseline conditions

FREQUENCY:

S = Single event—occurs once

MI = Multiple irregular event—occurs sporadically at irregular intervals

MR = Multiple regular event— occurs on a regular basis and at regular intervals

C = Continuous—occurs continuously throughout the life of the Project

REVERSIBILITY:

R = Reversible—effect will recover to existing baseline conditions after decommissioning phase or sooner

I = Irreversible—effect is permanent

CONTEXT:

L = Low resilience—low capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

M = Moderate resilience—moderate capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

H = High resilience—high capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

SIGNIFICANCE:

S = Significant

N = Not Significant

PREDICTION CONFIDENCE:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation, and assumptions made.

L = Low level of confidence

M = Moderate level of confidence

H = High level of confidence

LIKELIHOOD OF RESIDUAL EFFECT OCCURRING:

Based on professional judgment

L = Low likelihood that there will be a residual effect

M = Moderate likelihood that there will be a residual effect

H = High likelihood that there will be a residual effect

N/A = Not Applicable

NOTES:

[a] Residual effects extend into the facility RSA as a result of location of proposed disposal at sea sites.

Table 5.8-15: Schedule 1 Listed Species Potentially Occurring in the Marine Resources Facility and Shipping LSA

Common Name	Scientific Name	SARA - Schedule 1 Status	Species Habitat	Potential seasonal occurrence[a]	Likely Present in Facility LSA	Likely Present in Shipping LSA	Potential Project Effects					Mitigation Measures	Significance of Residual Effects	Accordance with Recovery Strategy and/or Action Plan
							Change in fish habitat	Harm to fish or marine mammals	Change in fish health as a result of toxicity	Change in behaviour of fish or marine mammals due to pressure waves of underwater noise (Facility)	Change in behaviour of fish or marine mammals due to pressure waves of underwater noise (Shipping)			
Marine Fish														
Blunt Nose sixgill shark	*Hexanchus griseus*	*special concern*	Present throughout Canada's Pacific waters, including inlets	Year Round	Yes	Yes	No	No	No	Yes	Yes	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-3 Mitigation 5.8-12	Not Significant	No recovery strategy or action plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.
Green sturgeon	*Acipenser medirostris*	*special concern*	Coastal marine waters, estuaries and lower reaches of large rivers. Habitat subtypes include: eelgrass beds, kelp beds, intertidal, and subtidal, pelagic, reefs, and sheltered marine waters.	Year Round	Yes	Yes	Yes	No	No	Yes	Yes	Mitigation 5.7-8 Mitigation 5.8-1 Mitigation 5.8-2 Mitigation 5.8-3 Mitigation 5.8-4 Mitigation 5.8-5 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-12	Not Significant	No recovery strategy or action plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.
Longspine thornyhead	*Sebastolobus altivelis*	*special concern*	Present in deep waters along the along the continental slope in Canada's Pacific waters	Year Round	No	Yes	No	No	No	No	Yes	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-3 Mitigation 5.8-12	Not Significant	No recovery strategy or action plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.
Northern abalone	*Haliotis kamtschatkana*	*endangered*	Found along exposed and semi-exposed rocky coastlines throughout BC	Year Round	No	Yes	No	No	No	No	No	n/a	Not Significant	A finalized action plan exists for the species (DFO 2012). No predicted residual effects on Northern abalone or their habitat.
Olympia oyster	*Ostrea conchaphila*	*special concern*	Found in the lower intertidal and shallow subtidal zones of sheltered bays and estuaries	Year Round	No	Possible	No	No	No	No	No	n/a	Not Significant	No recovery strategy or action plan exists for this species. It is unlikely that Olympia oyster or its habitat would be affected by residual Project activities.

Common Name	Scientific Name	SARA - Schedule 1 Status	Species Habitat	Potential seasonal occurrence[a]	Likely Present in Facility LSA	Likely Present in Shipping LSA	Potential Project Effects: Change in fish habitat	Harm to fish or marine mammals	Change in fish health as a result of toxicity	Change in behaviour of fish or marine mammals due to pressure waves of underwater noise (Facility)	Change in behaviour of fish or marine mammals due to pressure waves of underwater noise (Shipping)	Mitigation Measures	Significance of Residual Effects	Accordance with Recovery Strategy and/or Action Plan
Rougheye rockfish	*Sebastes sp. type I and type II*	*special concern*	Present along the continental slope in Canada's Pacific waters	Year Round	No	Yes	No	No	No	No	Yes	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-3 Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-11 Mitigation 5.8-4 Mitigation 5.8-8 Mitigation 5.8-7 Mitigation 5.8-12	Not Significant	No recovery strategy or action plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.
Tope (soupfin shark)	*Galeorhinus galeus*	*special concern*	Occur in Canada's Pacific continental shelf waters	Year Round	No	Yes	No	No	No	No	Yes	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-3 Mitigation 5.8-12	Not Significant	No recovery strategy or action plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.
Yelloweye rockfish	*Sebastes ruberrimus*	*special concern*	Present throughout BC coastal waters, including enclosed waters and inlets, in areas with hard substrate	Year Round	Yes	Yes	Possible	Yes	No	Yes	Yes	Mitigation 5.7-8 Mitigation 5.8-1 Mitigation 5.8-2 Mitigation 5.8-3 Mitigation 5.8-4 Mitigation 5.8-5 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-11 Mitigation 5.8-8 Mitigation 5.8-7 Mitigation 5.8-12	Not Significant	No recovery strategy or action plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.

Common Name	Scientific Name	SARA - Schedule 1 Status	Species Habitat	Potential seasonal occurrence[a]	Likely Present in Facility LSA	Likely Present in Shipping LSA	Potential Project Effects: Change in fish habitat	Harm to fish or marine mammals	Change in fish health as a result of toxicity	Change in behaviour of fish or marine mammals due to pressure waves of underwater noise (Facility)	Change in behaviour of fish or marine mammals due to pressure waves of underwater noise (Shipping)	Mitigation Measures	Significance of Residual Effects	Accordance with Recovery Strategy and/or Action Plan
Marine Mammals														
Humpback whale	*Megaptera Novaeangliae*	*threatened*	Open ocean and coastal waters	Year round	Yes	Yes	N/A	Yes	N/A	Yes	Yes	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-11 Mitigation 5.8-4 Mitigation 5.8-8 Mitigation 5.8-7 Mitigation 5.8-3 Mitigation 5.8-10 Mitigation 5.8-12	Not Significant	No action plan exists for this species. Mitigation measures are consistent with *Recovery Strategy for the North Pacific Humpback Whale (Megaptera novaeanglia) in Canada (DFO 2013).*
Fin whale	*Balaenoptera physalus*	*threatened*	Open ocean and coastal waters	Summer	No	Yes	N/A	No	N/A	No	Yes	Mitigation 5.8-12	Not Significant	Mitigation measures are consistent with *Draft Partial Action Plan for Blue, Fin, Sei and North Pacific Right Whales (Balaenoptera musculus, B. physalus, B. borealis, and Eubalaena japonica) in Pacific Waters* (DFO 2013) and *Recovery Strategy for Blue, Fin, and Sei Whales (Balaenoptera musculus, B. physalus, and B. borealis) in Pacific Canadian Waters* (Gregr et al. 2006).
Grey whale	*Eschrichtius robustus*	*special concern*	Open ocean and coastal waters	Spring	No	Unlikely	N/A	No	N/A	No	Yes	Mitigation 5.8-12	Not Significant	No Recovery Strategy or Action Plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.
Northern resident killer whale	*Orcinus orca*	*threatened*	Open ocean and coastal waters	Summer	Yes	Yes	N/A	Yes	N/A	Yes	Yes	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-11 Mitigation 5.8-4 Mitigation 5.8-8 Mitigation 5.8-7 Mitigation 5.8-3 Mitigation 5.8-10 Mitigation 5.8-12	Not Significant	Mitigation measures are consistent with *Recovery Strategy for the Northern and Southern Resident Killer Whales (Orcinus orca) in Canada* (DFO 2011) and the *Draft Action Plan*, which has just completed a public consultation process.

