Marine Resources Technical Data Report

LNG Canada Export Terminal

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LNG CANADA
Opportunity for British Columbia. Energy for the world

Joint venture companies

Mitsubishi Corporation

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EXECUTIVE SUMMARY

LNG Canada Development Inc. (LNG Canada) is proposing to construct and operate a liquefied natural gas (LNG) facility, including a LNG processing and storage site and marine terminal, in the District of Kitimat, British Columbia (BC), and to export LNG from the facility by shipping. This proposed project is called the LNG Canada Export Terminal (the Project).

This technical data report presents detailed technical data and analysis regarding the marine resources valued component to support the Application for an Environmental Assessment Certificate under the BC *Environmental Assessment Act* and a federal decision under the *Canadian Environmental Assessment Act, 2012*. The assessment of marine resources for the Project is divided into two sub-components: marine fish and fish habitat, and marine mammals.[1] The marine fish and fish habitat sub-component addresses fish species, invertebrate species, vegetation species, and fish habitat (as defined under the federal *Fisheries Act*). The marine mammal sub-component addresses cetaceans and pinnipeds. This report includes baseline information on each of these sub-components from a broad perspective; but it also focuses on the following:

- 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 *endangered*, *threatened*, or *special concern* under Schedule 1: List of Wildlife Species at Risk of the federal *Species at Risk Act* (SARA), or by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (herein referred to as species at risk).

This report presents background information, methods, and results from the baseline studies conducted for the Project.

There are two local study areas (LSAs) for marine resources. 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. The shipping LSA is defined as the confined channels along the marine access route and marine waters extending 6 km on either side of the marine access route between Browning Entrance and the Triple Island Pilot Boarding Station. The 6 km buffer encompasses the potential extent of the majority of area where underwater noise might exceed recommended acoustic thresholds.

There are two regional study areas (RSAs) for marine resources. The facility RSA encompasses marine waters from the head of Kitimat Arm south to the north tip of Coste Island. The shipping RSA encompasses the extent of shipping activities and surrounding waters within the confined channels (i.e.,

[1] The federal *Fisheries Act* defines “fish” as “parts of fish; shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals; and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals”. For the purposes of the Application, marine resources are split into two groups: marine fish (including invertebrates), and marine mammals.

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 of the route.

Three basin study areas (BSAs) are identified by LNG Canada as locations within which a disposal at sea site will be selected. They 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 dredging area
- 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.

A review of existing information on marine resources in the RSA, including traditional knowledge and traditional use studies, reveals that Kitimat Arm is home to at least 75 species of marine fish, 100 species of marine invertebrates, and 12 species of marine mammals. A number of these species are caught in CRA fisheries, including groundfish, pelagic fish, salmon, crab, shrimp, harbour seal, Steller sea lion, and sea otter.

The facility RSA overlaps with Fisheries and Oceans Canada (DFO) important areas (IAs) for eulachon, tanner crab, cloud sponge, and encompasses Pacific salmon spawning rivers, eulachon spawning rivers, and Pacific herring spawning areas. Eight marine fish and invertebrate species at risk may occur in the facility RSA, including the bluntnose sixgill shark, spiny dogfish, canary rockfish, yelloweye rockfish, quillback rockfish, eulachon, green sturgeon, and potentially northern abalone. Along with these species, an additional seven marine fish species at risk may occur in the shipping RSA, including bocaccio, darkblotched rockfish, longspine thornyhead, rougheye rockfish, yellowmouth rockfish, and Olympia oyster.

The facility RSA encompasses portions of the Kitimat River estuary and Kitimat Arm of Douglas Channel. Since the 1950s, the facility LSA has been subject to a variety of human disturbances associated with past and present industrial operations, including an aluminum smelter, a pulp and paper mill, a methanol plant, and log storage and handling facilities.

To collect baseline data and information about marine fish and fish habitat, four field studies were conducted in the facility LSA, including an intertidal survey, a salt marsh survey, and a subtidal survey; a subtidal survey was also conducted in the BSAs.

Intertidal habitat in the facility LSA consists primarily of a sand and mud tidal flats in the mid and low intertidal zones, and constructed riprap revetment walls in the high intertidal zone. During the intertidal surveys, 4 marine fish species, 15 invertebrate species, 1 seagrass species, 12 algae species, and 5 marsh plant species were observed. Overall vegetation coverage in the intertidal zone was low relative to other areas of the north coast. The backshore zone consists of altered marine riparian habitat.

One species of marine algae and seven species of marsh plants were observed in the salt marsh located in the facility LSA north of the Eurocan Basin. Rockweed, Lyngbye's sedge, and silverweed were abundant in the marsh. Two marine invertebrates were observed in the salt marsh, including gammarid amphipods and stubby isopods. The salt marsh provides habitat for marine fish, including all five species of Pacific salmon and sculpin.

Subtidal habitat in the facility LSA is characterized by soft substrates with limited structural complexity. Fifty-one marine fish and invertebrate species were observed in the subtidal zone. Six species of marine vegetation were observed, and algal coverage was sparse.

The BSAs are characterized by steep bedrock walls and a gently sloping, soft seabed comprised of mud and silt substrate; water depths range from 150 m to 350 m CD. During surveys, 42 marine fish and invertebrate species were observed in the BSAs, with an additional 18 unconfirmed species present. Eulachon were observed in the northern portion of BSA 3 during the subtidal survey.

Polycyclic aromatic hydrocarbons (PAH) in sediment are the main contaminants of concern, related to atmospheric emissions and effluent discharges from industrial, municipal, and residential inputs over the past 60 years. Concentrations are highest close to the RTA facility, but they are measurable throughout Kitimat Arm; they have decreased since the 1970s because of RTA facility upgrades that improved air emissions. Currently, PAHs in the proposed dredge area occur within the top 6 m of sediment, but are most concentrated in the top 3 m. The PAHs have low bioavailability, as they are associated with coarse particles, such as coke and coal, and low toxicity to test organisms. Flatfish from areas of high PAH levels show increased rates of DNA damage; however, overall effects on flatfish and juvenile salmon are lower than expected for areas of similarly high PAH levels. Copper levels are naturally elevated in Kitimat Arm; localized areas of elevated copper, zinc, and cadmium levels occur in the proposed dredge footprint, suggesting human sources.

The shipping RSA overlaps with DFO IAs for fin whale, northern resident killer whale, and humpback whale. Eight marine mammals in the shipping RSA are species at risk, including fin whale, humpback whale, grey whale, northern resident killer whale, Bigg's (transient) killer whale, habour porpoise, Steller sea lion, and sea otter. Humpback whale critical habitat identified and designated under SARA occurs in the shipping RSA, in Whale Channel and Squally Channel. Humpback whale is currently federally listed as *threatened* but a recommendation to ammend its status to *special concern* is under consideration by the federal government; this decision is pending at the time of writing. Potential critical habitat for northern resident killer whales has also been identified in Whale Channel, Squally Channel, and Estevan Sound/Caamaño Sound.

Twelve marine mammal line transect surveys were conducted in the shipping RSA, using distance sampling methods to estimate the number of animals in a given area (relative population abundance) for commonly observed species. These surveys identified several species of marine mammals in the shipping RSA, all of which varied in distribution and abundance through the survey periods: humpback whale, fin whale, minke whale, grey whale, northern resident killer whale, Bigg's (transient) killer whale, Pacific white-sided dolphins, Dall's porpoise, harbour porpoise, harbour seal, Steller sea lion, elephant seal, and sea otter.

Predicted relative abundance estimates and density maps revealed seasonal changes in marine mammal distributions during the overall survey period and areas of high use for marine mammals in the shipping LSA and RSA.

ACRONYMS AND ABBREVIATIONS

AIC	Akaike's Information Criteria
BCCDC	British Columbia Conservation Data Centre
BCCSN	British Columbia Cetacean Sightings Network
BCEAA	*British Columbia Environmental Assessment Act*
BCMCA	British Columbia Marine Conservation Analysis
BSA	basin study area
BSAF	biota-sediment accumulation factors
CCME	Canadian Council of Ministers of the Environment
CD	chart datum
CDS	conventional distance sampling
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CRA	commercial, recreational, and Aboriginal
CRIMS	Coastal Resource Information Management System
CSR	Contaminated Site Regulations
dB	decibels
DFO	Fisheries and Oceans Canada
BCEAO	Environmental Assessment Office
EBSA	Ecologically and Biologically Significant Area
GAM	generalized additive model
GAMM	generalized additive mixed model
GPS	global positioning system
Hz	hertz
ISQG	interim sediment quality guideline
kHz	kilohertz
km	kilometres
LNG	liquefied natural gas
LNG Canada	LNG Canada Development Inc.

LSA	local study area
MCDS	multiple covariate distance sampling
MMO	marine mammal observer
mS/cm	millisiemens per centimetre
ng/gm ww	nanograms per gram wet weight
NOAA	National Oceanographic and Atmospheric Administration
NTU	nephelometric turbidity unit
OC	organochloride
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEL	Probable Effects Level
PNCIMA	Pacific North Coast Integrated Management Area
Project	LNG Canada Export Terminal
PSU	practical salinity unit
PTS	permanent threshold shift
RCA	rockfish conservation area
REML	restricted maximum likelihood
ROV	remotely operated vehicle
RSA	regional study area
RTA	Rio Tinto Alcan
SARA	*Species at Risk Act*
SEL	sound exposure level
SPL	sound pressure level
TEF	toxicity equivalency factor
TEL	threshold effects level
TEQ	toxicity equivalency quotient
TK	traditional knowledge
TOC	total organic carbon
TTS	temporary threshold shift

TU .... traditional use

VC .... valued component

µg/kg dw .... micrograms per kilogram dry weight

µS/cm........ microsiemens per centimetre

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1 INTRODUCTION

LNG Canada Development Inc. (LNG Canada) is proposing to construct and operate a liquefied natural gas (LNG) facility (including a LNG processing and storage site and marine terminal) in the District of Kitimat, British Columbia (BC), and to export LNG from the facility by shipping. This proposed project is called the LNG Canada Export Terminal (the Project) (Figure 1.0-1).

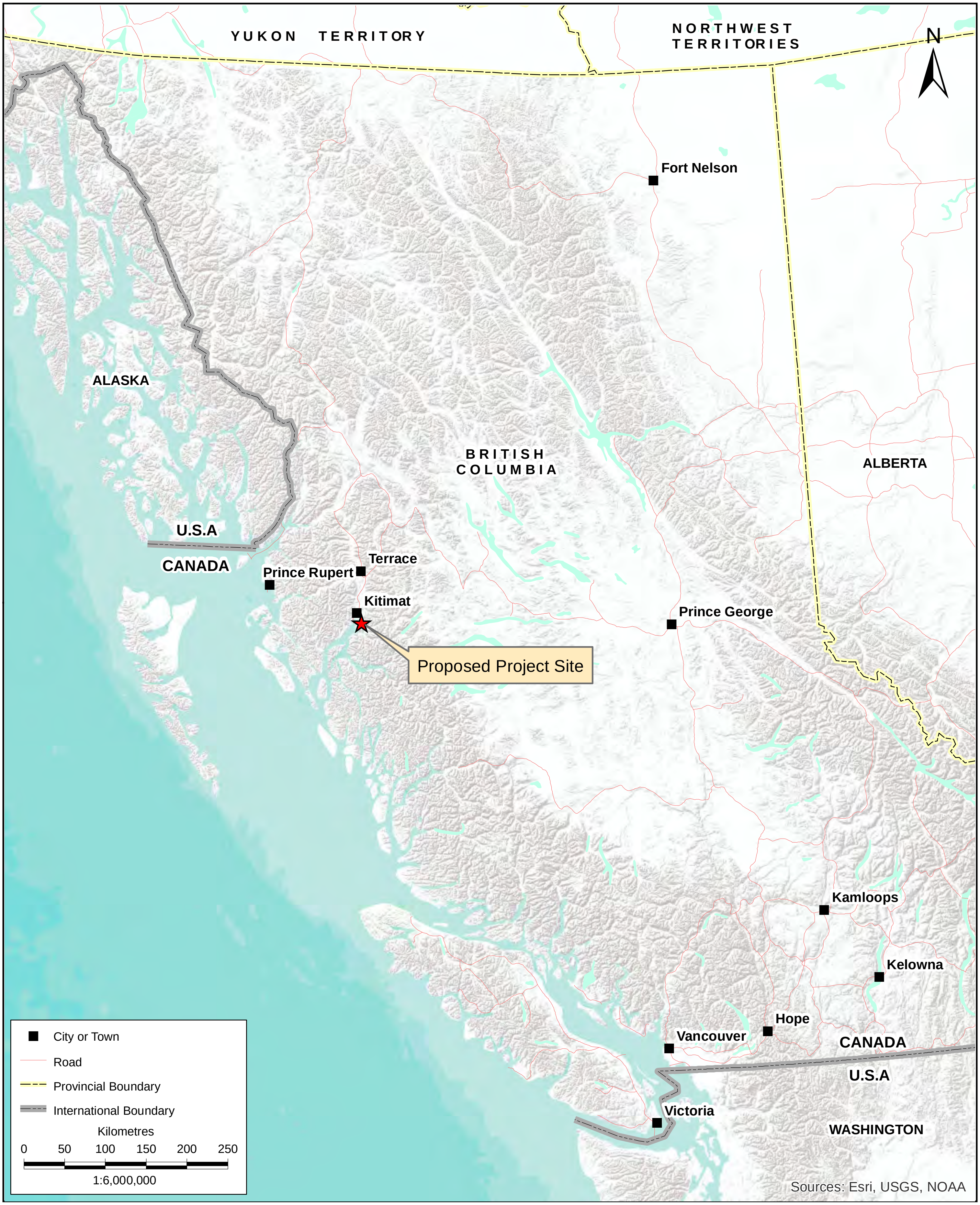
The Application for an Environmental Assessment Certificate focuses on a suite of valued components (VC). VCs are components of the natural and human environment that are considered by the proponent, public, Aboriginal Groups, scientists and other technical specialists, and government agencies involved in the assessment process to have scientific, ecological, economic, social, cultural, archaeological, historical, or other importance. VCs selected for the Project reflect the environmental effects to be considered as identified in the BC *Environmental Assessment Act* (BCEAA) and in section 5 of the *Canadian Environmental Assessment Act*, 2012.