Common Name	Scientific Name	SARA - Schedule 1 Status	Species Habitat	Potential seasonal occurrence[a]	Likely Present in Facility LSA	Likely Present in Shipping LSA	Potential Project Effects					Mitigation Measures	Significance of Residual Effects	Accordance with Recovery Strategy and/or Action Plan
							Change in fish habitat	Harm to fish or marine mammals	Change in fish health as a result of toxicity	Change in behaviour of fish or marine mammals due to pressure waves of underwater noise (Facility)	Change in behaviour of fish or marine mammals due to pressure waves of underwater noise (Shipping)			
Bigg's killer whale	*Orcinus orca*	*threatened*	Open ocean and coastal waters	Year round	Yes	Yes	N/A	Yes	N/A	Yes	Yes	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-11 Mitigation 5.8-4 Mitigation 5.8-8 Mitigation 5.8-7 Mitigation 5.8-3 Mitigation 5.8-10 Mitigation 5.8-12	Not Significant	No action plan exists for this species. Mitigation measures are consistent with *Recovery Strategy for the Transient Killer Whale (Orcinus orca) in Canada* (DFO 2007).
Harbour porpoise	*Phocoena phocoena*	*special concern*	Open ocean and coastal waters	Year round	Yes	Yes	N/A	Yes	N/A	Yes	Yes	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-11 Mitigation 5.8-4 Mitigation 5.8-8 Mitigation 5.8-7 Mitigation 5.8-3 Mitigation 5.8-12	Not Significant	No recovery strategy or action plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.
Steller sea lion	*Eumetopias jubatus*	*special concern*	Open ocean and coastal waters	Year round	Yes	Yes	N/A	Yes	N/A	Yes	Yes	Mitigation 5.8-2 Mitigation 5.8-10 Mitigation 5.8-6 Mitigation 5.8-11 Mitigation 5.8-4 Mitigation 5.8-8 Mitigation 5.8-7 Mitigation 5.8-3 Mitigation 5.8-12	Not Significant	No recovery strategy or action plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.
Sea otter	*Enhydra lutris*	*special concern*	Coastal waters	Year round	No	Yes	N/A	No	N/A	No	Yes	Mitigation 5.8-12	Not Significant	No recovery strategy or action plan exists for this species. Mitigation measures (see previous column) are expected to address any residual effects.

5.8.8 Assessment of Cumulative Effects

Cumulative effects are considered for each Project-specific residual effect. Three stages are involved: (1) establishing context by providing an overview of the cumulative effects of other projects and activities on the VC; (2) determining the potential for Project-specific residual effects to interact with the effects of other projects and activities; and (3) if the Project does interact cumulatively with other projects and activities, assessing the significance of the resulting overall cumulative effect and characterizing the Project's contribution to the change in cumulative effects.

5.8.8.1 Stage 1, Context for Cumulative Effects

Baseline information discussed in Section 5.8.3 and the Marine Resources TDR (Stantec Consulting Ltd. 2014) indicates the shipping and facility LSAs and RSAs provide habitat for a wide range of marine fish and marine mammal species, including species at risk. Large spatial and temporal variations in fish abundance are driven in part by harvesting for CRA fisheries, variations in climatic and oceanographic conditions, stock enhancement activities, and habitat status. For example, on the north coast of BC, which includes the shipping RSA, returns for all species of Pacific salmon have declined to well below the long-term average (Hyatt et al. 2007, DFO 2013). The same trend is evident in Douglas Channel and Kitimat Arm eulachon stocks (Schweigert et al. 2007). Marine mammal abundance, particularly for whales, is notably higher outside the facility RSA than inside. Eight marine fish and invertebrate species at risk may occur in the facility RSA (Table 5.8-3) and the Kitimat River and estuary provide spawning and rearing habitat for anadromous species, including Pacific salmon and eulachon. Five marine mammal species at risk could be present within the facility RSA (Table 5.8-5). In the shipping RSA, 15 marine fish and invertebrate species and 8 marine mammal species at risk may be present (Table 5.8-3 and Table 5.8-5). Humpback whale critical habitat overlaps with the shipping RSA around Gil Island. Potential critical habitat for northern resident killer whales and DFO Important Areas for humpback whales, northern resident killer whales and fin whales also overlap with the shipping RSA.

Past and present works and activities in the facility and shipping RSAs include the RTA facility, former Methanex/Cenovus Terminal, the former Moon Bay Marina, MK Bay Marina, vessel activity associated with these marine-based projects, BC ferries, cruise ships, and forestry (log handling). These projects have affected marine resources in various ways, including loss of habitat, short-term construction activities, release of contaminants, and noise from shipping, whose effects are integrated into the baseline conditions (though it is not possible to assign these projects as causes for specific conditions). Human activity since the 1950s has resulted in loss of 6.6 km of natural shoreline habitat—most of this within the facility LSA (81% of the facility LSA and 8.7% of the facility RSA; Table 5.8-4)—and its replacement with constructed shoreline such as wharfs and riprap (BC MFLNRO 2005).

The RTA facility at the head of Kitimat Arm has been operating since the 1950s. Construction of the RTA terminal resulted in loss of marine habitat during wharf construction. The facility is a known source of contaminants in the facility RSA, through release of PAHs in air emissions and effluent discharges that have affected sediment quality in Kitimat Arm (Warrington 1987; NOAA 2009). Levels of PAHs have decreased over time (Stantec Consulting Ltd. 2014) due to upgrades at the RTA facility and inputs of clean sediment from the Kitimat River. Currently about 80 vessels visit the RTA terminal per year.

The Eurocan Pulp and Paper Company kraft mill (unbleached) operated from the late 1960s to 2010 and discharged effluent into the Kitimat River, approximately 3 km upstream from Kitimat Arm. The construction of the facility resulted in a loss of habitat, and the mill effluent contributed to adverse effects on sediment, water quality and fish health in Kitimat Arm (Warrington 1987; NOAA 2009).

The former Methanex/Cenovus Terminal is the site of the LNG Canada Project. During construction, the existing terminal infrastructure will be modified and upgraded. Construction of the original terminal resulted in loss of intertidal and subtidal habitat. Vessels carrying condensate (8 vessels per year) currently use the terminal.

The former Moon Bay Marina on the western shore of Kitimat Arm operated until 2010. Construction of the recreational marina involved loss of marine habitat, and there may be localized areas of elevated contaminants typical of a recreational marina.

The MK Bay Marina on the eastern shore of Kitimat Arm, 5.8 km from the LNG Canada facility, provides 140 berths for recreational vessels. Marina construction involved loss of marine habitat and there may be localized areas of elevated contaminants typical of a recreational marina. No further works are identified for the MK Bay Marina that would affect marine resources.

BC Ferries vessels and cruise ships transit portions of the shipping RSA, with 225 BC ferries per year (BC Ferries 2013) and 35 cruise ships per year (Cruise Line International Association 2013).

Forestry activities have occurred throughout the Kitimat River valley. Log handling facilities located in the facility RSA, including those in Minette Bay and Clio Bay, have contributed to cumulative change in fish habitat through local accumulations of logs, bark, and other woody debris on subtidal fish habitats (G3 Consulting Ltd. 2000).

Commercial fishing occurs throughout the facility and shipping LSA and RSA on a seasonal basis. Commercial crab-by-trap, groundfish, hake, squid, salmon (gillnet, seine, troll), sardine, shrimp trawl, and smelt (family Osmeridae) fisheries occur within Kitimat Arm. Additionally, sea cucumber, geoduck, herring, and red urchin fisheries occur within the shipping LSA and RSA. Commercial fishing has contributed to declines in fish abundance and fishing vessel traffic may additionally contribute to adverse behavioural change in fish and marine mammals by increasing underwater noise. No finfish or shellfish aquaculture farms occur within the LNG facility or shipping RSA.

Reasonably foreseeable projects with the potential to interact cumulatively with residual effects from the LNG Canada Project are summarized below.

The RTA Terminal A Extension Project is located adjacent to the LNG Canada Project facility. Project components include an extension of RTA Wharf “A”, replacement of a barge ramp and tug dock, and a laydown area (WorleyParsons Canada Services Ltd. 2014). The extension of RTA Wharf “A” will be immediately south of the existing wharf (see Figure 5.8-8) as a replacement facility, and there will be no net increase in shipping activities as a result of the project (WorleyParsons Canada Services Ltd. 2014). The barge ramp and tug dock will either be located on the western shore of Kitimat Arm adjacent to the existing RTA boat ramp, or be a part of the extension of RTA Wharf “A” (WorleyParsons Canada Services Ltd. 2014). In-water construction activities and dredging are planned for 2015 through 2017 and existing operations will continue during this period and beyond. Infrastructure construction is expected to affect marine resources through the same mechanisms identified for the LNG Canada Project. Dredging and marine construction will overlap with the LNG Canada Project construction phase.

The Kitimat LNG Terminal at Bish Cove, on the west shore of Kitimat Arm, is 11.6 km from the LNG Canada Project facility (BCEAO 2006). Construction is underway (planned for 2012 to 2015/2016) and operation is planned for 2015/2016 to 2040/2041. Infrastructure construction is expected to affect marine resources through the same mechanisms identified for the LNG Canada Project. Dredging and marine construction at the Kitimat LNG Terminal will likely be complete before construction begins at the LNG Canada facility. About 90 vessels per year will visit the Kitimat LNG Terminal during the operation phase.

The Enbridge Northern Gateway Project, on the western shore of Kitimat Arm, is 8.8 km from the LNG Canada facility. Construction is planned for 2015 to 2018 and operation is planned for 2018 to 2048 (Enbridge Northern Gateway Project 2010). Infrastructure construction is expected to affect marine resources through the same mechanisms identified for the LNG Canada Project. About 250 vessels per year will visit the Enbridge Northern Gateway marine terminal during the operation phase.

The Douglas Channel LNG Terminal is a small-scale LNG plant proposed for the western shore of Kitimat Arm, near Moon Bay, 5.6 km from the LNG Canada facility (DCEP 2014). The construction and operation timelines are uncertain, but are assumed to overlap with the LNG Canada Project construction phase. The terminal will consist of a floating liquefaction plant that will likely require negligible amounts of marine construction and sediment disturbance. About 13 vessels per year are anticipated to visit this terminal during the operation phase.

The LNG Canada Project construction phase will overlap spatially and temporally with construction phases of the RTA Terminal A Extension Project, Kitimat LNG Terminal, and Enbridge Northern Gateway Project and are assumed to overlap with those for the Douglas Channel LNG Terminal.

Within the shipping RSA, the majority of activities and works mentioned for the facility RSA involve shipping traffic that contributes, or will contribute to, underwater sound levels. Because the shipping LSA extends to the Triple Island Pilotage Station near Prince Rupert, additional vessel activities considered for cumulative effects are associated with BC Ferries (currently 225 vessels per year; BC Ferries 2013) and cruise ships (currently 35 vessels per year; Cruise Line International Association 2013). Vessels travelling to the port in Prince Rupert are not considered to overlap with the LNG Canada Project because they will traverse the shipping RSA for only approximately 10 km during their approach to Triple Island (the Pacific Pilotage Authority boarding station) and then proceed to Prince Rupert.

5.8.8.2 Stage 2, Determination of Potential Interactions

The potential for interactions between past, present and future activities with the Project-related effects is identified in Table 5.8-16. The potential for cumulative effects is identified through spatial and temporal overlaps of effects and activities. Activities associated with pipeline projects (Coastal GasLink Pipeline Project, Pacific Trails Pipelines Project) do not have a marine component, so they do not contribute to cumulative effects.

There are spatial and temporal overlaps of residual effects from the LNG Canada Project (including effects from activities ranked as 1 in Table 5.8-6) with effects of past, present and reasonably foreseeable projects identified in Table 5.8-16; therefore, cumulative effects are discussed further.

Table 5.8-16: Potential for Cumulative Effects on Marine Resources

Other Projects and Activities with Potential for Cumulative Effects	Potential Cumulative Effects				
	Facility and Works				Shipping
	Change in Fish Habitat (Facility RSA)	Change in Fish Health (Facility RSA)	Harm to Fish or Marine Mammals (Facility RSA)	Change in Behaviour of Fish or Marine Mammals (Facility RSA)	Change in Behaviour of Fish or Marine Mammals (Shipping RSA)
Kitimat Area Project/Facility					
Douglas Channel LNG Project (also known as BC LNG)	✓	✓	✓	✓	✓
Enbridge Northern Gateway Project	✓	✓	✓	✓	✓
Former Eurocan Pulp and Paper Co. Site	✓	✓			
Former Methanex/Cenovus Terminal	✓	✓			
Former Moon Bay Marina (footprint only)	✓	✓			
Kitimat LNG Terminal Project	✓	✓	✓	✓	✓

Other Projects and Activities with Potential for Cumulative Effects	Potential Cumulative Effects				
	Facility and Works				Shipping
	Change in Fish Habitat (Facility RSA)	Change in Fish Health (Facility RSA)	Harm to Fish or Marine Mammals (Facility RSA)	Change in Behaviour of Fish or Marine Mammals (Facility RSA)	Change in Behaviour of Fish or Marine Mammals (Shipping RSA)
MK Bay Marina	✓	✓		✓	✓
Rio Tinto Alcan Facility and Modernization Project	✓	✓	✓	✓	✓
Activities					
BC Ferries					✓
Cruise Ships					✓
Forestry Activities	✓				
Fishing and Aquaculture Activities			✓	✓	✓

NOTES:
✓ **=** 'other projects and activities' whose effects have potential to interact cumulatively with the Project's residual effects.

5.8.8.3 Stage 3, Determination of Significance for Cumulative Effects

5.8.8.3.1 Change in Fish Habitat from the LNG Facility

Project construction activities planned for 2015 to 2020 will result in change in fish habitat associated with dredging and marine construction activities; however, habitat offsetting measures will result in residual effects that are not significant and will not affect viability of marine fish populations (Section 5.8.5.2).

The intertidal and subtidal mudflat and constructed habitats (i.e., rock riprap) are anticipated to have high resilience because they are already adapted to frequent natural and human disturbances, and are expected to be colonized by marine communities in the short-term following cessation of dredging and marine construction. The salt marsh habitat and eelgrass bed that will be lost have low resilience. With implementation of the Fish Habitat Offset Plan, the total area and productive capacity of marine fish habitat for species that support or are part of CRA fisheries, such as salmon and Dungeness crab, will be maintained or increased.

Project activities and works identified as having an interaction with fish habitat ranked as 1 in Section 5.8.4.1 include release of TSS during onshore construction and decommissioning, discharge of hydrostatic test waters into marine waters, propeller wash from escort tugs and support vessels, vessel wake from shipping activities, and release of ballast water with potential for introduction of non-native species. The overall magnitude of the residual effects from these activities effects on fish habitat will be negligible. Habitat loss will be localized to the facility LSA (in an area already altered by the presence of the Methanex jetty and RTA Wharf “A” and Wharf “B”) and habitat gains through offsetting will occur. All residual effects to fish habitat, except those from dredging and disposal at sea, will be short-term (construction phase) and occur as multiple regular events. Residual effects from maintenance dredging will be long term (operation phase) and will occur as a multiple irregular event. All residual effects are reversible and are assessed as not significant.

Although the Project-caused change in fish habitat in the facility LSA is, with mitigation, assessed as not significant, it will overlap temporally with other past existing or reasonably foreseeable projects, and therefore a cumulative effects assessment is completed.

Past and current projects that resulted in changes in marine fish habitat in the facility RSA are the RTA facility, Eurocan Pulp and Paper Company kraft mill, former Methanex/Cenovus Terminal, former Moon Bay Marina, MK Bay Marina, and forestry activities. These projects also involved loss of habitat, and these losses are recognized in the presence of 6.6 km of constructed habitat in the RSA (8.7% of the facility RSA; Table 5.8-4; BC MFLNRO 2005). The majority of habitat affected is common intertidal and shallow subtidal habitat (rocky shorelines, sand and mud substrates), although some productive salt marsh habitat and eelgrass beds have also been affected. To some extent, habitat lost at the time of construction has been re-colonized by marine organisms, which often re-establish themselves on constructed substrates such as rock riprap.

Reasonably foreseeable future projects that may have spatial and/or temporal overlap during their construction phases are as follows:

- RTA Terminal A Extension Project, marine construction planned for 2015 through 2017 will likely overlap with LNG Canada Project construction; habitat offsetting measures are not known, but assumed to be required (WorleyParsons Canada Services Ltd. 2014)
- Kitimat LNG Terminal, marine construction likely to end (2015/2016); any habitat losses will be offset, as required in commitments made for that project (BCEAO 2006)
- Enbridge Northern Gateway Project, marine construction planned for 2015 to 2018 will likely overlap with LNG Canada Project construction; any habitat losses will be offset, as required in commitments made for that project (Enbridge Northern Gateway Pipeline 2010)
- Douglas Channel LNG Terminal (DCEP 2014), minimal marine construction planned (floating liquefaction plant), but timing is unknown and assumed to overlap with Project construction; habitat offsetting measures are not known, but assumed to be required, and

These reasonably foreseeable projects are likely to result in no net loss in total area or productive capacity of marine fish habitat within the facility RSA, as required under the *Fisheries Act*. This is as a result of required offsetting and other mitigation measures, similar to commitments required for the LNG Canada Project.

The cumulative effects of all past, present, and reasonably foreseeable projects on fish habitat are assessed as not significant. They are moderate in magnitude (i.e., past project may not have had offsetting although no net change expected from construction of new projects due to habitat offsetting requirements), occur in the facility RSA, are permanent (i.e., habitats permanently altered or destroyed), irreversible (although there is implementation of habitat offsetting measures), and continuous (recognizing existing footprints). Habitat in the RSA generally has high resilience, given the exposure to frequent natural and human disturbances and the ability to be recolonized in the short term by marine organisms.