The marine resources VC has two sub-components: marine fish and fish habitat, and marine mammals[2]. This report includes baseline information on these sub-components from a broad perspective, and a focus 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) (herein referred to as species at risk).

This report also describes the general physical and chemical characteristics of the marine environment.

[2] The federal *Fisheries Act* defines “fish” as “parts of fish; shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals; and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals”. For the purposes of the Application, marine resources are split into two groups: marine fish (including invertebrates), and marine mammals.



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MARINE RESOURCES TECHNICAL DATA REPORT

PROJECT LOCATION

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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Background information, methods, and results are based on baseline studies conducted for the Project. Professional judgment of the study team and input from regulators, Aboriginal Groups, and the public guided the scope of the studies. The process was initiated with a review of existing information, followed by field studies and marine mammal modelling to address information gaps and support an authorization under paragraph 35(2)(b) of the *Fisheries Act*. Potential effects of the Project on marine resources include 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 fish or marine mammal behaviour due to pressure waves or underwater noise. Environmental effects are characterized based on a combination of quantitative and qualitative measurable parameters. Wherever possible, quantitative measurable parameters were selected based on available thresholds, guidelines, and best practices developed by regulatory agencies, scientific bodies, and industry. Where quantitative measurable parameters were not available, qualitative measurable parameters were selected that are based on professional judgment of the assessment team. Measurable parameters for change in fish habitat includes the total area (m^2) of fish habitat permanently altered or destroyed, and productive capacity of fish habitat permanently altered or destroyed (qualitative). For harm to fish or marine mammals, the measurable parameters are the likelihood of harm to fish species that support or are part of CRA fisheries; likelihood of harm to marine mammals; and likelihood of harm to species at risk. The measurable parameter for change in fish health as a result of toxicity is chemical composition of sediment and water. For change in behaviour due to pressure waves or underwater noise, the measurable parameter is exposure to underwater noise relative to available thresholds.

2 STUDY AREAS

Spatial boundaries are established for baseline information about marine resources to support assessment of potential environmental effects and cumulative environmental effects of the Project on marine resources. The primary consideration in establishing these boundaries is the probable geographical extent of the environmental effects (i.e., the zone of influence) on this VC. For this assessment, the spatial boundaries are referred to as "study areas."

The local study area (LSA) encompasses the area in which Project effects can be predicted or measured with a level of confidence that allows for assessment, and the area in which there is a reasonable expectation that those effects could be of concern.

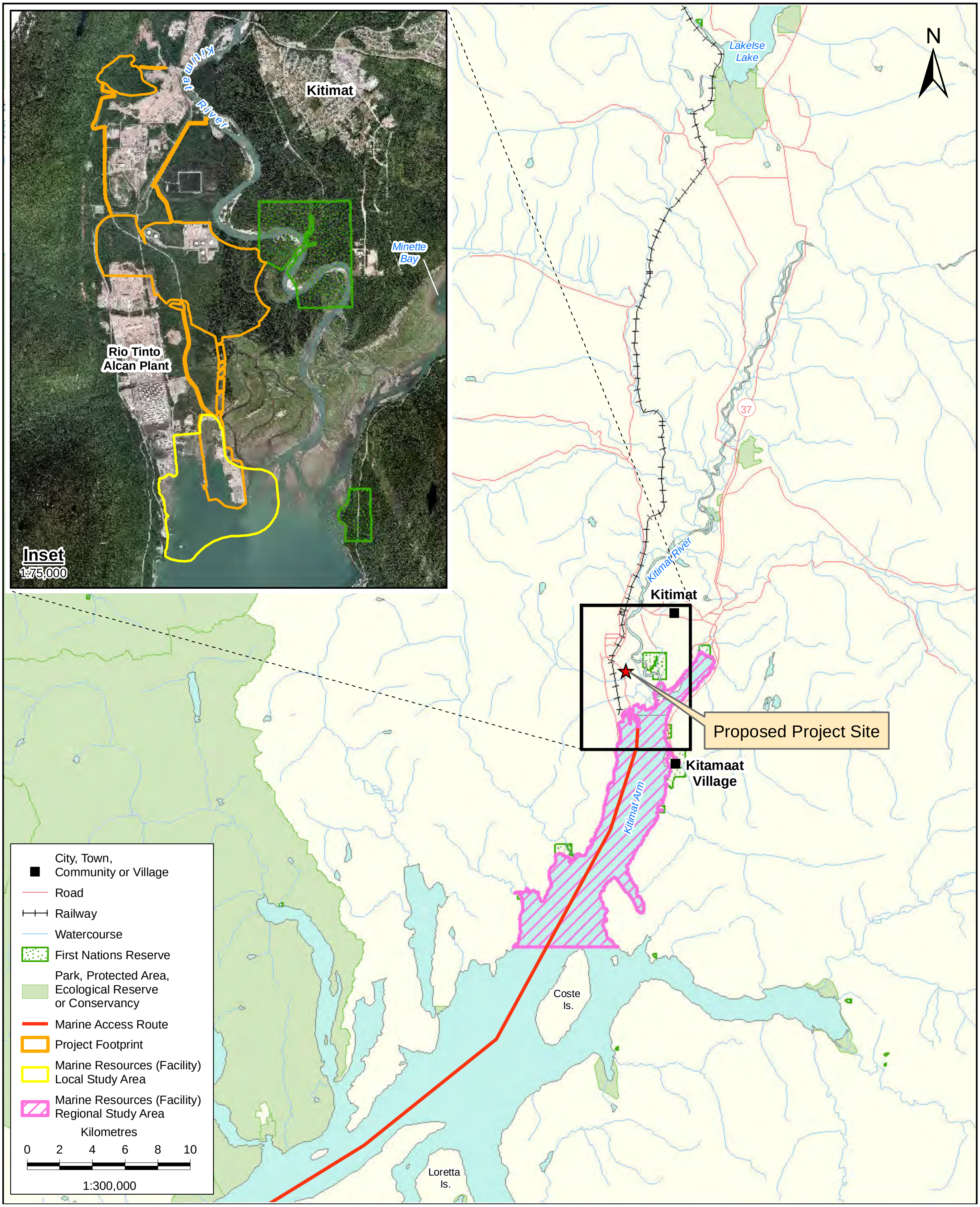
The regional study area (RSA) establishes the context for the determination of significance. It encompasses the area where Project effects overlap with effects of past, present, and reasonably foreseeable future activities, and is, therefore, the area within which the Project's contribution to cumulative effects is assessed.

Marine resources are discussed in terms of two LSAs and RSAs (facility and shipping), and basin study areas (BSAs), to cover relevant components of the assessment. These are shown in Figure 2.0-1, Figure 2.0-2, and Figure 2.0-3 (see Sections 2.2 through 2.4 for more detail).

2.1 Regional Setting

Kitimat is at the head of the Kitimat Arm in the Kitimat Ranges, a sub-province of the Coast Mountain Range. It is located in the Coastal Western Hemlock Biogeoclimatic Zone. Kitimat Arm is approximately 3 km wide and 20 km long. Kitimat River, which flows south approximately 75 km from the southwestern slope of Mount Davies, discharges into Kitimat Arm from the north at the Kitimat River estuary.

Kitimat Arm is located in the North Coast Fjords Ecodistrict of Environment Canada's Pacific Shelf Ecoregion (Harding 1997; Table 2.1-1). The North Coast Fjords are characterized by deep troughs bounded by sills, turbid surface layers with slow tidal currents and low productivity, hypoxic deep waters, and considerable freshwater input, refreshed with inflowing seawater at irregular intervals (Harding 1997; Lucas et al. 2007b). Water temperature and salinity in the North Coast Fjords are strongly influenced by seasonal outflow of freshwater from rivers (Pickard 1961). Surface salinity typically increases from zero at the head of the inlets to coastal sea values at their mouth (Pickard 1961).



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MARINE RESOURCES TECHNICAL DATA REPORT

MARINE RESOURCES (FACILITY) LOCAL AND REGIONAL STUDY AREAS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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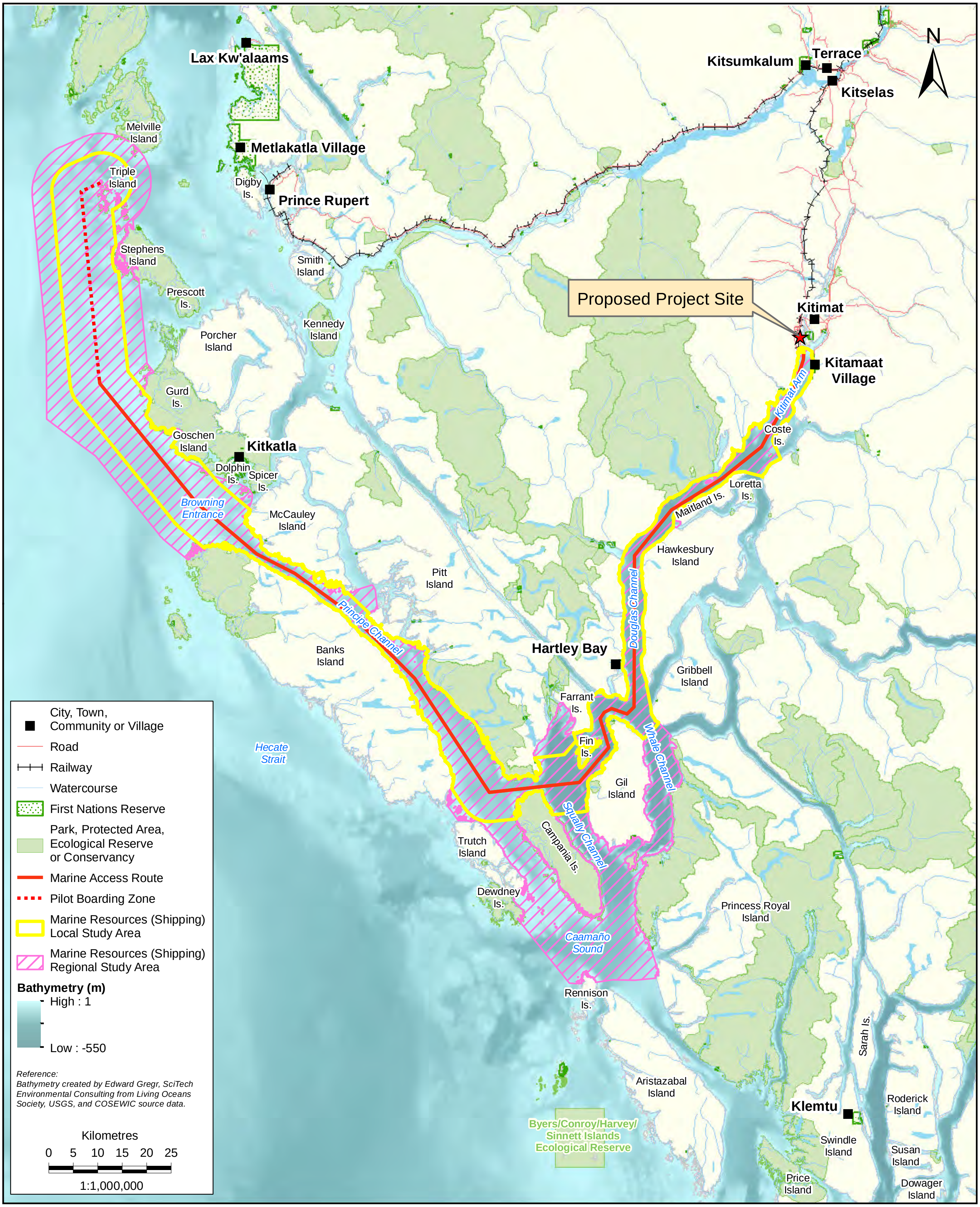

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MARINE RESOURCES TECHNICAL DATA REPORT

MARINE RESOURCES (SHIPPING)
LOCAL AND REGIONAL STUDY AREAS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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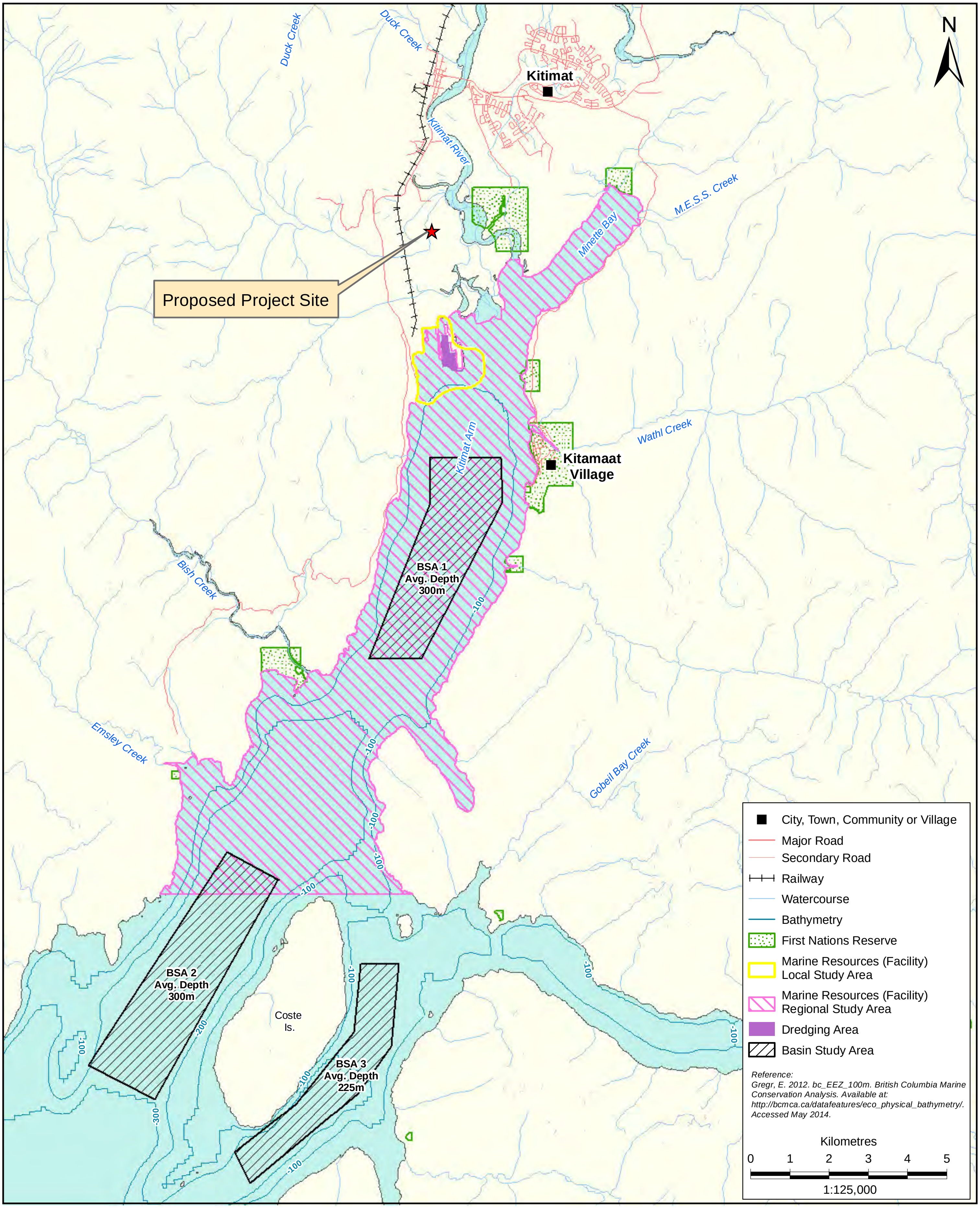