Because permanent alteration and destruction of fish habitat from the LNG Canada Project activities and works can be offset through habitat creation, restoration, and enhancement measures, the Project's contribution to cumulative change in fish habitat will not adversely affect the long-term viability of populations of fish species that support or are part of CRA fisheries, or fish species at risk, and is assessed as not significant.

There is a high likelihood of negligible magnitude Project effects on fish habitat, as well as low magnitude cumulative effects of past, present, and reasonably foreseeable projects.

No residual effects of shipping activities on marine fish habitat during the Project construction, operation, and decommissioning phases are identified (Section 5.8.4.1), and no further assessment of cumulative change in fish habitat from these activities is warranted.

5.8.8.3.2 Change in Fish Health at the LNG Facility as a Result of Toxicity

Project activities and works during the construction phase are anticipated to result in a low magnitude, localized, short-term change in fish health as a result of disturbance of existing contaminants in the Project footprint (Section 5.8.5.3). Dispersed contaminants are expected to settle close to the dredge area because currents are slower in the facility LSA than elsewhere in Kitimat Arm (Bell and Kallman 1976). Removal of sediment containing elevated PAH levels from the Project footprint and facility LSA will result in a long-term net improvement in fish health due to reduced exposure to contaminants. Project activities and works identified as having an interaction with fish habitat, ranked as 1 in Section 5.8.4, are also identified and include wastewater discharges (all Project phases), release of hydrostatic test waters, propeller wash from escort tugs and support vessels at the facility, and bilge water release. With mitigation, change in fish health from the LNG facility is assessed as not significant. No residual effects of shipping activities on fish health as a result of toxicity during any phases of the Project are identified (Section 5.8.4.1), and no further assessment of cumulative change in fish health as a result of toxicity due to shipping is warranted.

Although the change in fish health as a result of toxicity is assessed as not significant, with mitigation, residual effects will overlap temporally with other past existing or reasonably foreseeable projects; therefore, a cumulative effects assessment is completed.

The main past and current project that resulted in changes in fish health and contaminant levels in the facility RSA is the RTA facility (the identified main source of PAHs in sediment, present throughout the facility RSA; Warrington 1987; NOAA 2009). The Eurocan Pulp and Paper Company kraft mill, former Methanex/Cenovus Terminal, former Moon Bay Marina, MK Bay Marina, and forestry activities may have been responsible for localized areas of contaminants. The PAHs in sediment of the Project footprint and facility LSA have been shown to have low bioavailability and low toxicity (i.e., low potential for adverse effects on health of marine organisms), as they are associated with soot particles (Paine et al. 1996, NOAA 2009).

Reasonably foreseeable future projects that may have spatial and/or temporal overlap during their construction phases (through dredging and other activities that disturb sediment and existing contaminants) are as follows:

- RTA Terminal A Extension Project, marine construction planned for 2015 through 2017 will likely overlap temporally and spatially with LNG Canada Project construction; TSS plumes from dredging for the extension of RTA Wharf “A” and construction of the barge ramp and tug dock are likely to extend to the LNG Canada facility LSA (WorleyParsons Canada Services Ltd. 2014)
- Kitimat LNG Terminal, marine construction likely to end (2015/2016) before LNG Canada Project construction begins (BCEAO 2006) so no overlap in time for sediment disturbance; no overlap in space, as sediment plume modelling conducted for the nearby Enbridge Northern Gateway terminal indicated TSS plumes would not reach the LNG Canada facility LSA (Enbridge Northern Gateway Pipeline 2010)
- Enbridge Northern Gateway Project, marine construction planned for 2015 to 2018 will likely overlap with Project construction, given that sediment plume modelling for that project indicated TSS plumes would not extend to the LNG Canada facility LSA (Enbridge Northern Gateway Pipeline 2010), and
- Douglas Channel LNG Terminal (DCEP 2014), construction assumed to overlap in time but not space with LNG Canada Project construction; the minimal marine construction planned for the floating liquefaction plant should result in localized sediment disturbance.

Of these reasonably foreseeable projects, there may be spatial and temporal overlap for the LNG Canada Project and the RTA Terminal A Extension Project because these projects will be at the head of Kitimat Arm and will involve dredging and disturbance of existing contaminants in sediment. However, requirements for mitigation of sediment disturbance will be similar for these projects. The construction phase for the RTA Terminal A Extension Project is expected to result in a low magnitude, short-term, reversible change in fish health, within the facility RSA, in an area where organisms are already exposed to similar contaminant levels. Furthermore, Kitimat LNG, Enbridge Northern Gateway, and Douglas Channel LNG projects are located away from the area of elevated PAH at the head of Kitimat Arm, as discussed in Section 5.8.3 and the Marine Resources TDR (Stantec Consulting Ltd. 2014a), where sediment disturbance would result in lower amounts of PAH dispersal compared to the LNG Canada Project and the RTA Terminal A Extension Project.

For the LNG Canada Project and past, present, and foreseeable future projects in the facility RSA, cumulative change in fish health as a result of toxicity is assessed as not significant. Effects are moderate in magnitude (above sediment guidelines but with low bioavailability and effects on marine organisms), within the facility RSA, short term, irregular, reversible (annual inputs of sediment during Kitimat River spring freshet bury the contaminants), and in an area of high resilience. The NOAA (2009) study, a comprehensive assessment of sediment contaminant levels and fish health (salmonids and flatfish) in Kitimat Arm, supports an overall determination of cumulative effects being not significant. The LNG Canada Project and RTA Terminal A Extension Project are not expected to contribute to cumulative change in fish health because there will be short-term and localized dispersal of PAHs during dredging, with an overall net benefit of removing sediment with elevated PAHs from the marine environment. Cumulative changes in fish health are not anticipated to affect the population viability of any fish species (including species at risk) or result in harm to *endangered* or *threatened* fish species.

5.8.8.3.3 Harm to Fish or Marine Mammals from the LNG Facility

Project activities and works during the construction phase are expected to result in harm to fish through underwater noise and pressure waves generated by pile installation and, through burial and crushing, exposure to elevated TSS levels, and, when the salt marsh is reclaimed, desiccation. Marine mammals have a low likelihood of being harmed by underwater noise and pressure waves, due to underwater noise above injury thresholds (Section 5.8.5.4). Mitigation measures will restrict harm to fish to a limited number of individuals (none for *endangered* or *threatened* species) relative to the total population size in the facility RSA and the residual effect is not expected to affect quality or sustainability of fish populations (including CRA fishery species and species at risk). Effects on marine mammals will be mitigated to reduce the exposure of marine mammals to underwater noise that could result in injury and the area over which harmful effects of underwater noise from pile installation will occur. This, combined with the low number of marine mammals estimated to be within the area where PTS-onset could occur, will result in few marine mammals that could be exposed to noise above the PTS threshold. The residual effect is assessed as not significant, recognizing a negligible magnitude for fish (in the facility LSA) and moderate magnitude for marine mammals (in the facility RSA), long-term duration and a multiple irregular event for dredging, and short-term duration and multiple regular events for all other Project activities, irreversible but with no effect on population levels or harm to *endangered* or *threatened* species.

It is expected the Project residual effects will contribute to cumulative effects because the residual effect is moderate in magnitude for marine mammals and effects are similar to other projects. This change is likely short-term in duration and limited to construction or decommissioning phases for all Project activities and works except dredging. Harm to fish from dredging is likely long term in duration and is expected during construction and operation phases.

Past and current projects likely to have caused harm to fish or marine mammals through dredging and marine construction activities include the RTA facility and the former Methanex/Cenovus terminal. The former Moon Bay Marina and MK Bay Marina could also have harmed fish or marine mammals during construction but it is unlikely that effects were at a similar scale to the other projects. For past and current projects, harm to fish and marine mammals ceased following construction.

Reasonably foreseeable projects are likely to include dredging and marine construction activities that result in harm to fish or marine mammals in the facility LSA and RSA through similar mechanisms as the Project (underwater noise, pressure waves, burial and crushing and exposure to elevated TSS levels) and are likely to use mitigation measures. Construction phases for the following projects are likely to have spatial and/or temporal overlap with the LNG Canada Project (duration and extent of overlap is not always known):

- RTA Terminal A Extension Project, marine construction planned for 2015 through 2017 will likely overlap spatially and temporally with LNG Canada Project construction; mitigation measures are not known, but assumed to be required (WorleyParsons Canada Services Ltd. 2014)
- Kitimat LNG Terminal, marine construction likely to end (2015/2016) before LNG Canada Project construction begins; mitigation measures will be used as required in commitments made for that project (BCEAO 2006)
- Enbridge Northern Gateway Project, marine construction planned for 2015 to 2018 will likely overlap with Project construction; mitigation to reduce harm to fish or marine mammals will be in place as required in commitments made for that project (Enbridge Northern Gateway Pipeline 2010), and
- Douglas Channel LNG Terminal (DCEP 2014), minimal marine construction planned (floating liquefaction plant) but timing unknown and assumed to overlap with LNG Canada Project construction; mitigation measures are not known, but assumed to be required.

These reasonably foreseeable projects are likely to result in harm to marine fish and marine mammals within the LNG Canada facility RSA over the short-term. However, mitigation measures to reduce harm to fish or marine mammals will be required for the other projects, similar to those committed to for the LNG

Canada Project and as required the *Fisheries Act*. In addition to past, present, and reasonably foreseeable projects, commercial fishing has adverse effects on fish abundance. Proportionally, more fish are/will be lost through harvest than through past, current, or future construction projects in the LNG Canada facility and shipping RSA. However, it is assumed that DFO conducts adequate stock assessment and management so that stocks remain ecologically viable for harvest in perpetuity.

For the LNG Canada Project, combined with past, present and foreseeable future projects in the facility RSA, cumulative harm to fish and marine mammals is assessed as not significant, and LNG Canada Project contributions will be not significant. The residual effects will be moderate in magnitude (few marine mammals and fish are expected to be affected, population viability will not be affected, no harm to *threatened* or *endangered* species), long term in duration (as a result of Project maintenance dredging), occurring as a multiple regular event during construction and decommissioning phases of all the projects. Fish and invertebrate populations in the facility LSA are expected to have high resilience and will recover from losses associated with dredging and pile driving. Cumulative effects for underwater noise could extend beyond the facility RSA during construction activities because there could be areal extents that exceed marine mammal injury thresholds, which would increase the number of marine mammals that potentially could be harmed.

Mitigation measures, such as monitoring of marine mammal exclusion zones, soft start procedures, and sound dampening methods (Mitigation 5.8-2 and 5.8-10), will be considered to reduce the potential of harm to marine mammals and fish from construction activities of the individual projects. Further mitigation for cumulative effects could be considered, such as coordination of timing of construction activities among the foreseeable projects to reduce any increases in underwater noise from pile installation.

5.8.8.3.4 Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressure Waves from the LNG Facility and Shipping

Project activities and works associated with facility construction and decommissioning are expected to result in a change in behaviour of fish and marine mammals due to underwater noise from dredging and marine construction activities (Section 5.8.5.5). Underwater noise levels are expected to exceed the marine mammal behavioural disruption threshold (NOAA 2013) up to 9.3 km from source activities (Stantec Consulting Ltd. 2014). Fish populations near Project activities are expected to have a high resilience to underwater noise and are not expected to result in a large-scale displacement of fish populations from foraging, spawning, rearing, or migration habitat or otherwise affect population viability (Section 5.8.5.5). The residual effect on fish and marine mammals is assessed as not significant, considering there is a low magnitude effect for fish and moderate magnitude effect for marine mammals, within the facility RSA; the residual effects are long term in duration (as a result of maintenance dredging), occur as multiple irregular events, and are reversible.

For Project shipping activities (Section 5.8.6), residual effects are assessed as not significant, although effects are identified as long term (through all Project phases). Shipping activities are expected to temporarily create noise above the marine mammal behavioural disruption threshold up to 14.2 km from the terminal during berthing and 4.3 km to 9.5 km from LNG carriers during transit, when travelling at 10 knots (Stantec Consulting Ltd. 2014). Although berthing-related LNG carrier movement would occur for no more than a few hours per carrier, the number of hours per year will increase as a result of increased numbers of vessels berthing in the facility RSA. Effects from LNG carrier travel depend on location of the vessel within the shipping RSA (Table 5.8-12). A stationary marine mammal would be exposed to noise above the behavioural disruption threshold for 40 minutes to 108 minutes for one vessel travelling at 12 knots, and for 28 minutes to 62 minutes for one vessel travelling at 10 knots, depending on location. For the majority of marine mammal species within the shipping RSA, there are relatively low numbers of individual exposures to noise above the threshold when compared to relative abundance of marine mammals in the shipping RSA and along the BC coast. Potential changes in behaviour for Bigg's and northern resident killer whales are more difficult to determine due to uncertainty around how many individuals are in the area and therefore could be affected by underwater noise, as well as the consequence of that effect on already small populations (Ellis et al. 2011).

It is reasonable to expect change in behaviour of fish and marine mammals from the LNG Canada Project will contribute to cumulative effects that could affect the quality or sustainability of marine resources; this contribution is expected to be adverse; however, adverse effects on population viability is not anticipated. Mitigation will reduce the numbers of marine mammals exposed to noise above the behavioural disruption threshold, with relatively few individuals exposed to noise above the threshold relative to the number of individuals in BC waters.

Past and current activities and projects likely to have caused change in fish or marine mammal behaviour include the RTA facility, RTA Modernization Project, former Methanex/Cenovus Terminal, MK Bay Marina, cruise ships and BC Ferries, which contributed underwater noise from vessel transit and berthing. Up to 348 vessels currently travel within the LNG Canada shipping RSA each year (80 for RTA and 8 for Methanex, which traverse Douglas Channel and Kitimat Arm; 225 ferries and 35 cruise ships in the shipping RSA outside of Douglas Channel). This number does not include smaller commercial and recreational boats that use MK Bay Marina. Commercial fishing vessels may have, and continue to, produce underwater noise at levels that could induce behavioural change (e.g., avoidance of noisy areas) in fish or marine mammals.

Reasonably foreseeable projects are likely to include dredging, marine construction and shipping activities that affect fish or marine mammal behaviour in the facility and shipping RSAs. The following projects are likely to have spatial and/or temporal overlap with the Project during their construction and operation phases, although the duration and extent of overlap is not always known:

- RTA Terminal A Extension Project, marine construction planned for 2015 through 2017 will likely overlap spatially and temporally with LNG Canada Project construction, and existing shipping activities will continue during this period; mitigation measures are not known, but assumed to be required (WorleyParsons Canada Services Ltd. 2014)
- Kitimat LNG Terminal, marine construction likely to end (2015/2016) before Project construction begins; operation (2015/2016 to 2040/2041) overlaps with Project operation; 90 vessels per year expected (BCEAO 2006)
- Enbridge Northern Gateway Project, marine construction planned for 2015 to 2018 will likely overlap with Project construction; operation (approximately 2018 to 2048) overlaps with Project operation; 250 vessels per year expected (Enbridge Northern Gateway Pipeline 2010), and
- Douglas Channel LNG Terminal, minimal marine construction planned (floating liquefaction plant) but timing unknown and assumed to overlap with Project construction; 13 vessels per year expected (DCEP 2014).

These reasonably foreseeable projects are likely to result in temporary and long-term changes in behaviour of fish and marine mammals within the LNG Canada facility and shipping RSA, and add an estimated maximum of 353 vessels per year to the LNG Canada shipping RSA.

Underwater noise produced by past, present and reasonably foreseeable future projects is not currently known but noise, individually and cumulatively from these projects, is expected to increase the spatial extent of potential behaviour changes of fish and marine mammals. Considering the Douglas Channel and Kitimat Arm portion of the marine access route, the current annual levels of 88 commercial shipping vessels (0.5 transits per day) plus 353 vessels annually from reasonably foreseeable projects will result in 441 vessels (2.4 transits per day) likely using the marine access route per year. The LNG Canada Project will add up to an additional 350 LNG carriers (1.9 transits per day), for a total of 791 vessels, with an equivalent of 4.3 transits per day. This is an increase in shipping traffic of approximately eight times over current levels. Approximately 50% of this increase in traffic will be attributable to the LNG Canada Project. It is assumed that vessels have similar size and speed during transit, with similar spatial and temporal extent of noise above the behavioural disruption threshold. If all vessels present within the shipping RSA were travelling at 12 knots, and created similar underwater noise levels as Project vessels, there would be noise above the behavioural disruption threshold for marine mammals within 7.5 km to 19.9 km of the vessel, 4.3 times per day, for 40 to 108 minutes each time, depending on location. Exposure would be between 28 and 62 minutes if the vessels were travelling at 10 knots, if marine mammals were within 4.3 km to 9.5 km, depending on location. This would result in the potential for marine mammals within 7.5 km to 19.9 km of the vessel to be exposed to noise exceeding the behavioural disruption threshold for 11.9% to 32.2% of the day if all vessels were travelling at 12 knots, and for 8.4% to 18.5%, within 4.3 km to 9.5 km, if all vessels were travelling at 10 knots. Cumulatively, higher traffic levels will prolong the duration and potentially increase the magnitude over which noise levels are increased in the LNG Canada shipping RSA, causing changes in fish and marine mammal behaviour.