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MARINE RESOURCES TECHNICAL DATA REPORT

BASIN STUDY AREAS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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Table 2.1-1: Marine Ecological Classifications

Marine Ecoregion or Ecodistrict	Physiographic Characteristics	Oceanographic Characteristics	Biological Characteristics
Pacific Shelf Ecoregion	Generally shallow, gently sloping shelf (less than 200 m), except Queen Charlotte Sound, which is slightly deeper with a series of banks and channels; numerous fjords, and islands	Characterized by transitional estuarine and marine water masses and associated currents; open Pacific wave exposure; generally northerly currents in winter, southerly currents in summer	Strong coastal signature of neritic plankton species; high primary productivity; rich benthic community; feeding grounds for temperate fish, mammals (e.g., Bigg's and resident killer whales, grey whales, dolphins, harbour seals), and coastal and marine birds
North Coast Fjords Ecodistrict	Complex coastline cut by many fjords with deep troughs bounded by sills	Turbid surface layers; estuarine circulation; vigorous mixing at sills; internal waves; typically hypoxic deep waters, but refreshed with inflowing seawater at irregular intervals	Diverse attached invertebrate communities at sills; low productivity of surface water; benthos characteristic of soft bottom substrates; large concentrations of wintering seaducks and coastal seabirds; concentrations of avian and mammalian predators during salmon migrations
Queens Charlotte Sound	Wide, deep shelf characterized by several large banks and inter-bank channels	Ocean wave exposures with depths mostly greater than 200 m and dominated by oceanic water intrusions	Mixture of neritic and oceanic plankton communities; northern limit for many temperate fish species; lower benthic invertebrate production
Hecate Strait Ecodistrict	Very shallow strait dominated by coarse bottom sediments; surrounding coastal lowlands	Semi-protected waters with strong tidal currents that promote mixing; dominantly marine waters	Neritic plankton communities with some oceanic intrusion; nursery area for salmon and herring; abundant benthic invertebrate stocks; feeding grounds for marine mammals and birds
Dixon Entrance Ecodistrict	Across-shelf trough with depths mostly greater than 300 m; surrounded by low-lying coastal plains (Hecate Depression)	Strong freshwater influence from mainland river runoff drives northwestward-flowing, coastal buoyancy-driven current and estuarine-like circulation	Mixture of neritic and subpolar plankton species; migratory corridor for Pacific salmon; some productive and protected areas for juvenile fish and invertebrate development

SOURCE: Harding (1997)

Kitimat Arm is an extension of the Douglas Channel fjord system and is connected to Gardner Canal through Devastation Channel (Bell and Kallman 1976). The main section of Kitimat Arm from Clio Point to the Kitimat River delta is approximately 3 km wide (Bell and Kallman 1976). Water depth increases rapidly from the head to depths over 200 m (Bell and Kallman 1976). Kitimat Arm is characterized by low salinity in the surface waters (less than 5 m water depth) at the head attributable to freshwater input from Kitimat River, with well-developed, variable estuarine circulation depending on the rate of freshwater input (Bell and Kallman 1976; MacDonald and Shepherd 1983). Salinity in deep water of Kitimat Arm exceeds 33‰ (Bell and Kallman 1976). Dissolved oxygen levels in surface waters of Kitimat Arm are near saturation, whereas dissolved oxygen levels in deeper water seldom drops below 4 mg/l, indicating that bottom water is regularly replaced (Bell and Kallman 1976). Along with estuarine circulation, wind and tide generated currents influence circulation in Douglas Channel and exchange of surface waters between the inlet and open waters of Hecate Strait (MacDonald and Shepherd 1983). The average surface temperature in Kitimat Arm is approximately 14°C in the summer and 6°C in the winter (Lucas et al. 2007b).

According to Bell and Kallman (1976), tides in Kitimat Arm are mixed, mainly semi-diurnal, meaning two high tides and two low tides occur each day, with irregularities in height and time of succeeding tidal oscillations. The mean tidal amplitude is 4.2 m; the large tidal amplitude is 6.5 m (Bell and Kallman 1976). Surface currents in Kitimat Arm are mainly attributable to wind and runoff and seldom exceed 50 cm/s (Bell and Kallman 1976). Wind waves are largest in winter during southerly winds, with the maximum wave height in Kitimat Arm estimated to be 1.5 m (Bell and Kallman 1976).

The Kitimat River estuary is strongly influenced by the heavy sediment loads carried by the river during spring freshet and periods of high precipitation, which increase turbidity and inhibit primary production in some areas of the estuary (MacDonald and Shepherd 1983). Sediment in Kitimat Harbour and in intertidal areas is sand-dominated, whereas fine-grained substrate is found in the deep areas of the inlet (Bornhold 1983).

Portions of the lower Kitimat River and estuary have been used for industrial activities since the 1950s, including an aluminum smelter, a pulp and paper mill, a methanol plant, and log storage and handling facilities (Levings 1976; MacDonald and Shepherd 1983). The municipal wastewater treatment plant discharges effluent into the lower Kitimat River. Elevated concentrations of hydrocarbons (polycyclic aromatic hydrocarbon [PAH]) and metals have been recorded in Kitimat Arm sediment since the 1950s; however, concentrations of PAHs have declined since the 1970s as a result of technological advancements in scrubber technology decreasing PAHs in air emissions, effluent discharges, and marine sediment (Warrington 1987).

The marine access route extends across the North Coast Fjords, Queen Charlotte Sound, Hecate Strait, and Dixon Entrance Ecodistricts within the Pacific Shelf Marine Ecoregion. The physiographic, oceanographic, and biological characteristics of these areas are summarized in Table 2.1-1.

Jamieson and Davies (2004) reviewed marine communities and habitats on the BC north coast, including phytoplankton, zooplankton, pelagic fish, benthic fish, marine mammals, and marine birds and shorebirds. Marine habitat types include intertidal habitats, soft-bottom estuarine habitats and benthic subtidal habitats.

2.2 Local Study Area

Two LSAs (facility and shipping) are assessed for marine resources, reflecting the two components of the assessment.

2.2.1 Facility

The facility LSA is defined by a 500 m buffer around the terminal to encompass the marine terminal footprint, LNG vessel berthing areas, and marine waters affected by underwater noise from construction, operation, and decommissioning activities (Figure 2.0-1). The 500 m buffer is based on professional judgment and past experience of the environmental assessment team.

2.2.2 Shipping

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 2.0-2). 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 with LSAs for marine transportation and use, and wildlife resources (marine birds).

2.3 Regional Study Area

Two RSAs (facility and shipping) are assessed for the marine resources assessment.

2.3.1 Facility

The facility RSA encompasses marine waters from the head of Kitimat Arm south to the north tip of Coste Island (Figure 2.0-1); this area is based on professional judgment and experience of the environmental assessment team. It encompasses habitats used during sensitive life stages of fish species that might be affected by the Project, including important spawning areas and migration routes.

2.3.2 Shipping

The shipping RSA 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 approximately 10 km is used on either side of the marine access route (Figure 2.0-2). The 10 km buffer is based on professional judgment and experience of the environmental assessment team to provide context for marine mammal presence in the area. The shipping RSA overlaps with the RSAs for marine transportation and use, and wildlife (marine birds). The shipping LSA lies in the shipping RSA; therefore, when the shipping RSA is referenced, the LSA is implied.

2.4 Basin Study Areas

BSAs in upper Kitimat Arm are identified as locations within which a disposal at sea site will be selected (Figure 2.0-3). 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 dredging area
- 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.

3 REVIEW OF EXISTING DATA

The study included a review of traditional knowledge (TK) and traditional use (TU) information, relevant literature, previous and current environmental assessments, and historical data.

3.1 Traditional Knowledge and Traditional Use

3.1.1 Methods

Information on TK and TU was acquired from a variety of publicly available sources: TK studies, ethnographic and ethno-historic sources, academic papers and sources related to other environmental assessments for similar projects in the region. Haisla Nation, Gitxaala Nation, Gitga'at First Nation, Metlakatla First Nation, and Kitsumkalum First Nation each provided a study to LNG Canada (Powell 2013; Calliou Group 2014; Crossroads CRM 2014; DM Cultural Services Ltd. 2014; Satterfield et al. 2014).

3.1.2 Results

3.1.2.1 Marine Fish and Fish Habitat

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 (*Oncorhynchus keta*), sockeye (*O. nerka*), coho (*O. kisutch*), chinook (*O. tshawytscha*), pink (*O. gorbuscha*), steelhead (*O. mykiss*), and bullhead (*Salvelinus confluentus*); small pelagic fish, such as eulachon (*Thaleichthys pacificus*) and Pacific herring (*Clupea pallasii*); demersal fish, such as 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, shimps/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 its 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 (*Anoplopoma fimbria*), ling cod, rock cod and snapper, salmonids, and invertebrates such as crab, prawns and shrimp, clams, cockles, mussels, chitons, abalone, sea cucumbers, urchins, and octopus (Calliou Group 2014 a,b; Firelight Group 2014).

Salmon migration routes and general occurrence by species identified by Gitxaala Nation are listed and mapped in Calliou Group (2014a). For example, Gitxaala Nation reported 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 are also reported in Calliou Group (2014a). As examples, herring spawn around Gurd, Goschen, Dolphin, and Spicer islands, and around Ander Island; halibut is harvested throughout the shipping RSA; crab is found around Kitkatla Inlet and the southwest tip of Pitt Island. In addition to fish and invertebrates, Gitxaala Nation harvests kelp and other seaweeds in various locations throughout the shipping RSA and at specific times during the year.

Metlakatla First Nation harvests seaweeds and herring roe from kelp beds, halibut, flounder, cod, Pacific salmon, abalone and other shellfish, octopus, sea urchins, sea prunes, and sea cucumbers (DM Cultural Services Ltd. 2014).

Kitsumkalum First Nation harvests cod, halibut, herring, octopus, dogfish, eels, flounders, rockfish, shrimp and prawns, bivalves, crab, sea cucumber, barnacles, and snails (Crossroads CRM 2014). Kelp is also harvested. Eulachon is fished on the Skeena River near tidal limits below Kwinitsa, and in other tributaries of the river.

Lax Kw’alaams First Nation harvest cod, halibut, herring, octopus, dogfish, eels, flounders, rockfish, shrimp and prawns, bivalves, crab, sea cucumber, barnacles, snails, sea urchin, sea prunes, Chinese slippers, abalone, pilchard, all five salmon species, red snapper, Pollock, lingcod, sablefish, and squid (Lax Kw'alaams 2004). Loss of eulachon and eulachon habitat and its restoration is of particular importance to Lax Kw'alaams First Nations (Lax Kw'alaams 2004). 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.

3.1.2.2 Marine Mammals

Information obtained from TK and TU studies mention several seal and sea lion haulouts and areas used by whales in the shipping RSA. Haisla Nation reported that seals are present in Minette Bay, the flats around Zagwis, and the Kitamaat Village area (Powell 2011; Powell 2013). 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). Lax Kw'alaams First Nation (2004) noted that seals can also be found in the Pearl Harbour area. Hecate Strait was also identified by Kitsumkalum First Nation as an area used by both humpback whales (*Megaptera novaeangliae*) and killer whales (*Orcinus orca*) (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 the north end of Principe Channel up through to Edye

Passage as a migration corridor for this species (Calliou Group 2014a). Gitxaala Nation also 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). Seals were reported to breed along Ander Island.

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).

Feedback from Gitga'at First Nation on timing of marine mammal surveys indicated that Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) aggregations were largest (greater than 100 animals) in the shipping RSA during February (Picard 2013, pers. comm.).

3.2 Literature Review and Previous Investigations

3.2.1 Methods

3.2.1.1 Marine Fish and Fish Habitat

The literature review for marine fish and fish habitat included a search of relevant scientific literature, government reports, and spatial data from the following sources:

- Fisheries and Oceans Canada (DFO) WAVES online catalogue: http://waves-vagues.dfo-mpo.gc.ca/waves-vagues/
- DFO Canadian Science Advisory Secretariat publications: http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm
- DFO Mapster v3: http://www.pac.dfo-mpo.gc.ca/gis-sig/maps-cartes-eng.htm
- Environment Canada publications
- COSEWIC assessments and status reports: http://www.cosewic.gc.ca
- Species at Risk Public Registry: http://www.sararegistry.gc.ca
- Government of British Columbia publications
- BC Coastal Resource Information Management System (CRIMS): http://geobc.gov.bc.ca/coastal/index.htm
- BC Species and Ecosystems Explorer: http://www.env.gov.bc.ca/atrisk/toolintro.html
- BC Marine Conservation Analysis (BCMCA): http://bcmca.ca/
- US National Oceanic and Atmospheric Administration (NOAA) publications
- Science Direct and EBSCO host research databases
- Stantec Consulting Technical Data Report for the Enbridge Northern Gateway Pipeline, and
- peer-reviewed literature on contaminants in Kitimat Arm.

3.2.1.2 Marine Mammals

A literature review was conducted to provide baseline information on marine mammals likely to be present in the shipping RSA as well as recommended marine mammal underwater noise acoustic thresholds.

Resources used included:

- peer-reviewed literature (e.g., *Journal of Marine Mammal Science*)
- grey literature (e.g., *Canadian Technical Report of Fisheries and Aquatic Sciences*, Raincoast Conservation Foundation reports), and
- BC Cetacean Sightings Network (BCCSN) data.

3.2.1.2.1 Raincoast Conservation Foundation

Raincoast Conservation Foundation is a non-profit research and public-education organization comprising research scientists and conservationists. The foundation conducted marine mammal surveys along the BC coast from 2002 to 2008 using line transect and distance sampling methods. These data, summarized in a technical report (Best and Halpin 2011), are included in this literature review. Attempts were made to obtain the raw data on marine mammals collected during these surveys through data-sharing requests; but, at the time of writing, no data were received.

3.2.1.2.2 BC Cetacean Sightings Network

The BCCSN, a Vancouver Aquarium research program, operates in partnership with DFO. The BCCSN gathers data on sightings of cetaceans and sea turtles along the BC coast and surrounding waters from a variety of sources, including researchers, tugboat captains, whale-watching operators, recreational boaters, coastal residents, BC Ferries personnel, and others. Data obtained from BCCSN included sightings of cetaceans in the study area from October 1989 to June 2013 (with one sighting from 1979). Data obtained from BCCSN were collected opportunistically with limited knowledge of the temporal or spatial distribution of observer effort. As a result, absence of sightings at any location does not demonstrate absence of cetaceans.

3.2.1.2.3 CetaceaLab

CetaceaLab is a non-profit research station that conducts land-based cetacean observations and acoustic recordings. It has two established stations in the study area (on Gil Island and Aristazabal Island) and one new station in 2013 (Rennison Island) that are operated by researchers, students, and volunteers. The data are not publicly available, and a data-sharing request was unsuccessful.

3.2.2 Results

A brief overview of the process used by COSEWIC, SARA, and British Columbia Conservation Data Centre (BCCDC) for listing species is provided below. Definitions used in DFO Important Areas (IAs) are also described. Results of the literature review for marine fish and invertebrates and marine mammals follows.

Committee on the Status of Endangered Wildlife in Canada

COSEWIC provides a “scientifically sound classification of wildlife species at risk of extinction” (Government of Canada 2013b). Scientific research and Aboriginal and community knowledge are used by the committee to determine the status of a species in Canada and to assess the species for protection under SARA. COSEWIC identifies seven risk categories: *not at risk*, *data deficient*, *special concern*, *threatened*, *endangered*, *extirpated,* and *extinct*. Species of *special concern* may become *threatened* or *endangered* because of biological traits and threats. Species listed as *threatened* are likely to become *endangered* if the factors contributing to their potential extirpation or extinction are not reversed. *Endangered* species face imminent extirpation or extinction. *Extirpated* species are no longer in the wild in Canada but exist elsewhere; *extinct* species no longer exist anywhere.

Species at Risk Act

SARA legislation implemented by the federal government is intended to prevent species from becoming *extirpated* or *extinct* and to plan for their recovery. SARA protects *threatened* and *endangered* species and their critical habitat on federal lands and waters. When a SARA species is also protected under the *Migratory Bird Convention Act* or the *Fisheries Act*, SARA also applies on provincial and territorial lands and waters. Species that are designated as species at risk by COSEWIC (*special concern*, *threatened*, *endangered,* or *extirpated*) may be listed under Schedule 1: List of Wildlife of Species at Risk. Once a species is listed under Schedule 1 as *threatened* or *endangered*, the species is formally protected under SARA, and a recovery plan is developed.

BC Wildlife Act and Provincial Lists of Species at Risk

The BC *Wildlife Act* is intended to guide 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 the BC Ministry of Environment 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. There are no legal obligations associated with red and blue listed species; 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*.

Ecologically and Biologically Significant Areas and Important Areas

Ecologically and Biologically Significant Areas (EBSAs) were defined as part of research conducted on the Pacific North Coast Integrated Management Area (Clarke and Jamieson 2006a, 2006b). Regional experts were consulted to define IAs based on uniqueness, aggregation, and fitness consequences for a variety of species, including marine fish and marine mammals. These IAs were then used as the basis for defining EBSAs. Experts ranked the IAs as low, medium, or high importance.

3.2.2.1 Marine Fish and Fish Habitat

3.2.2.1.1 Sediment and Water Quality

Water and sediment quality in Kitimat Arm have been influenced by a variety of historical and current human activities. These include the Methanex Corporation methanol plant, Eurocan Pulp and Paper Company kraft mill, District of Kitimat wastewater treatment plant and Rio Tinto Alcan (RTA) facility. Details about these operations are provided in Table 3.2-1. Log storage and handling operations have also occurred in the estuary. Numerous studies have identified PAHs as contaminants of concern in the region, largely attributed to the RTA facility (Norecol Dames & Moore Inc. 1997; NOAA 2009).

Table 3.2-1: Sources of Contaminants in Kitimat Arm

Operation	Operational Period	Discharge Details	Effluent Constituents[a]
Methanex Corporation methanol plant	1982–2005	Effluent discharge into Kitimat Arm and stormwater discharge into Beaver Creek and the Kitimat River	TSS, sodium and methyl formates, COD, methanol, ammonia, oil and grease
Eurocan Pulp and Paper Company kraft mill (unbleached)	late 1960s–2010	Effluent from unbleached kraft pulp and paper mill discharged into the Kitimat River, approximately 3 km upstream from Kitimat Arm	TSS, BOD5, colour, resin acids, tannin and lignin
District of Kitimat wastewater treatment plant	1969–present	Effluent discharged into Kitimat River approximately 4 km upstream of Kitimat Arm	TSS, BOD5, phosphorous, ammonia, nitrate, fecal coliform bacteria
Rio Tinto Alcan facility	1954–present	Effluent discharged indirectly through Moore and Anderson creeks and directly into Kitimat Arm	TSS, petroleum coke, aluminum, oil and grease, dissolved fluoride, dissolved iron, cyanide, PAHs

NOTES:

[a] TSS (total suspended solids); COD (chemical oxygen demand; a measure of oxygen consumed when organic matter in water is decomposed chemically or biologically); BOD5 (biochemical oxygen demand; the amount of oxygen consumed when organic matter in water is oxidized biologically, during a standard five day test).

SOURCES: BCMOE (1987), Warrington (1987), Norecol Dames & Moore Inc. (1997)

3.2.2.1.2 Sediment Quality

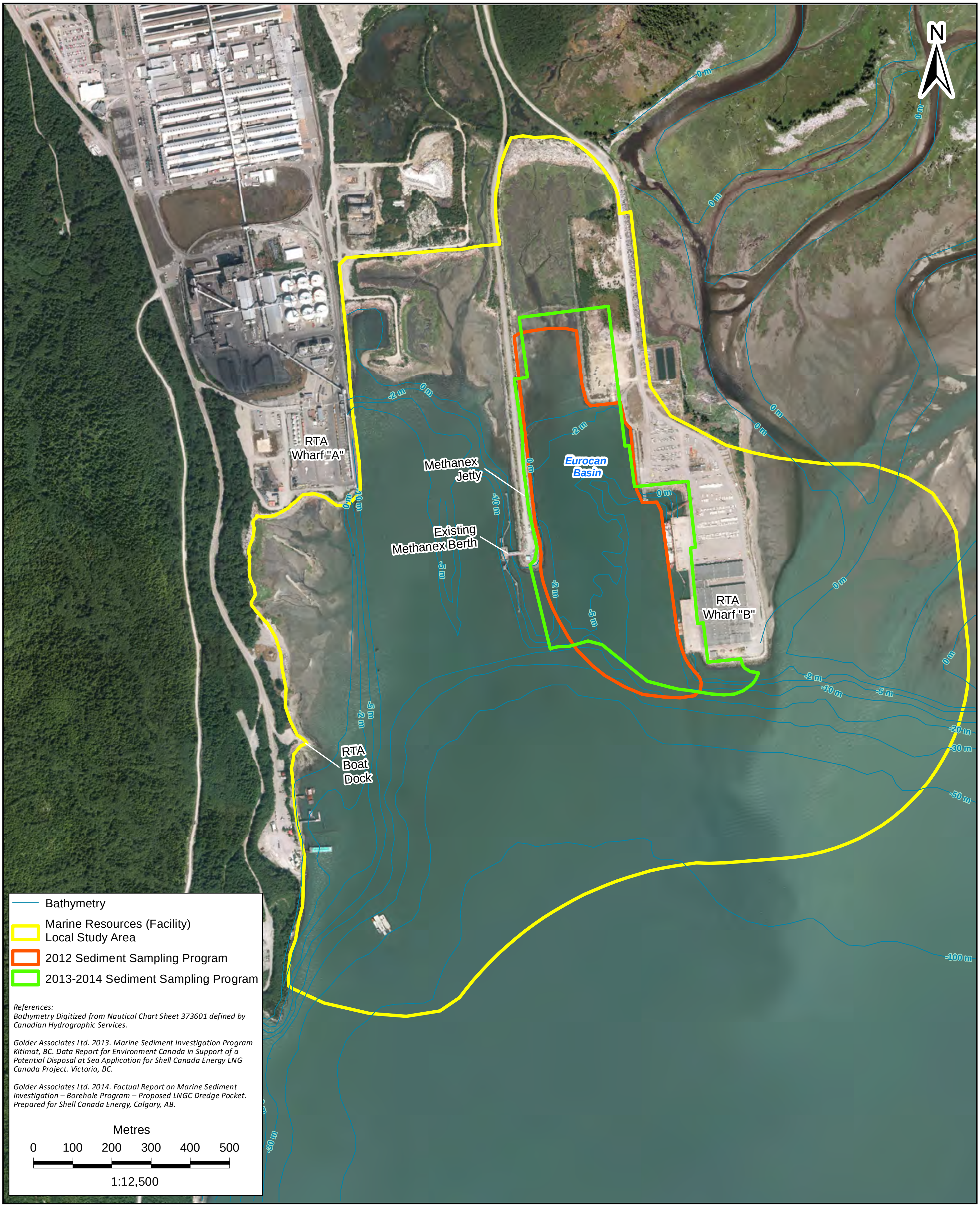
Sediment characteristics are used to assess the health of marine organisms in Kitimat Arm and the potential effects of the Project on the marine environment. Hydrophobic chemicals, such as PAHs, bind to sediment preferentially and settle out of the water column. Depositional areas comprise the habitat of many benthic invertebrates and can act as a sink for contaminants. Contaminants can affect organisms that are directly in contact with the sediment or bioaccumulate in species that prey on these organisms. PAHs are considered to be most relevant and most studied of the contaminants listed in Table 3.2-1. This review also considers metals, polychlorinated biphenyls (PCBs), dioxins and furans, and fluoride from a variety of sources.

Two studies, the Golder Associates Ltd. (2013, 2014a) sediment study conducted for the Project and the NOAA (2009) study, include recent sediment and biota sampling in the facility LSA and RSA.

Golder Associates Ltd. (2013, 2014a) describe a sediment sampling program conducted on behalf of LNG Canada from 2012 to 2014 to support analysis of dredging and disposal options at the marine terminal (between the Methanex jetty and RTA Wharf “B” in the Eurocan Basin, Figure 3.2-1). This study provides the most detailed data available on sediment PAHs and other contaminants in the facility LSA.

Vibracore samples were taken at 64 evenly distributed sites within the proposed dredge area (Golder Associates Ltd. 2013). Sediment core sample depths ranged from 0.26 m to 2.53 m below mudline. Deeper samples (1.5 m to 14.3 m below mudline) were taken at five locations using a rotary drill. Sample analysis included particle size and concentration of metals, PAHs, PCBs, extractable hydrocarbons and total organic carbon (TOC).

Sonic borehole samples were taken at an additional 42 sites in the dredge area (Golder Associates Ltd. 2014a). The target depth for each borehole site was 1 m below the design elevation of the base of the dredge area. The design elevation is -10 m CD in a small area at the north end of the dredge area and -14 m CD in all other areas. Sediment core samples were collected from each borehole at intervals of 0.5 m from mudline to 3.0 m below mudline, and at 1.0 m intervals from 3.0 m below mudline to maximum investigated depth of the borehole. High-frequency samples were also collected at select borehole sites at 0.25 m intervals from mudline to 3.0 m below mudline. Sediment core sample analysis included particle size, organic matter content, pH, moisture content, and concentrations of metals, PAHs, PCBs, petroleum hydrocarbons, volatile organic compounds, dioxins and furans, organic and inorganic carbon, chloride, and fluoride.



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MARINE RESOURCES TECHNICAL DATA REPORT

EXTENT OF SEDIMENT SAMPLING AT THE MARINE TERMINAL

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION UTM9	DRAWN BY SS
DATUM NAD 83	CHECKED BY SW
DATE 04-JUL-14	FIGURE NO. **3.2-1**

Because the main objective of the study was to support investigation of disposal options, the results were compared to Schedule 7 of the BC Contaminated Sites Regulations (BC CSR) for disposal on land and the federal Disposal at Sea Regulations (Schedule 5 of the *Canadian Environmental Protection Act, 1999*). The disposal at sea screening criteria for total PAH (2.5 mg/kg) is the sum of 16 individual PAHs. Results were compared to the Canadian Council of the Ministers of the Environment (CCME) sediment quality guidelines for the protection of aquatic life (CCME 1999b) for the threshold effect levels (TEL) and probable effect levels (PEL). Threshold effect levels are conservative values that have been adopted as Interim Sediment Quality Guidelines (ISQG) and represent concentrations above which adverse biological effects are expected occasionally. Concentrations above PELs are likely to result in frequent adverse biological effects. Relevant guidelines are summarized in Table 3.2-2.