Subject to navigational safety needs, Project mitigation includes vessel speed reduction (vessels will travel at 8 knots to 10 knots) in areas of higher marine mammal densities within the confined channels of the marine access route; between the northern end of Campania Island and the southern end of Hawkesbury Island (Mitigation 5.8-12). Other future projects have also proposed similar mitigation (i.e., Enbridge Northern Gateway Project 2010) which has the potential to reduce the number of marine mammals exposed to noise above the behavioural disruption threshold. This can potentially reduce the exposure time for marine mammals to lower percentages of the day in these areas, estimated at 9% of the day, assuming similar vessel size and speed as Project vessels.

The change in behaviour as a result of all past, present and reasonably foreseeable projects combined with the LNG Canada Project is expected to be low magnitude for fish and moderate magnitude for marine mammals because baseline conditions and thresholds will be exceeded, but are not anticipated to affect the ongoing population viability of fish or marine mammal species (including species at risk) present within the facility and shipping RSA, or to harm *threatened* or *endangered* species. The effect will be long-term in duration (throughout the construction and operation phases of the projects), frequent and reversible. There is uncertainty and low confidence in determining the level of behavioural response by the marine mammals present, including species at risk, but it is anticipated that, for most species, relatively low numbers will be affected compared to abundance estimates in BC waters. As a result, the cumulative change in behaviour of fish and marine mammals due to all past, present, and reasonably foreseeable projects combined with the LNG Canada Project are assessed as not significant, and the LNG Canada Project contributions will be not significant.

5.8.8.3.5 Additional Mitigation Measures for Cumulative Effects

Sections 5.8.5 and 5.8.6 identify mitigation measures required to reduce the potential effects of the Project: change in fish habitat, change in fish health as a result of toxicity, harm to fish or marine mammals, and change in behaviour of fish or marine mammals. These or similar types of mitigation measures will be required of present and reasonably foreseeable projects, to meet requirements of the *Fisheries Act* and SARA. As a result, there is high likelihood that the residual effects on fish and fish habitat and marine mammals will be not significant.

For the noise-related cumulative effects associated with construction (particularly pile installation) and operation (vessel traffic) of the LNG Canada Project and other projects with potential to harm or change behaviour of fish and marine mammals, there is some uncertainty about the actual behavioural responses by the marine mammals, including species at risk. Additional mitigation measures could be taken cooperatively by the industries in Kitimat Arm to avoid situations of temporal overlap by timing the periods of pile installation and vessel transits to reduce the potential for cumulatively intensifying or extending the areas of elevated sound levels. Similarly, a coordinated approach among the project proponents to development of habitat offsetting programs, in consultation with regulatory agencies, Haisla Nation and key stakeholders, would create a more comprehensive approach for restoration of habitat, building on local knowledge.

5.8.8.4 Summary of Cumulative Effects

Table 5.8-17 provides a summary and characterization of cumulative effects. Cumulative effects on fish habitat from past, present, and foreseeable future projects are assessed as low in magnitude, restricted to the facility RSA, continuous, reversible, and not significant. Due to the negligible magnitude of Project effects on fish habitat, and the low magnitude of past, present, and foreseeable project cumulative effects, the Project contribution to cumulative effects on fish habitat in the facility RSA will not adversely affect the long-term viability of populations of fish species that support or are part of CRA fisheries, or fish species at risk.

Cumulative effects on fish health are assessed as not significant and will not adversely affect the viability of fish populations (including species at risk), and it is unlikely that individual fish species at risk will be affected. Levels of contaminants at other sites in the facility RSA are likely to be similar or lower than those at the Project site, and similar mitigation measures are expected to be used for all projects. Deposition of cleaner sediment over dispersed contaminants is expected to occur at all sites.

Cumulative harm to fish or marine mammals from past, current and foreseeable future projects through construction activities is anticipated to be moderate in magnitude, because of the use of mitigation measures. These effects are assessed as short term and not significant. The Project is expected to contribute to these cumulative effects, but not substantially. The resulting cumulative effect will be moderate in magnitude, short term in duration, and not significant because the population viability of fish, marine mammals, or species at risk will not be affected, and *threatened* or *endangered* species are not expected to be harmed.

Table 5.8-17: Summary of Cumulative Effects on Marine Resources

Effect	Other Projects, Activities, and Actions	Cumulative Effects Characterization					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context
Facility Activities and Works							
Cumulative Change in Fish Habitat							
Cumulative effect with the Project and other projects, activities and actions ▪ Effects from past activities included construction that resulted in a loss of fish habitat, without current offsetting regulations. ▪ Future projects will be required to effectively offset potential effects to fish habitat.	▪ Former Eurocan Pulp and Paper Co. Site ▪ Former Methanex/Cenovus Terminal ▪ Former Moon Bay Marina (footprint only) ▪ MK Bay Marina ▪ Forestry activities ▪ Rio Tinto Alcan Facility and Kitimat Modernization Project ▪ RTA Terminal A Extension Project ▪ Kitimat LNG Terminal ▪ Enbridge Northern Gateway Project ▪ Douglas Channel LNG Terminal	M	RSA	P	C	I	H
Contribution from the Project to the overall cumulative effect ▪ Change in fish habitat associated with dredging and marine construction activities, with habitat loss localized to the facility LSA and habitat gains through offsetting in the facility RSA		N	LSA	ST–LT	MI–MR	R	L–H

Effect	Other Projects, Activities, and Actions	Cumulative Effects Characterization					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context
Cumulative Change in Fish Health as a Result of Toxicity							
Cumulative effect with the Project and other projects, activities and actions ▪ Past projects increased sediment contaminant levels in the facility RSA. ▪ Future projects will not affect population viability through requirements for mitigation of sediment disturbance and will have an overall net benefit of removing sediment with elevated PAHs from the marine environment.	▪ Former Eurocan Pulp and Paper Co. Site ▪ Former Methanex/Cenovus Terminal ▪ Former Moon Bay Marina (footprint only) ▪ MK Bay Marina ▪ Forestry activities ▪ Rio Tinto Alcan Facility and Modernization Project ▪ RTA Terminal A Extension Project ▪ Kitimat LNG Terminal ▪ Enbridge Northern Gateway Project ▪ Douglas Channel LNG Terminal	M	RSA	ST	MI	R	H
Contribution from the Project to the overall cumulative effect ▪ During construction, dredging will disturb sediment that contains existing contaminants		L	LSA	ST	S	R	H

Effect	Other Projects, Activities, and Actions	Cumulative Effects Characterization					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context
Cumulative Harm to Fish or Marine Mammals							
Cumulative effect with the Project and other projects, activities and actions ▪ Effects from past activities including construction (e.g., pile installation) and dredging. ▪ Future projects will not affect population viability through mitigation and requirements of the *Fisheries Act*.	▪ Former Eurocan Pulp and Paper Co. Site ▪ Former Methanex/Cenovus Terminal ▪ Former Moon Bay Marina (footprint only) ▪ MK Bay Marina ▪ Rio Tinto Alcan Facility and Modernization Project ▪ RTA Terminal A Extension Project ▪ Kitimat LNG Terminal ▪ Enbridge Northern Gateway Project ▪ Douglas Channel LNG Terminal ▪	M	RSA	LT	MR	R	H
Contribution from the Project to the overall cumulative effect ▪ Construction activities could result in harm to marine mammals or fish through underwater noise and pressure waves, burial or crushing during marine terminal construction, but will not affect population viability through mitigation and requirements of the *Fisheries Act*.		N–M	LSA–RSA[a]	ST–LT	MI–MR	R	L–H

Effect	Other Projects, Activities, and Actions	Cumulative Effects Characterization					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context
Cumulative Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressure Waves							
Cumulative effect with the Project and other projects, activities and actions ▪ Effects from past activities including underwater noise and pressure waves as a result of construction (e.g., pile installation) and dredging. ▪ Future projects will also result in changes in behaviour by fish or marine mammals through construction, decommissioning and dredging.	▪ Former Eurocan Pulp and Paper Co. Site ▪ Former Methanex/Cenovus Terminal ▪ Former Moon Bay Marina (footprint only) ▪ MK Bay Marina ▪ Rio Tinto Alcan Facility and Modernization Project ▪ RTA Terminal A Extension Project ▪ Kitimat LNG Terminal ▪ Enbridge Northern Gateway Project ▪ Douglas Channel LNG Terminal ▪	L–M	RSA	LT	MI	R	M-H
Contribution from the Project to the cumulative effect ▪ Project activities are expected to result in a change in behaviour of fish and marine mammals due to underwater noise.		L–M	RSA	LT	MI-MR	R	M–H

Effect	Other Projects, Activities, and Actions	Cumulative Effects Characterization					
		Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Context
Shipping Activities							
Cumulative Change in Behaviour of Fish or Marine Mammals Due to Underwater Noise or Pressure Waves							
Cumulative effect with the Project and other projects, activities and actions ▪ Past and current activities include underwater noise as a result of shipping and vessel activities. ▪ Future projects will contribute to underwater noise via increases in shipping activities.	▪ MK Bay Marina ▪ Rio Tinto Alcan Facility and Modernization Project ▪ Kitimat LNG Terminal ▪ Enbridge Northern Gateway Project ▪ Douglas Channel LNG Terminal	L–M	RSA	LT	MR	R	M-H
Contribution from the Project to the cumulative effect ▪ Shipping activities are expected to temporarily create noise above the marine mammal behavioural disruption threshold.		L–M	LSA–RSA	ST–LT	MR	R	M–H

NOTES:

[a]Residual effects extend into the facility RSA as a result of location of proposed disposal at sea sites.