Table 3.2-2: Sediment Quality Guidelines Used in Review of Historical Data

Parameter	Unit	CCME ISQG	CCME PEL	BC CSR	Disposal at Sea Screening Criterion
Total PAH	mg/kg	N/A	N/A	N/A	2.5
PCB	mg/kg	0.0215	0.189	0.23	0.10
Cadmium	mg/kg	0.7	4.2	1.5	0.6
Chromium	mg/kg	52.3	160	60	52.3
Copper	mg/kg	18.7	108	90	18.7
Zinc	mg/kg	124	271	150	124
Dioxins and furans	pg/g TEQ	0.85 a	21.5 a	350 b	N/A

NOTES:

[a] TEQ (toxicity equivalency quotient) for fish (CCME 1999a)

[b] TEQ for mammals (U.S. EPA 2008)

N/A = Not Applicable

The NOAA conducted a study of PAHs and fish health indicators in Kitimat Arm on behalf of Haisla Nation and RTA (NOAA 2009). Biological effects of PAHs were assessed in representative fish from the Kitimat region by comparing PAH concentrations in sediment at sites used by the fish with levels of PAH metabolites in the fish (see Figure 3.2-2 for location of sampling sites). Relative bioavailability of smelter-derived PAHs was assessed by comparing PAH levels in fish from Kitimat Arm with those from other areas with PAHs from non-smelter sources (Puget Sound). The following sampling and analyses were conducted:

- Juvenile chinook salmon were collected from 2000 to 2004 across six sites in Kitimat Arm and one reference site (Kildala Arm) outside Kitimat Arm. Juveniles of this species spend time feeding on plankton in the Kitimat River estuary before going out to marine waters and could be exposed to PAHs accumulated in their food supply during that time.
- Subadult to adult English sole (*Parophrys vetulus*) were collected over the same time span at four sites in Kitimat Arm and two reference sites outside Kitimat Arm (Kildala Arm and Kitlope). Adult yellowfin sole (*Limanda aspera*) were collected at the same sites in 2000 and

2002. These flatfish reflect a benthic pathway of PAH exposure and are resident year round in Kitimat Arm. Studies in Puget Sound, Washington State, indicate that English sole have a small home range, with the exception of annual winter spawning migrations (Meyers et al. 2008).

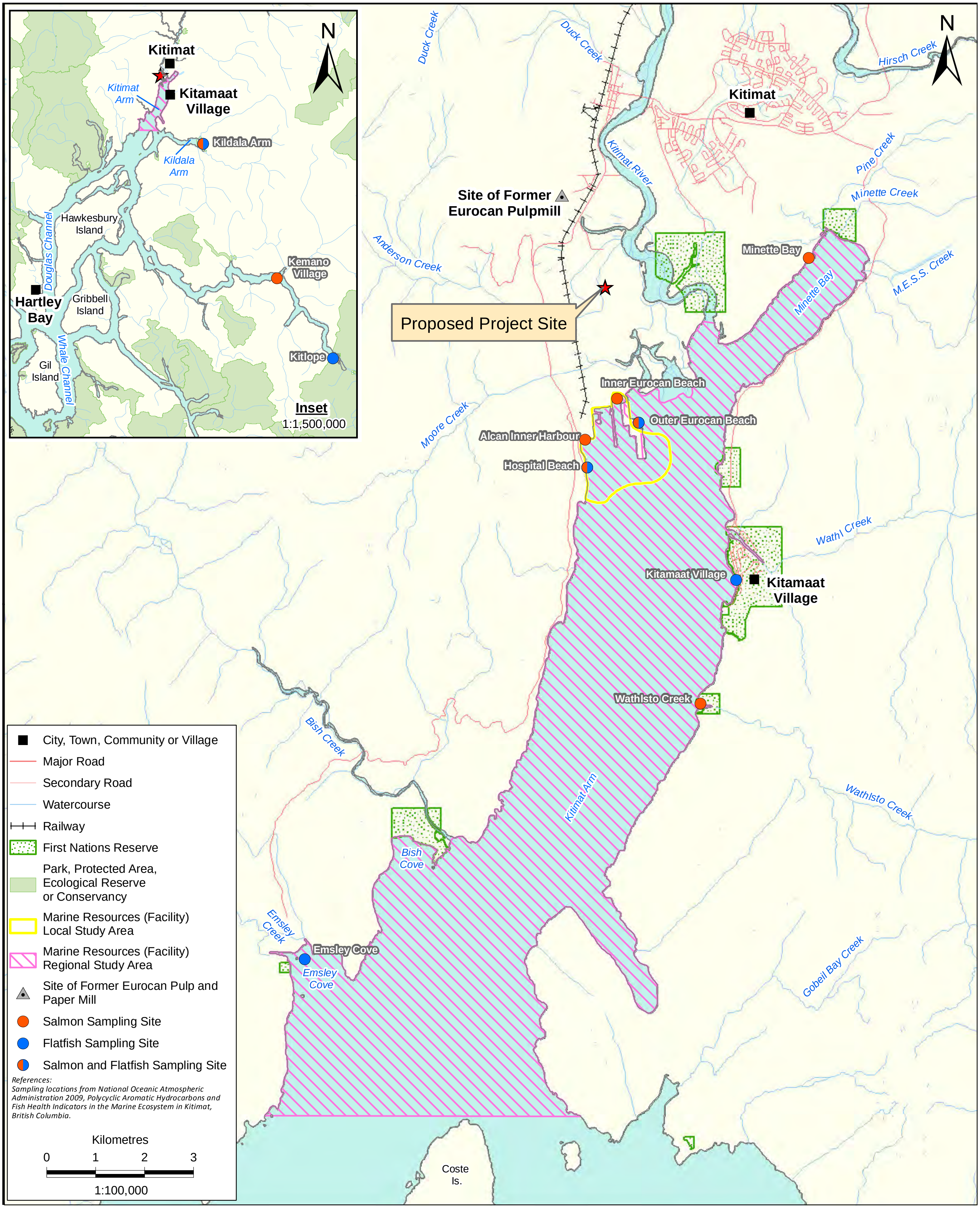
- Sediment grabs were taken at each salmon and sole sampling site; the top 2 cm to 3 cm of sediment from the sediment grab were taken for analysis.
- Sediment samples were analyzed for high and low molecular weight PAHs. Fish samples were aged and analyzed for PAHs (in stomach content), organochlorines (in stomach content and fish tissue), metals (in fish tissue), and PAH metabolites (in bile). Fish were also analyzed for evidence of PAH-induced health effects (e.g., DNA damage, liver lesions, inhibited gonadal development).

Appendix A, Table A-1, summarizes the sediment quality results for a variety of studies in Kitimat Arm. Sediment PAH concentrations listed in the table are grouped into results for the facility LSA and for the facility RSA, shown in Figure 3.2-2.

3.2.2.1.3 Sediment Chemistry in the Facility Regional Study Area

Sand is the dominant seabed substrate in the Alcan Inner Harbour (area between Methanex jetty and western shore of Kitimat Arm in the northwest of the facility LSA) where sand input from Kitimat River is high and in intertidal areas, while finer-grained substrates are common in deeper areas (Bornhold 1983). The TOC concentrations generally increase with distance from Kitimat River and range from 1.0% at Minette Bay to 1.8% on the western side of Kitimat Arm at Emsley Cove, and 3% in Douglas Channel (Cretney et al. 1983).

Sediment chemistry in Kitimat Arm has been strongly influenced by industrial developments in Kitimat (Table 3.2-1). PAH concentrations began to increase in the early 1950s (corresponding with opening of the aluminum smelter), and peaked in the 1970s, after which technological advancements in scrubber technology decreased PAHs in air emissions, effluent discharges, and marine sediment (Warrington 1987). Spatially, the concentration of PAHs declines with increasing distance from the RTA facility, with detectable levels measured as far as 12 km down Kitimat Arm (NOAA 2009).



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MARINE RESOURCES TECHNICAL DATA REPORT

LOCATION OF FISH SAMPLING SITES FROM NOAA 2009 REPORT

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION: UTM9	DRAWN BY: SS
DATUM: NAD 83	CHECKED BY: SW
DATE: 21-AUG-14	FIGURE NO. **3.2-2**

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PAHs

Several researchers have analyzed PAH concentrations in Kitimat Arm, using a variety of sampling locations, depths, methods, analysis and reporting units, which makes identification of spatial or temporal trends difficult.

The earliest field study was that of Cretney et al. (1983), conducted in the late 1970s. The reported total PAH levels included most, but not all, of the 16 parent PAHs used in modern sediment chemistry studies, including the disposal at sea screening criterion. Total PAH concentrations were highest at:

- the head of Kitimat Arm along the western shore (5.4 mg/kg to 10 mg/kg at Moon Bay, across from Kitamaat Village)
- lower down the Arm on the western shore (3.4 mg/kg near Bish Cove, 9 km from the RTA facility). and
- the eastern shore (2.4 mg/kg at Kitamaat Village, 3.5 km from the RTA facility).

Concentrations were lowest in the deep areas of the centre zone of Kitimat Arm (0.27 mg/kg to 0.74 mg/kg). The less soluble (i.e., less bioavailable) high molecular weight PAHs were predominant (Cretney et al. 1983).

Studies done in the 1990s in the deep, mid-channel areas of Kitimat Arm reported total PAH using all 16 parent PAHs. Simpson et al. (1996) reported the highest total PAH concentrations at the head of the Arm near the smelter (12 mg/kg to 528 mg/kg), and lower levels moving southward (21 mg/kg on the eastern shore, south of Wathlsto Creek, 8 km from the RTA facility; 41 mg/kg on the western shore north of Bish Cove, 7.5 km from the aluminum smelter). Paine (1996) and Simpson et al. (1998) reported high total PAH values adjacent to the smelter wharf (9,890 mg/kg and 5,500 mg/kg) and lower values down the Arm on the eastern shore (7 km from the RTA facility, 17 mg/kg) and western shore (Bish Cove, 2.44 mg/kg). The decrease over time in total PAH on the western side of Kitimat Arm was attributed to accumulation of cleaner sediment from Kitimat River (Paine et al. 1996). Simpson et al. (1998) concluded that PAH concentrations were higher in large particle size sediment than in fine sediment.

Recent studies have shown a decline in total PAH concentrations throughout Kitimat Arm, particularly near the smelter. Samples collected in Alcan Harbour from 2000 to 2004 had a mean value of 26 mg/kg total PAH. Mean values from the same period for Kitamaat Village (4 km from smelter), Wathlsto Creek (6 km from smelter), and Emsley Cove (12 km from smelter) ranged from 0.07 mg/kg to 1.5 mg/kg total PAH (NOAA 2009). Samples taken in 2006 on the western side of the Arm (7 km south of the smelter) ranged from less than 0.05 mg/kg to 3.16 mg/kg total PAH, and on the eastern side, near Wathlsto Creek (6 km from smelter), ranged from 0.06 mg/kg to 0.21 mg/kg total PAH (Jacques Whitford 2010).

The composition of individual parent PAHs in sediment indicates that the major source is pyrogenic (i.e., emissions from burning) rather than petrogenic (from oil sources), with historical smelter emissions likely to be the predominant source (Yunker et al. 2011). Some PAHs associated with decay of organic matter have also been recorded and were attributed to natural sources, logging operations, and pulp mill discharges (Yunker et al. 2011).

Other Constituents

Elevated metal (copper, lead, zinc, cadmium, and mercury) and fluoride concentrations have been reported in Kitimat Arm. Elevated fluoride concentrations are associated with the smelter; metal concentrations in the fine-grained sediment of the deep areas of Kitimat Arm are linked to a variety of industrial effluents (Warrington 1987). These deep areas are not well flushed, allowing metals to settle and accumulate over time. Naturally elevated levels of copper, lead, and mercury have been recorded in Kitimat River (MacDonald and Shepherd 1983; Warrington 1987).

Copper and chromium exceeded CCME ISQGs in samples taken in the southeast (6 km from the smelter) and southwest (7 km from the smelter) of the Arm in 2006 (Jacques Whitford 2010). Copper concentration ranged from 34.3 mg/kg to 51.1 mg/kg (CCME ISQG: 18.7 mg/kg); chromium ranged from 44.3 mg/kg to 55.7 mg/kg (CCME ISQG: 52.3 mg/kg).

Elevated dioxin and furan concentrations were recorded in the 1990s in the facility RSA. Sawmills in the area may have used chlorophenols for wood treatment, which can be a source of dioxins and furans (Warrington 1987). The Eurocan pulp and paper mill used a thermo-mechanical process and did not use a chlorine bleaching process, so it would not be expected to release dioxins and furans.

3.2.2.1.4 Sediment Chemistry in the Facility Local Study Area

PAHs

At the head of Kitimat Arm, mean total PAH concentrations (for 16 parent PAHs) in surface sediment collected between 2000 and 2004 ranged from 5 mg/kg (Hospital Beach) to 26 mg/kg (Alcan Harbour), with the highest values reported for sites nearest to the RTA smelter (NOAA 2009). Total PAH concentrations at Alcan Harbour, inner Eurocan Beach, and Hospital Beach fluctuated over the five-year study, with the lowest concentrations recorded in the final year (2004). PAH composition in sediment was similar to that in pitch used in the smelting process, whereas the PAH composition for samples from reference sites was indicative of natural sources (wood or decomposing matter).

Total parent PAH concentrations in the marine terminal were measured at 64 vibracore, 5 rotary drill sites (Golder Associates Ltd. 2013) and 42 sonic borehole sites (Golder Associates Ltd. 2014a).

Vibracores were collected from sediment depths between 0.26 m and 2.53 m below mudline, with two to three samples (depending on core length and percent recovery of sediment) taken from discrete depths in each core, resulting in a total of 133 samples collected from 64 cores. Total PAH concentrations in the samples submitted for analysis, ranged from less than laboratory detection limit (less than 0.05 mg/kg) to 163.7 mg/kg. Forty-six of the 64 cores contained concentrations of total PAH above Environment Canada’s disposal at sea screening criterion for sediment quality of 2.5 mg/kg. Individual PAH concentrations also exceeded the CCME PEL in various cores. Total PAH concentration varied widely across the site, with the highest levels recorded in the following areas:

- three cores taken adjacent to the south end of RTA Wharf “B” (63.3 mg/kg to 163.7 mg/kg)

- two cores taken adjacent to the north end of RTA Wharf "B" (68.9 mg/kg to 133.9 mg/kg), and
- three cores taken in the centre of the marine terminal (10.8 mg/kg to 16 mg/kg for samples taken at greater than 1 m depth below mudline or about three times higher than total PAH concentrations from less than 1 m depth in the same cores).

The deeper rotary drill samples (five cores, 26 total samples taken between 1.5 m and 14.3 m below mudline) ranged from 1.37 mg/kg to 5.86 mg/kg total PAH, with one sample greater than the disposal at sea screening criterion for sediment quality. This sample, taken adjacent to the south end of the Methanex jetty at a depth of 3.0 m to 3.7 m below mudline, had no individual parent PAH concentrations above CCME PEL guidelines or BC CSR standards. Total PAH concentrations were below the reported detection limit of 0.05 mg/kg in all samples collected deeper than 5.2 m below mudline.

Sonic sediment cores were collected from depths between 0 m and 14 m below mudline. Representative samples were collected at 0.5 m and 1.0 m intervals, depending on sample depth, in each core, resulting in 452 samples collected from 42 cores. Total PAH concentrations in the samples submitted for analysis ranged from 0.139 mg/kg to 207.7 mg/kg. Thirty-one of the 42 cores sampled contained concentrations of total PAH greater than the disposal at sea screening criteria for sediment quality. Individual PAH concentrations also exceeded the BC CSR standards and or CCME PEL and ISQG guidelines in various cores. Total PAH concentrations varied widely across the site, with the highest total PAH concentrations recorded between RTA Wharf "A" and the Methanex jetty. The greatest concentrations were recorded in two cores taken adjacent to the western portion of the Methanex jetty at 149.6 mg/kg and 207.7 mg/kg.

In most locations across the area sampled, total PAH concentrations decreased with depth below mudline. In the southeast and centre of Alcan Harbour, total PAH concentrations were highest in samples from 0.2 m to 1.0 m below mudline. In the northwest, adjacent to RTA Wharf "B," concentrations were highest in samples from 1.0 m to 2.5 m below mudline. In the northwest between RTA Wharf "A" and the Methanex jetty, total PAH concentrations were greatest between 4.5 m to 5.5 m below mudline.

3.2.2.1.5 Other Constituents

Concentrations of PCBs were analyzed in all sediment samples collected by Golder Associates Ltd. (2013) and contained concentrations below the reported detection limit of 0.030 mg/kg. This detection limit is greater than the IQSG; however, it is below all other relevant provincial and federal sediment quality guidelines outlined in Table 3.2-2. Golder Associates Ltd. (2014a) submitted 10 sediment samples for analysis of PCB concentrations. All samples submitted for analysis contained concentrations below the reported detection limit of less than 0.020 mg/kg, with the exception of one sample collected between 0 m and 0.25 m below mudline, which contained PCB concentrations greater than the IQSG (0.0215 mg/kg).

Levels of PCBs in stomach contents from salmon and flatfish collected for the NOAA (2009) study were higher in fish from Kitimat Arm than in fish from the reference site (Kildala Arm), with highest values reported for fish collected from Alcan Inner Harbour and Hospital Beach. However, concentrations were low in all samples (less than 50 ng/g ww). These concentrations are not considered to be harmful to fish and are below guidelines for human consumption (NOAA 2009).

Dioxins and furans were analyzed in six sediment cores collected by Golder Associates Ltd. (2013) and in seven sediment cores collected by Golder Associates Ltd. (2014a). Dioxin and furan levels are reported as toxicity equivalencies (TEQs), using toxicity equivalency factors (TEFs) for mammals (U.S. EPA 2008) for comparison with BC CSR standards for relocation to non-agricultural land; the highest value recorded was 12.64 pg/g TEQ, well below the BC CSR standard of 350 pg/g. Results were also calculated using the CCME ISQG and PEL (CCME 1999a). TEQ concentrations ranged from 1.51 pg/g up to 12.64 pg/g, with 9 of the 18 samples submitted for analysis (from 13 cores) containing concentrations greater than the ISQG (0.85 pg/g TEQ) but well below the PEL guidelines (21.5 pg/g TEQ).

Metals were analyzed in 133 vibracore and 26 rotary drill core samples collected by Golder Associates Ltd. (2013) and in 180 sonic samples collected from 35 borehole sites collected by Golder Associates Ltd. (2014a). In some samples, copper, cadmium, and zinc concentrations were higher than the ISQG guidelines, which are used for comparison when the parameter of concern does not have an applicable disposal at sea screening criterion. These results indicate naturally elevated levels of copper in sediment, with some isolated high concentrations of copper, cadmium, and zinc that could be related to human activities:

- Copper concentrations in the vibracore samples (0.26 m to 2.53 m below mudline) ranged from 11.2 mg/kg to 175 mg/kg. Fifty-nine samples submitted for analysis contained copper concentrations exceeding the CCME ISQG guideline of 18.7 mg/kg, and two samples collected off the southwestern side of RTA Wharf “B” had copper concentrations exceeding the CCME PEL guideline (108 mg/kg).
- Copper concentrations in the deeper rotary drill cores ranged from 14.1 mg/kg to 42.1 mg/kg and exceeded the CCME ISQG, but not the PEL, in 21 samples, including the deepest samples (14.3 m below mudline).
- Copper concentrations from the sonic sediment core samples (collected from 0 m to 14 m below the mudline) ranged from 13.4 mg/kg to 71.8 mg/kg. Of 180 samples submitted for analysis, 162 contained concentrations of copper that exceeded the CCME ISQG; however, concentrations were below both the PEL guideline and the BC CSR standard.
- Cadmium exceeded the disposal at sea screening criterion (0.60 mg/kg) and CCME ISQG (0.7 mg/kg) in three vibracore samples collected at depths of 1 m to 2 m below mudline, adjacent to RTA Wharf “B.” The highest concentration recorded was 1.62 mg/kg, lower than the CCME PEL of 4.2 mg/kg.
- Zinc concentrations exceeded the CCME ISQG (124 mg/kg) at four sites and exceeded the CCME PEL guideline of 271 mg/kg at one of these sites (391 mg/kg).

Concentrations of sodium chloride (184 mg/kg to 11,700 mg/kg) and soluble sodium (996 mg/kg to 9,690 mg/kg) were above BC CSR standards and may affect consideration for disposal on land; however, these parameters are not considered contaminants in the marine environment.

3.2.2.1.6 PAH Bioavailability

Despite the numerous studies showing elevated PAH concentrations in Kitimat Arm, particularly near the RTA smelter, studies conducted since the 1990s indicate low bioavailability of these PAHs (Paine et al. 1996; NOAA 2009; Yunker et al. 2011).

Paine et al. (1996) and Eickhoff et al. (2003) used a sediment-quality triad approach to assess the biological effects of elevated PAH levels. Concentrations of PAH in sediment were measured, toxicity of sediment to sand dollars (*Dendraster excentricus*) and the amphipod *Rhepoxynius abronius* was assessed, and resident community structure (benthic infauna and Dungeness crab) was characterized. There was a negative correlation between benthic community richness and PAH concentration in Alcan Harbour. However, there was no evidence of sediment toxicity to the species tested, despite total PAH concentrations of up to 9,890 mg/kg in Alcan Inner Harbour. There were minimal differences in the health of crabs from Alcan Harbour and the reference site.

Jacques Whitford (2010) also included toxicity testing of benthic invertebrates outside the LSA (7 km from the smelter) but found no evidence of toxicity.

Bioaccumulation of PAHs in soft shell clams (*Mya arenaria*) was studied between 1995 and 2000 (Yunker et al. 2011). PAH concentrations in sediment and clam tissue were highest at Hospital Beach and generally decreased with distance from the smelter. While clam tissue PAH concentrations were higher in Kitimat Arm than in the Kildala Arm reference site, bioaccumulation of smelter-related PAHs by clams in Kitimat Arm was low. Low uptake and associated low bioavailability of PAHs have been attributed to PAHs being associated with large particle sizes (Paine et al. 1996) and presence of the PAHs in pitch or soot (Yunker et al. 2011). The study concluded that plant-derived hydrocarbons were far more bioavailable to clams than smelter-derived PAHs, as evidenced by high concentrations of pulp mill–derived hydrocarbons in clams sampled near the outflow of Kitimat River. The composition of hydrocarbons found in these clams was similar to that of effluent released from the Eurocan Plant into Kitimat River.

Results reported by Eickhoff et al. (2003) for sampling conducted between 1995 and 1996 conflicted with those of Paine et al. (1996) and Yunker et al. (2011). Eickhoff et al. (2003) found PAH concentrations were higher in crabs near the smelter than in the rest of Douglas Channel. However, PAH concentrations detected in crabs near the smelter were low, potentially explaining why elevated concentrations were not detected by Paine et al. (1996), when higher detection limits were used.

Extensive sampling of PAHs in sediment, fish tissue, and fish stomach contents was done from 2000 to 2005, and results were compared with concentrations in the sediment at Puget Sound, Washington, where total PAH levels are similar to Alcan Harbour but composition is different (associated with industrial and urban sources, not a smelter source) (NOAA 2009). The study concluded that there was some evidence of PAH toxicity in flatfish, but not salmon, in the facility LSA.

3.2.2.1.7 Water Quality

In the facility LSA and RSA, air emissions and effluent discharges from the sources listed in Table 3.2-1 have influenced water quality in Kitimat Arm since the 1950s, with elevated concentrations of fluoride, metals, and PAHs documented at various times. In the 1980s, fluoride concentrations of up to 15 mg/L were recorded in Alcan Harbour (the facility LSA), which were 10 times higher than the BC water quality guideline of 1.5 mg/L (Warrington 1987). A study from the late 1970s reported elevated PAH concentrations in water in the facility RSA, attributed to a variety of sources, including air emissions and effluent discharges from the RTA smelter, woodstove exhaust, and residential waste (Warrington 1987; Harris 1999). Samples of bottom water taken at eight sites in the RSA in February 2006, south of Kitimat on the western and eastern shores (north of Bish Cove, 7 km from the smelter), were generally below BC water quality guidelines. The exceptions were cadmium (slightly above the BC guideline of 0.00012 mg/L at five sites), zinc (above the guideline of 0.01 mg/L at one site, with a value of 0.02 mg/L), and the PAHs chrysene and benzo(a)pyrene at several sites (Jacques Whitford 2010).

3.2.2.1.8 Tissue Contamination and Fish Toxicity

Several studies have been conducted on contaminant levels in tissue of marine organisms in Kitimat Arm as a result of community concerns and the interests of Haisla Nation. The primary focus has been on PAHs, related to smelter sources; but PCBs, metals, dioxins and furans have also been studied (see study details in Appendix A, Table A-2).

Marine organisms considered most likely to be exposed to and most likely to accumulate contaminants include pelagic fish (e.g., juvenile chinook salmon), demersal fish (e.g., yellowfin sole, English sole), and benthic organisms that live in or on sediments or filter feed near the benthos (e.g., clams, mussels, crabs). Anthropogenic and natural inputs of PAHs associated with particulate matter such as soot and sediment appear to be resistant to degradation and exhibit carcinogenic properties (Paine et al. 1996).

Dungeness crab, studied in 1994, had concentrations of 5 µg/kg to 20 µg/kg total PAHs in hepatopancreas tissue, barely above the laboratory detection limit used at that time (Paine et al. 1996). Abnormality and mortality for echinoderm toxicity tests in sediment were less than or equal to 10% abnormality, less than or equal to 30% mortality, and less than or equal to 50% combined, indicating minimal effects because of low bioavailability (Paine et al. 1996).

The clam *Mya arenaria*, studied in 1997, had mean total PAH concentrations ranging from 83 µg/kg dw (at a reference location in Kildala Arm) to 5,657 µg/kg dw (at Hospital Beach, closest to the RTA facility), with intermediate values at Eurocan Beach and Kitamaat Village (general locations overlap with those described in Simpson 1997 and NOAA 2009) (Figure 3.2-2).

Dungeness crab was also studied from 1994 to 1996 (Eickhoff et al. 2003). Evidence was found of bioavailability of PAHs, particularly low molecular weight PAHs, contradicting the Paine et al. (1996) report, which used higher analytical detection limits. There were differences in benzo(a)pyrene toxicity expressed as TEQ, with a mean of 1.36 at Hospital Beach, compared with a mean of 0.20 to 0.24 for the Kildala Arm reference site (Eickhoff et al. 2003). In the human health risk assessment done for the study, excess incidental lifetime cancer risks greater than 1E-6 were determined for every age group studied for consumption of crab at Hospital Beach, based on Haisla Nation consumption rate surveys.

Soft shell clam (*Mya arenaria*) studies conducted between 1995 and 2000 used Biota-Sediment Accumulation Factors (BSAFs) to further evaluate bioavailability of PAHs (Yunker et al. 2011). Results indicated that smelter-derived PAHs (from pitch, coke, or anode combustion) are not likely to be bioavailable to benthic organisms, whereas pulp mill–related plant diterpenes had BSAFs 20 to 50 times higher than those for smelter-derived sources (Yunker et al. 2011).

The NOAA study conducted from 2000 to 2004 included analysis of sediment, fish tissue, and fish health indicators in Kitimat Arm (NOAA 2009). Primary objectives of the study were to assess exposure of PAHs, PCBs, and organochlorines (OCs) in juvenile chinook salmon, flatfish, and their prey items in terms of stomach contents, muscle tissue concentrations, and biochemical response. Sampling locations are shown in Figure 3.2-2. Findings from NOAA (2009) are as follows:

- Concentrations of metals were near or below detection limit in English sole tissue samples and are not considered a significant source of deleterious effects in flatfish.
- Mean concentrations of total PCBs and OCs in juvenile chinook salmon and English sole stomachs ranged from 1 ng/g ww at reference locations in Kildala Arm to 7 ng/g ww (OCs in juvenile chinook salmon) and 22 ng/g to 44 ng/g ww (PCBs in English sole).
- Mean total PAH concentrations were several times higher in the stomachs and bile of juvenile chinook salmon and flatfish at the Alcan Inner Harbour compared with reference locations at Kildala Arm.
- Total PAH concentrations in muscle tissue were low in all fish species studied and not significantly different from reference values, in contrast to prey items such as *Mya arenaria,* which bioaccumulate PAHs in edible tissue.
- Mutagenic properties of PAHs were assessed based on levels of DNA adducts and liver damage in juvenile chinook salmon, and English and yellowfin sole. English and yellowfin sole had increased levels of DNA adducts, suggesting damage from mutagenic PAHs. Approximately 10% to 20% of English sole and 5% to 10% of yellowfin sole exhibited evidence of liver damage compared with 0% to 2% for reference locations. Juvenile chinook salmon DNA adducts and liver function were relatively unaffected, likely because of their wider range and pelagic, rather than benthic, habitat use.
- Light molecular weight PAHs (especially those from wood and plant diterpenes) were more likely to accumulate in tissues than were smelter-derived PAHs, as noted for fish samples from Eurocan Beach compared with the Alcan Inner Harbour. The plant diterpene retene comprised 17% of light molecular weight PAHs at Eurocan Beach near the pulp mill and 1% to 2% at the Inner Harbour.