KEY

MAGNITUDE:

N = Negligible—no detectable or measurable change from existing baseline conditions

L = Low—a measurable change from existing baseline conditions but is below environmental and/or regulatory thresholds and does not affect the ongoing viability of fish or marine mammal populations

M = Moderate—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds but does not affect the ongoing viability of fish or marine mammal populations

H = High—a measurable change from existing baseline conditions that is above environmental and/or regulatory thresholds and adversely affects the ongoing viability of fish and marine mammal populations

GEOGRAPHIC EXTENT:

PF = Project footprint—residual effects are restricted to the marine terminal footprint

LSA—residual effects extend into the LSA

RSA—residual effects extend into the RSA

DURATION:

ST = Short-term—residual effect restricted to Project construction and/or decommissioning phases and is predicted to return to existing baseline conditions with no lasting effect

MT = Medium-term—residual effect continues for up to two years following Project construction phase before returning to existing baseline conditions

LT = Long-term—residual effect continues for more than two years after the Project construction phase, or continues during Project operation and decommissioning phases, before returning to existing baseline conditions

P = Permanent—residual effect is unlikely to return to existing baseline conditions

FREQUENCY:

S = Single event—occurs once

MI = Multiple irregular event—occurs sporadically at irregular intervals

MR = Multiple regular event— occurs on a regular basis and at regular intervals

C = Continuous—occurs continuously throughout the life of the Project

REVERSIBILITY:

R = Reversible—effect will recover to existing baseline conditions after decommissioning phase or sooner

I = Irreversible—effect is permanent

CONTEXT:

L = Low resilience—low capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

M = Moderate resilience—moderate capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

H = High resilience—high capacity for the VC to recover from a perturbation, with consideration of the baseline level of disturbance

SIGNIFICANCE:

S = Significant

N = Not Significant

PREDICTION CONFIDENCE:

Based on scientific information and statistical analysis, professional judgment and effectiveness of mitigation, and assumptions made.

L = Low level of confidence

M = Moderate level of confidence

H = High level of confidence

LIKELIHOOD OF RESIDUAL EFFECT OCCURRING:

Based on professional judgment

L = Low likelihood that there will be a residual effect

M = Moderate likelihood that there will be a residual effect

H = High likelihood that there will be a residual effect

N/A = Not Applicable

Cumulative effects on fish or marine mammal behaviour from past, current, and foreseeable future projects result from vessel activities along the marine access route and at the marine terminal that add underwater noise above behavioural disruption thresholds. The Project's contribution to cumulative effects from underwater noise or pressure waves in the facility and shipping LSAs is assessed as not significant because the effects are low in magnitude and reversible. Cumulative effects on behaviour will not affect the ongoing viability of fish populations (including species at risk). The Project's contribution to the cumulative change in behaviour of marine mammals is assessed as not significant because of mitigation measures that will reduce the areal extent of underwater noise and reduce the time marine mammals are exposed to that noise. The Project's contribution to cumulative effects on behaviour is expected to be moderate in magnitude and is assessed as not significant for marine mammals, although there is low confidence in this prediction because of uncertainties in population-level effects from changes in behaviour. The increase in vessel transits will increase the time when the behavioural disruption threshold is exceeded, but it is anticipated that for most species, when compared to provincial population estimates, relatively low numbers of marine mammals will be affected and their population viability will not be affected.

Cumulative effects on fish from all past, current, and foreseeable future projects, including the Project's contribution, from change in fish habitat, change in fish health as a result of toxicity, harm to fish and change in behaviour of fish, are not anticipated to adversely affect the long-term viability of populations of fish species. Cumulative effects on marine mammals from all past, current and foreseeable future project, including the Project's contribution, from harm and changes in behaviour are not expected to adversely affect population viability, although there is low confidence due to uncertainties associated with population-level effects from changes in behaviour.

5.8.9 Prediction Confidence and Risk

The confidence in predictions of Project residual effects and cumulative effects to marine resources relies on the quality and quantity of baseline data, understanding of Project mechanisms, effectiveness of mitigation measures, and assumptions made. The uncertainties associated with this environmental assessment of marine resources are addressed by using conservative assumptions that err on the side of over-stating an effect and using mitigation measures that are more than adequate for reducing the magnitude and geographic extent of effects.

The quality and quantity of available scientific information on fish species and habitats, effectiveness of mitigation, and understanding of Project mechanisms are sufficient to have a high level of confidence in predictions for both residual effects from the Project and cumulative effects from all projects. The one exception is for change in fish behaviour due to underwater noise, for which there is a lack of relevant scientific literature, and a moderate level of confidence. Fish species that are part of CRA fisheries or are species at risk that occur in the facility and shipping RSAs are managed by DFO, and are subject to regular scientific stock/population assessments. Scientific literature on ecologically and socio-economically important species and habitats that occur in the facility and shipping RSAs is widely available. This information was complemented by baseline field surveys (Stantec Consulting Ltd. 2014a). The mechanisms for effects to marine fish and fish habitat are common and well understood. Mitigation measures in Section 5.8.5 are based on well accepted industry guidelines and BMPs. There is a high degree of confidence that these mitigation measures will be effective in reducing the effects to marine fish and fish habitat from Project activities and works.

For marine mammals, the level of confidence in predicting effects of harm, changes in behaviour, and potential cumulative effects varies based on the effect and the species potentially affected. The variation in confidence is largely due to the level of data available on marine mammal presence within the facility and shipping RSAs and on how Project activities can potentially affect marine mammals and their populations. Modelled marine mammal abundance and distributions added to the quality and quantity of data available for marine mammals in the area and allow for estimates to be made of numbers of individuals potentially affected by Project activities, although there is inherent uncertainty associated with using predictions of abundance and distribution. In addition, not all species likely to be present could be modelled (e.g., Bigg's and northern resident killer whales), due to low numbers of observations. There is also some uncertainty associated with mitigation of some Project activities (e.g., pile installation). Mitigation measures are prescribed using information from published literature of mitigation effectiveness and professional judgment. Uncertainties are addressed, when possible, by using conservative assumptions. The confidence level for this assessment of harm to marine mammals related to the construction at the facility is considered moderate because the predictions of relative abundance allowed for estimates of average numbers of individuals potentially affected by unmitigated pile installations. Mitigation measures used for pile installation can vary, depending on location and associated logistics. The mitigation measures suggested are known to reduce the exposure of marine mammals to levels of underwater noise above injury thresholds, but until sound levels are determined and sound dampening techniques are decided upon there is uncertainty in the amount of reduction in underwater noise produced. Lastly, killer whale distribution and abundance in the facility RSA is uncertain, so the number that could be exposed to noise that could cause harm is not known and caution is required as they are listed as *threatened* under SARA.

There is moderate confidence in the prediction of effects on behaviour for most marine mammal species, and low confidence for killer whales, associated with facility and shipping activities. The reasons for variation in degree of confidence are the same as for assessment of harm to marine mammals. In addition, disruptions in behaviour and subsequent effects on marine mammal populations have not been well researched, particularly in terms of underwater noise from shipping.

5.8.10 Follow-up Program and Compliance Monitoring

No follow-up programs are proposed for marine resources. Compliance monitoring to be implemented through Management and Activities Plans is described in Section 5.8.11, Section 12 and Section 21 (Table 21.3-1), and includes:

- A comprehensive MAP monitoring program will be developed to provide detailed guidance on implementing specific mitigation measures and BMPs designed to reduce or eliminate effects to marine resources during construction, dredging, and disposal activities. The purpose of the MAP monitoring program will be to verify that mitigation measures recommended in the environmental assessment are implemented and effective. The program will include on-site compliance monitoring and reporting to DFO and other applicable authorities.
- A post-construction Fish Habitat Offsetting Plan monitoring program will be developed to verify compliance with the terms of the authorization under paragraph 35(2)(b) of the Fisheries Act for Project activities and works that result in serious harm to fish. The program will be designed to verify compliance with stipulated mitigation and offsetting measures and to verify that performance criteria and objectives for the offsetting measures are met.