3.2.2.1.9 Marine Fish and Invertebrates

A total of 409 species of marine fish have been reported in the coastal and offshore waters of BC (Hart 1973; Peden 2013). At least 75 species of marine fish and 100 species of marine invertebrates are known to occur in Kitimat Arm (see Appendix A, Table A-1). A number of these species are captured in CRA fisheries, including groundfish, pelagic fish, and Pacific salmon (Lucas et al. 2007b). Fisheries and Oceans Canada conducts regular stock assessments and scientific studies on marine fish species that are targeted by fisheries. As a result, generally more information is available for these species than for non-fishery species.

The facility RSA overlaps with IAs for eulachon, tanner crab (*Chionoecetes bairdi*), and cloud sponge (*Aphrocallistes vastus*) (Clarke and Jamieson 2006b). Based on recommendations by scientific experts, DFO selects IAs for individual species or species groups on the basis of three core criteria: (1) uniqueness of the habitat features, (2) the degree to which the species aggregates in the area, and (3) the importance of the area for use by the species for life history activities that contribute to the fitness of individuals of the species (DFO 2013g). Identifying IAs is the first step in the process of identifying a smaller number of spatially distinct EBSAs (DFO 2013g). No EBSAs have been identified in Kitimat Arm to date (Clarke and Jamieson 2006a). Temporal and spatial variations exist in the abundance of eulachon, tanner crab, and cloud sponge within the boundaries of the designated IA. Designation of an area as an IA for a species does not afford the specific area or the species within it any additional regulatory or legislative protection.

Certain species of marine fish that occur in Kitimat Arm have high ecological and or socio-economic importance, such as Pacific salmon, eulachon, and Pacific herring. The sensitive life history periods of these fish species are listed in Table 3.2-3. The ecological role, life history, and present status of these and other species of ecological and socio-economic importance are described below.

Table 3.2-3: Sensitive Life History Stages of Marine Fish in Kitimat Arm

Species	Inbound Spawner Migration	Spawning Period	Peak Spawning Period	Outbound Juvenile Migration
Chinook salmon *Oncorhynchus tshawytscha*	early May–late July	June 15–September 15	August 15	early April– early June
Chum salmon *Oncorhynchus keta*	mid-June– September 1	July 15–October 15	August 9	early April– early June
Pink salmon *Oncorhynchus gorbuscha*	mid-June– September 1	July 15–September 15	August 8	early April–late May
Sockeye salmon *Oncorhynchus nerka*	June 10–July 15	August 5–September 30	August 25	late May
Coho salmon *Oncorhynchus kisutch*	July 1–October 31	August 25–December 15	November 5	mid-April–July
Steelhead trout *Oncorhynchus mykiss*	mid-March–June 1	March 15–May 30	April 15	May–June
Eulachon *Thaleichthys pacificus*	February–March	early March	March	April–August

Species	Inbound Spawner Migration	Spawning Period	Peak Spawning Period	Outbound Juvenile Migration
Pacific herring *Clupea pallasii*	January–February	February–May	March	September–October
Pacific halibut *Hippoglossus stenolepis*	N/A	November–March	NS	P
Dungeness crab *Metacarcinus magister*	N/A	April–May	NS	P
Shrimp Family Pandalidae	N/A	late fall – early winter	NS	P

NOTES:
NS – not specified
N/A – not applicable
P – passive transport of larvae away from spawning grounds by currents
SOURCES: Morris and Eccles (1977); MacDonald and Shepherd (1983); McCarter and Hay (1999); Hyatt et al. (2007); Schweigert et al. (2007); Hay and McCarter (2012); DFO (2013d, 2014)

Pacific Salmon

Pacific salmon belong to the family Salmonidae, which includes whitefishes, graylings, salmon, trout, and char. Six species of Pacific salmon in Canada belong to the genus *Oncorhynchus,* including pink salmon, chum salmon, sockeye salmon, coho salmon, chinook salmon, and steelhead trout. Pacific salmon are the most socio-economically valuable species in BC and are targeted in CRA fisheries.

Pacific salmon occur in an estimated 1,300 to 1,500 rivers and streams in BC and the Yukon (DFO 2013f). The most important rivers for Pacific salmon in BC include the Skeena River and Nass River in the north, and the Fraser River in the south, which together account for 75% of the salmon population in the province (DFO 2013f).

The Kitimat River watershed supports all five species of Pacific salmon as well as steelhead trout (Bell and Kallman 1976; MacDonald and Shepherd 1983). The sensitive life history stages of Pacific salmon in the Kitimat, Kildala, and Dala river watersheds identified by Hyatt et al. (2007) and MacDonald and Shepherd (1983) are listed in Table 3.2-4. Salmon spawning rivers in the facility RSA are shown in Figure 3.2-3 (DFO 2013c, 2013e). In Kitimat, Pacific salmon spawn from June to December, and steelhead trout spawn from March to May. Pink salmon are the most abundant species of salmon on the BC north coast, including Kitimat Arm (Hyatt et al. 2007). In North America, pink salmon have a fixed two-year lifecycle where even-year fish and odd-year fish are completely reproductively isolated (DFO 2001; Merchant et al. 2014). In the Kitimat River watershed, the spawning aggregations of even-year pink salmon greatly exceed those of odd-year pink salmon (Hyatt et al. 2007). Pink and chum salmon tend to spawn in lower and tidal areas of rivers (MacDonald and Shepherd 1983).

From 1997 to 2006, total returns of all species of Pacific salmon on the BC north coast have declined to well below the long-term average (Hyatt et al. 2007). The BC north coast chum stock is currently depressed; DFO’s 2013 salmon outlook identified it as a stock of conservation concern (DFO 2013f).

Table 3.2-4: Marine Fish and Invertebrate Species at Risk in the Facility and Shipping RSAs

Species	Population	Provincial Status[a]	SARA Status[b]	COSEWIC[c]	Use of RSA[b,c]
Bluntnose sixgill shark *Hexanchus griseus*	Northeast Pacific Ocean	no status	Schedule 1, *special concern*	*special concern*	May occur in the facility and shipping RSA; present throughout Canada's Pacific waters, including inlets
Bocaccio *Sebastes paucispinis*	Pacific Ocean	no status	no status	*endangered*	May occur in the shipping RSA; distributed along the outer Pacific coast of Canada
Canary rockfish *Sebastes pinniger*	Northeast Pacific Ocean	no status	no status	*threatened*	May occur in areas of the facility and shipping RSA with hard substrate; widely distributed throughout BC coastal waters, including enclosed waters and inlets
Darkblotched rockfish *Sebastes crameri*	Pacific Ocean	no status	no status	*special concern*	May occur in the shipping RSA; widespread in continental shelf and slope waters along the entire coast of BC
Eulachon *Thaleichthys pacificus*	Central Pacific Coast population	*blue*	no status	*endangered*	Facility RSA encompasses a major spawning river (the Kitimat River); larvae rear near the surface of estuaries in deep, cold fjords
Green sturgeon *Acipenser medirostris*	Pacific Ocean	*red*	Schedule 1, *special concern*	*special concern*	May occur in the facility and shipping RSA; found on the Pacific coast near the mouths of large rivers
Longspine thornyhead *Sebastolobus altivelis*	Pacific Ocean	no status	Schedule 1, *special concern*	*special concern*	May occur in the shipping RSA; present in deep waters along the along the continental slope in Canada's Pacific waters
North Pacific spiny dogfish *Squalus suckleyi*	Northeast Pacific Ocean	no status	no status	*special concern*	May occur in the facility RSA; present throughout Canada's Pacific waters from the intertidal to shelf slope
Northern abalone *Haliotis kamtschatkana*	Northeast Pacific Ocean	*red*	Schedule 1, *endangered*	*endangered*	May occur in the facility RSA and present within the shipping RSA; found along exposed and semi-exposed rocky coastlines throughout BC
Olympia oyster *Ostrea conchaphila*	Pacific Ocean	*blue*	Schedule 1, *special concern*	*special concern*	May occur at a few locations within the shipping RSA; found in the lower intertidal and shallow subtidal zones of sheltered bays and estuaries

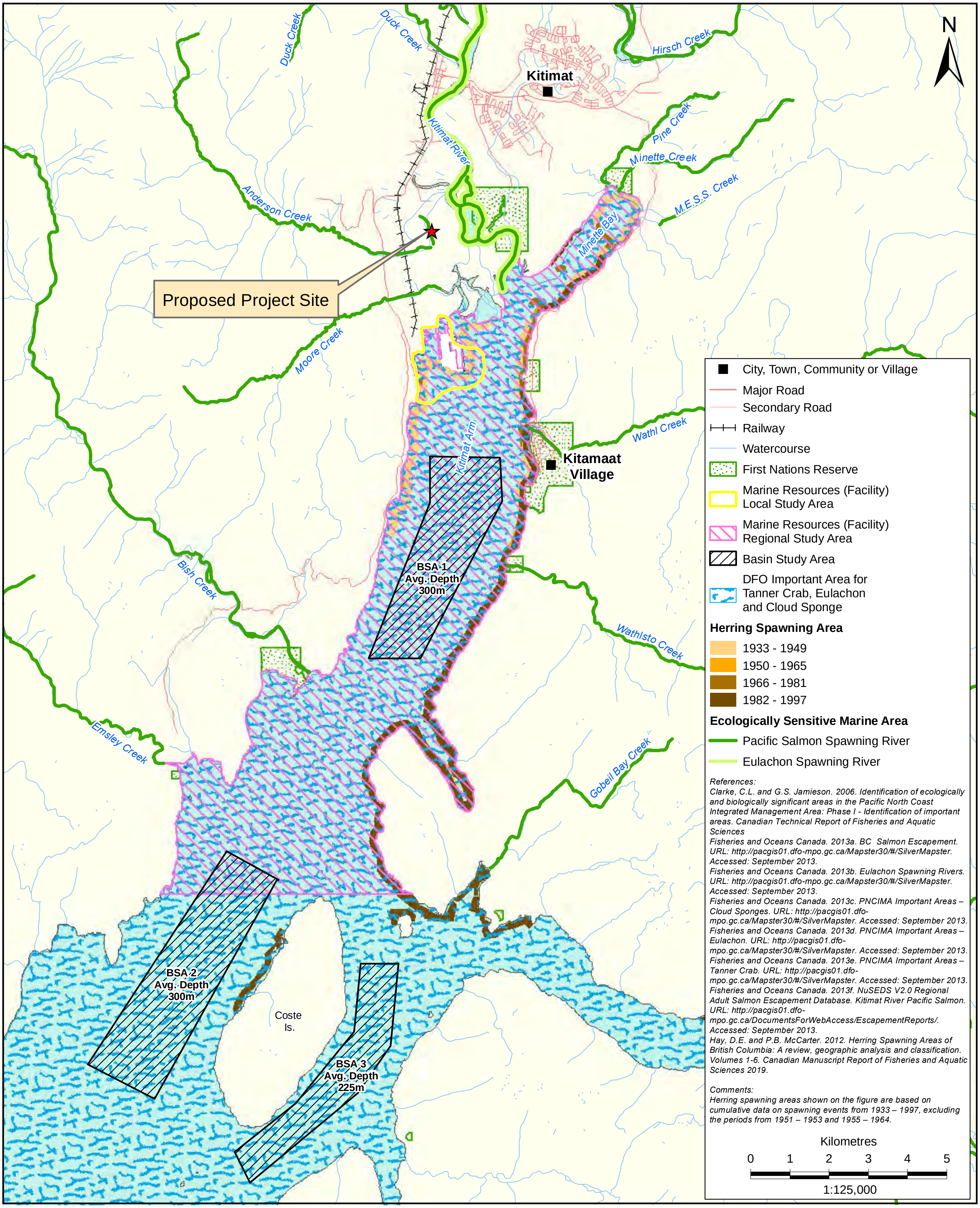
Species	Population	Provincial Status[a]	SARA Status[b]	COSEWIC[c]	Use of RSA[b,c]
Quillback rockfish *Sebastes maliger*	Northeast Pacific Ocean	no status	no status	*threatened*	May occur in areas of the facility RSA with hard substrate; present throughout BC coastal waters, including enclosed waters and inlets
Rougheye rockfish *Sebastes* sp. type I and type II	Pacific Ocean	no status	Schedule 1, *special concern*	*special concern*	May occur in the shipping RSA; present along the continental slope in Canada's Pacific waters
Tope *Galeorhinus galeus*	Pacific Ocean	no status	Schedule 1, *special concern*	*special concern*	May occur in the shipping RSA; occur in Canada's Pacific continental shelf waters
Yelloweye rockfish *Sebastes ruberrimus*	Pacific Ocean inside and outside waters populations	no status	Schedule 1, *special concern*	*special concern*	May occur in areas of the facility and shipping RSA with hard substrate; present throughout BC coastal waters, including enclosed waters and inlets
Yellowmouth rockfish *Sebastes reedi*	Pacific Ocean	no status	no status	*threatened*	May occur in the shipping RSA; distributed throughout coastal marine waters in BC

SOURCES:

[a] BCCDC (2014)

[b] Government of Canada (2012)

[c] Government of Canada (2013a)



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MARINE RESOURCES TECHNICAL DATA REPORT

MARINE FISH HABITAT FEATURES

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION UTM9	DRAWN BY SS
DATUM NAD 83	CHECKED BY SW
DATE 21-AUG-14	FIGURE NO. 3.2-3

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Pacific Herring

Pacific herring is a small, widely-distributed pelagic fish. It is considered an ecologically important species because it is an important forage fish for many species of fish, birds, and marine mammals (Livingston 1993; Saulitis et al. 2000; Gustafson et al. 2006). Herring is among the most socio-economically valuable species in BC; it is targeted in CRA fisheries, which include roe, spawn on kelp, food and bait, and special-use fisheries (DFO 2013l).