5.8.11 Summary of Mitigation Measures

LNG Canada will implement mitigation measures and compliance monitoring programs to limit Project residual effects and cumulative effects on marine resources.

5.8.11.1 Change in Fish Habitat from the LNG Facility

- A Fish Habitat Offsetting Plan will be developed and implemented to offset unavoidable permanent alteration or destruction of fish habitat from Project activities and works. The Plan will be developed in consultation with DFO, Haisla Nation, and key stakeholders (Mitigation 5.7-8).
- If and where quay walls/slopes are required, use materials that promote post-construction colonization of marine algae and invertebrate communities (Mitigation 5.8-1).
- Develop and implement a Marine Activities Plan (MAP) in accordance with applicable federal and provincial legislation and regulations. The MAP will include measures to address potential effects from dredge activities, pile installation (including marine mammal exclusion zone, soft start procedures and consideration of sound dampening technologies) and shipping (Mitigation 5.8-2).
- Construction of the marine terminal does not currently plan for blasting in the marine environment. If blasting is determined to be required, it will comply with all regulatory requirements (Mitigation 5.8-3).

- A Disposal at Sea Permit will be obtained prior to any sediment disposal in the marine environment. A disposal site will be selected in consultation with Environment Canada, DFO, affected Aboriginal Groups, and key stakeholders (Mitigation 5.8-4).
- Vessels arriving at the marine terminal will comply with legislation and regulations on the management of ballast water. LNG Canada may conduct random audits of vessel logs. No ballast will be discharged until compliance has been determined. Only clean ballast from segregated ballast tanks will be allowed to be discharged into the sea at the marine terminal (Mitigation 5.8-5).

5.8.11.2 Change in Fish Health at the LNG Facility as a Result of Toxicity

- Develop and implement a Marine Activities Plan (MAP) in accordance with applicable federal and provincial legislation and regulations. The MAP will include measures to address potential effects from dredge activities, pile installation (including marine mammal exclusion zone, soft start procedures and consideration of sound dampening technologies) and shipping (Mitigation 5.8-2).
- In-water marine construction, dredging, and sediment disposal activities will be conducted throughout the year. For the periods outside the timing windows of least risk, additional mitigation measures will be implemented to protect sensitive species and life stages as appropriate. Timing windows and mitigations will be developed in consultation with DFO at the permitting stage and will consider the location and timing of sensitive life stages specific to CRA fishery species (Mitigation 5.8-6).
- Optimization of sediment containment will be considered when selecting dredging and sediment disposal methods/equipment (Mitigation 5.8-7).
- Full assessment of effects of the selected sediment disposal methods and use of mitigation measures, with details to be provided in the Disposal at Sea Permit application (Mitigation 5.8-8).
- Movement of barge anchors will be minimized to limit sediment disturbance (Mitigation 5.8-9).
- A Disposal at Sea Permit will be obtained prior to any sediment disposal in the marine environment. A disposal site will be selected in consultation with Environment Canada, DFO, affected Aboriginal Groups, and key stakeholders (Mitigation 5.8-4).

5.8.11.3 Harm to Fish or Marine Mammals from the LNG Facility

- Develop and implement a Marine Activities Plan (MAP) in accordance with applicable federal and provincial legislation and regulations. The MAP will include measures to address potential effects from dredge activities, pile installation (including marine mammal exclusion zone, soft start procedures and consideration of sound dampening technologies) and shipping (Mitigation 5.8-2).

- For marine pile installation, LNG Canada will proactively manage pile installation with noise measurement and active monitoring of marine mammal exclusion zones (see MAP for more detail). Additional sound dampening methods and/or alternative pile installation methods will be investigated and applied if necessary, to prevent the exposure of marine mammals to underwater noise exceeding defined thresholds. These methods and the defined thresholds will be described in the MAP (Mitigation 5.8-10).
- In-water marine construction, dredging, and sediment disposal activities will be conducted throughout the year. For the periods outside the timing windows of least risk, additional mitigation measures will be implemented to protect sensitive species and life stages as appropriate. Timing windows and mitigations will be developed in consultation with DFO at the permitting stage and will consider the location and timing of sensitive life stages specific to CRA fishery species (Mitigation 5.8-6).
- Prior to isolation of the salt marsh habitat immediately north of the dredge area, fish using the area will be captured with a beach seine net strung across tidal channels. Fish will be relocated to more suitable areas in the marine resources facility RSA that will not be affected by Project activities (Mitigation 5.8-11).
- A Disposal at Sea Permit will be obtained prior to any sediment disposal in the marine environment. A disposal site will be selected in consultation with Environment Canada, DFO, affected Aboriginal Groups, and key stakeholders (Mitigation 5.8-4).
- Full assessment of effects of the selected sediment disposal methods and use of mitigation measures, with details to be provided in the Disposal at Sea Permit application (Mitigation 5.8-8).
- Optimization of sediment containment will be considered when selecting dredging and sediment disposal methods/equipment (Mitigation 5.8-7).
- Construction of the marine terminal does not currently plan for blasting in the marine environment. If blasting is determined to be required, it will comply with all regulatory requirements (Mitigation 5.8-3).

5.8.11.4 Change in Behaviour of Fish and Marine Mammals Due to Underwater Noise or Pressure Waves from the Facility

- Develop and implement a Marine Activities Plan (MAP) in accordance with applicable federal and provincial legislation and regulations. The MAP will include measures to address potential effects from dredge activities, pile installation (including marine mammal exclusion zone, soft start procedures and consideration of sound dampening technologies) and shipping (Mitigation 5.8-2).

- For marine pile installation, LNG Canada will proactively manage pile installation with noise measurement and active monitoring of marine mammal exclusion zones (see MAP for more detail). Additional sound dampening methods and/or alternative pile installation methods will be investigated and applied if necessary, to prevent the exposure of marine mammals to underwater noise exceeding defined thresholds. These methods and the defined thresholds will be described in the MAP (Mitigation 5.8-10).
- In-water marine construction, dredging, and sediment disposal activities will be conducted throughout the year. For the periods outside the timing windows of least risk, additional mitigation measures will be implemented to protect sensitive species and life stages as appropriate. Timing windows and mitigations will be developed in consultation with DFO at the permitting stage and will consider the location and timing of sensitive life stages specific to CRA fishery species (Mitigation 5.8-6).
- Construction of the marine terminal does not currently plan for blasting in the marine environment. If blasting is determined to be required, it will comply with all regulatory requirements (Mitigation 5.8-3).

5.8.11.5 Change in Behaviour of Fish and Marine Mammals Due to Underwater Noise or Pressure Waves from Shipping Activities

- LNG carriers will travel at speeds up to 14 knots. Speeds will vary depending on navigational safety, weather conditions, location, and marine mammal presence, and will be determined based on the judgment of the ship's master who receives advice from the BC Coast Pilots on board. Subject to navigational safety needs, in areas of high whale density between the northern end of Campania Island and the southern end of Hawkesbury Island, LNG carriers will travel at speeds of 8 or 10 knots from July through October (recognizing predicted periods of high use by marine mammals) (Mitigation 5.8-12).

5.8.12 Conclusion

Residual effects of the Project are assessed as not significant. With mitigation and offsetting measures, no net loss in the total area or productive capacity of marine fish habitat is anticipated. Change in fish habitat is likely to be negligible magnitude with reversible effects. Change in fish health as a result of toxicity is likely to be low magnitude in the facility LSA, with reversible effects and long-term improvement of sediment quality with removal of contaminants. There is potential for harm to fish and marine mammals during construction, with few fish and marine mammals likely to be harmed, and no expected effects on fish and marine mammal population viability (including species at risk). Changes in behaviour by fish and, to a greater extent, marine mammals are expected to occur during construction, operation, and decommissioning. The effect is likely to be short term for construction and decommissioning and long term during operation. Mitigation measures will be implemented to reduce the potential for harm and changes in behaviour, fish health, and fish habitat. The overall Project effect on marine resources is assessed as not significant.

The prediction confidence is considered moderate to high for all Project residual effects, with one exception. The exception is for change behaviour due to underwater noise from shipping activities for which the prediction confidence is considered low to moderate (specifically for killer whales, due to the low level of information about behaviour changes and population level effects).