In Kitimat Arm, Pacific herring spawn in late winter from February to May, with the peak spawning period occurring in March (Hay and McCarter 2012). Spawning occurs along the shoreline in the intertidal to shallow subtidal zones between high tide and depths of 11 m (Hart 1973; Rooper et al. 1999). The eggs are very sticky when deposited and adhere, in large masses, to a variety of substrates (Taylor 1964; Hart 1973): rocks, pilings, and debris, but primarily marine vegetation, such as common eelgrass (*Zostera marina*), Japanese wireweed (*Sargassum muticum*), and rockweed (Taylor 1964; Hart 1973). Pacific herring will spawn every year, with each female depositing as many as 20,000 eggs (Hay 1985; DFO 2013l). However, the rate of spawn mortality is high, with estimates ranging from 56% to 100% depending on spawning location (Taylor 1964; Rooper et al. 1999).

Although there is inter-annual variation in specific spawning locations, general spawning areas are relatively consistent from one year to the next (Hay 1985). Pacific herring spawning areas in the facility LSA and RSA identified by Hay and McCarter (2012) are shown in Figure 3.2-3. Spawning areas shown on the figure are based on cumulative data on spawning events from 1933 to 1997.[3] Once spawning is complete, adult Pacific herring return to offshore feeding areas (DFO 1974).

In BC, two of the five major stock assessment areas for Pacific herring have been closed to commercial fishing for a number of years because of low estimated stock abundance, including Haida Gwaii and the Central Coast (DFO 2013l). Kitimat Arm is not included as one of DFO's five major herring stock assessment areas; however, the 2011 to 2012 recruitment forecast for the nearby Prince Rupert District and Central Coast stocks were rated as average and poor, respectively (DFO 2013l).

Eulachon

Eulachon is a short-lived, anadromous species of pelagic fish, meaning that it spends most of its life in marine waters before spawning in coastal rivers (McCarter and Hay 1999; Schweigert et al. 2007). Eulachon is distributed across the northeast Pacific Ocean and surrounding freshwater rivers from northern California to Alaska (McCarter and Hay 1999). Eulachon is an ecologically important species because it is preyed on by a wide variety of marine fish, mammals, and birds during its annual spawning migration (Hart 1973). The species is valued for its high oil content and is particularly important to First Nations communities who harvest it for food, social, and ceremonial purposes (COSEWIC 2011b; Schweigert et al. 2007).

[3] Data for 1951 through 1953 and 1955 through 1964 are not available.

The preferred spawning habitats of eulachon are estuaries at the lower reaches of rivers that are associated with glaciers and snowpacks and spring freshets (COSEWIC 2011b; McCarter and Hay 1999; Schweigert et al. 2007). Timing of eulachon spawning varies among rivers in BC, with the Kitimat River being among the earliest, beginning in early March (Pedersen et al. 1995; McCarter and Hay 1999). Eulachon that spawn in Kitimat River might be the same population that spawn in adjacent rivers and streams at the head of Douglas Channel, and might be able to switch among spawning rivers (McCarter and Hay 1999).

The facility RSA encompasses one major eulachon spawning river, Kitimat River, and overlaps with an IA for eulachon that extends south to Maitland and Hawkesbury islands and includes Foch Lagoon and Gilttoyees Inlet (Hay and McCarter 2000; Clarke and Jamieson 2006b; Schweigert et al. 2007; DFO 2013h). Figure 3.2-3 shows eulachon spawning rivers and the IA for eulachon in the RSA.

Declines in eulachon spawning runs were observed from California to southeast Alaska during the early to mid-1990s (Schweigert et al. 2007). Since 1994, eulachon populations have declined in Douglas Channel and Kitimat Arm, with particularly poor runs since the early 2000s (Schweigert et al. 2007). By 2011, eulachon populations in Douglas Channel and Kitimat Arm had declined to such low levels that they were considered to be virtually extirpated in the Kitimat River (COSEWIC 2011b). Widespread declines in eulachon are likely related to large-scale climate change that has resulted in a gradual shift in the timing of freshet events from spring to summer and fall (McCarter and Hay 1999; Schweigert et al. 2007; COSEWIC 2011b). This shift in the timing of freshet events alters patterns of estuarine circulation in eulachon spawning and rearing habitat (McCarter and Hay 1999). Habitat degradation and industrial discharges have likely contributed to eulachon declines in some areas (McCarter and Hay 1999; COSEWIC 2011b). Eulachon is on the provincial Blue List and has been designated as *endangered* by COSEWIC (Table 3.2-4).

Rockfish

Rockfish (*Sebastes* spp.) are distributed across the northeast Pacific, where they live in subtidal habitats in water depths ranging from 14 m to 143 m (COSEWIC 2009; DFO 2012). Inshore rockfish (yelloweye [*S. ruberrimus*], quillback [*S. Maliger*], copper [*S. caurinus*], china [*S. nebulosus*], black [*S. melanops*], tiger [*S. nigrocinctus*]) tend to live near rocky reefs in relatively shallow water (Yamanaka and Lacko 2001). Many species of rockfish are harvested in CRA fisheries in BC (DFO 2012).

Rockfish are inherently vulnerable to human activities and overexploitation in fisheries because of their life history traits (i.e., slow growth, late maturation, and low natural mortality) (COSEWIC 2009). A number of rockfish populations in BC have been overfished, and fishing is considered the primary threat to rockfish. In an effort to conserve rockfish populations, DFO has established rockfish conservation areas (RCAs) throughout BC coastal waters where commercial and recreational fishing activities are prohibited year round to conserve rockfish populations. A total of 164 RCAs have been established in BC to date, which together account for an estimated 30% of inshore rockfish habitat in the province (COSEWIC 2009). No RCAs have been designated in the facility RSA, although there are a number of RCAs in the shipping RSA.

A number of rockfish species in BC waters have been identified as species at risk (see Table 3.2-4). Rougheye rockfish (*Sebastes* sp. types I and II) and yelloweye rockfish are listed as *special concern* under Schedule 1 of SARA (Government of Canada 2012). Bocaccio (*S. paucispinis*), canary rockfish (*S. pinniger*), darkblotched rockfish (*S. crameri*), quillback rockfish, and yellowmouth rockfish (*S. reedi*) have been designated as species at risk by COSEWIC, but are not listed under SARA.

Dungeness Crab

Dungeness crabs are distributed from the Aleutian Islands, Alaska to Magdalena Bay, Mexico within the intertidal to depths of 230 m (Fong and Gillespie 2008; DFO 2013k). They are usually found on sandy bottoms less than 50 m deep, subject to moderate to strong currents (DFO 2000). Dungeness crabs are among the most common benthic macroinvertebrates in BC, including within the facility and shipping LSA and RSA, and are harvested in CRA fisheries (DFO 2000; Fong and Gillespie 2008).

The shipping LSA and RSA overlap significantly with the North Coast Mainland – Management Area B of the commercial crab-by-trap fishery (DFO 2013k, 2014). Recreational and Aboriginal crab fishing may occur year round in the shipping RSA where they extend over nearshore areas in closer proximity to coastal communities.

Mating is generally synchronous coast-wide in BC and normally occurs from April to May (DFO 2013k, 2014). Hatching occurs from December to June, with a peak in March (Fong and Gillespie 2008). Larvae develop for three to four months and become dispersed by currents before settling to substrate (DFO 2000). Larvae typically settle in inshore intertidal and subtidal habitats, often in estuaries such as the Kitimat River estuary (DFO 2013k, 2014), which falls in the facility LSA and RSA.

The diet of a Dungeness crab depends on its life stage. Larvae feed offshore in the water column on zooplankton and phytoplankton; juveniles forage in littoral habitats on clams and mussels, small fish, molluscs, shrimp, and other crabs (DFO 2013k). Adults feed on clams and mussels, crustaceans, worms and fish (DFO 2013k).

Tanner Crab

Tanner crabs are distributed through the Sea of Japan, the Sea of Okhotsk, the Bering Sea, the Gulf of Alaska, and along the west coast of North America to California (Parvin et al. 2007). In BC, tanner crabs are found in both coastal inlets and offshore. While there have been attempts to establish a fishery for tanner crabs in the past, there is no commercial fishery for tanner crabs in BC at present; and, they are only rarely caught by recreational fishers. The biology of tanner crabs, described in detail in Krause et al. (2001), is summarized here.

Tanner crabs occur in the shallow subtidal zone to depths of approximately 4,600 m (Fong and Dunham 2007). Adults are distributed over a wide bathymetric range, but generally remain deeper than 100 m. Juveniles are typically found in depths less than 80 m. Tanner crabs undertake seasonal migrations patterned around major life-history events, including hatching, spawning, and moulting. In the spring, tanner crabs aggregate for mating at depths of approximately 150 m.

Tanner crabs prefer soft substrates and may be found on, or buried in, sand and mud. Juveniles may also be found in biogenic habitats (i.e., habitats created by biota) created by epiphytic bryozoans and hydroids. Oceanographic features, such as water temperature, salinity, currents, and upwelling, also have a strong influence on their dispersal, mortality, growth rates, and abundance. Tanner crabs are sensitive to variation in salinity and remain at depths where salinity remains relatively stable.

Tanner crabs are opportunistic feeders and feed on a variety of prey, including molluscs, crustaceans, polychaetes, fish, and the bodies of post-spawning salmon. They are prey for invertebrates, fish, and marine mammals, and serve as an important food source for Pacific cod (*Gadus macrocephalus*).

The facility RSA overlaps with an IA for tanner crabs that includes Kitimat Arm and a large portion of inside waters of the BC north coast (Figure 3.2-3; Clarke and Jamieson 2006b; DFO 2013a).

Clams

Clams are bivalve molluscs that live in soft substrates in the intertidal zone. Clams are broadcast spawners and reproduce by releasing gametes into the water column, where fertilization occurs (DFO 2013b). Following fertilization, pelagic larvae are distributed in the water column for three to four weeks before settling in the mid to low intertidal zone of suitable beaches where they will remain for life (DFO 2013b).

In BC, four intertidal clam species comprise most landings in CRA fisheries: Manila (*Venerupis philipinarum*), butter (*Saxidomus gigantea*), littleneck (*Leukoma staminea*), and razor (*Siliqua patula*) clams (DFO 2013b). The commercial clam fishery primarily targets Manila clams, which are predominantly found in DFO's South Coast Management Areas. There are few Manila populations in the BC north coast. The Baltic macoma (*Macoma inconspicua*) is the dominant bivalve mollusc in Kitimat Arm (Bell and Kallman 1976). The entire RSA is closed to bivalve shellfish harvesting because of biotoxin and sanitary contamination (DFO 2013m). Abundance estimates are not available for individual beaches or clam management areas (DFO 2013b).

Shrimp and Prawn

In BC, seven species of shrimp in the family Pandalidae (pandalid shrimp) are harvested in CRA fisheries, including spot prawn (*Pandalus platyceros*), humpback shrimp (*P. hypsinotus*), coonstripe shrimp (*P. danae*), smooth pink shrimp (*P. jordani*), northern pink shrimp (*P. borealis eous*), flexed shrimp (*P. goniurus*), and sidestripe shrimp (*Pandalopsis dispar*) (DFO 2013d).

Pandalid shrimp have a life span of approximately four years, maturing and mating first as males before becoming females in the final one to two years of their lives (DFO 2013d). Spawning typically occurs in late fall and early winter, and the females carry the developing eggs externally (DFO 2013d). Eggs hatch in spring, and pelagic larvae are then released into the water column for approximately three months before settlement. Pandalid shrimp settle in benthic habitats where they are often preyed upon by benthic fish (DFO 2013d). They are opportunistic foragers, consuming fresh or decaying organic material (DFO 2013d).

Large decreases in catches of pandalid shrimp were observed coast wide in 2010 and 2012, but a high annual catch was observed in 2011 (DFO 2013d).

3.2.2.1.10 Marine Fish and Invertebrate Species at Risk

In this report, species at risk refers to species designated as *extirpated*, *endangered*, *threatened*, or *special concern* under Schedule 1: List of Wildlife Species at Risk of SARA, or by COSEWIC. Eight marine fish and invertebrate species at risk may occur in both the facility and shipping RSAs, and an additional seven may occur in the shipping RSA (Table 3.2-4). All 15 species are designated as at risk by COSEWIC; seven species are listed under Schedule 1 of SARA; two species are on the provincial Red List; and two species are on the provincial Blue List (Government of Canada 2012, 2013a; BCCDC 2014).

Marine Fish Habitat

Fish habitat is defined under the *Fisheries Act* as “spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to carry out their life processes.” BC’s north coast provides ample habitat for a wide variety of marine fish species. Some species reside in the region throughout their lives, whereas other species migrate to the north coast seasonally or during certain life stages (Lucas et al. 2007b).

Marine fish habitat types on BC’s north coast include marine riparian habitat, intertidal habitat, subtidal habitat, estuaries and salt marshes, and kelp and eelgrass beds (Jamieson and Davies 2004; Lucas et al. 2007a; Lucas et al. 2007b). The biological and physical characteristics of these habitats are described below.

Marine Riparian Habitat

Marine riparian habitat (also known as the backshore zone) is the area that extends landward from the higher high-water large tide to the top of a coastal cliff or limit of marine processes (Williams 1993). Although freshwater riparian areas have been studied extensively, the processes, structure, and functions of marine riparian areas and their role as fish and fish habitat are poorly understood (Levings and Jamieson 2001; Brennan and Culverwell 2004; Lemieux et al. 2004).

Marine riparian vegetation in BC includes numerous species of marsh plants, grasses, sedges, shrubs, and trees found at or near higher high-water large tide (Levings and Jamieson 2001; Williams 1993). Many plant species in marine riparian areas are limited by the presence of salt water, whereas others, such as Lyngbye’s sedge (*Carex lyngbyei*) and cottonwood (*Populus balsamifera*), grow in soils subject to inundation or saturation by brackish water (Levings and Jamieson 2001). Common vegetation species that occur in the marine riparian zone of the facility RSA include western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*), yellow-cedar (*Chamaecyparis nootkatensis*), Lyngbye’s sedge, tufted hair-grass (*Deschampsia cespitosa*), and seaside arrowgrass (*Triglochin maritima*) (MacKenzie et al. 2000).

Vegetation and woody debris in marine riparian areas serve a number of ecological functions, including foraging, refuge, and spawning substrate for fishes, and foraging, refuge, spawning, and attachment substrate for invertebrates and algae (Brennan and Culverwell 2004; Lemieux et al. 2004). Marine riparian habitat does not necessarily have to be vegetated to be considered important fish habitat because unvegetated substrates are used by some fish species, such as Pacific herring and sand lance (family Ammodytidae), for spawning and egg incubation (Levings and Jamieson 2001).

Intertidal Habitat

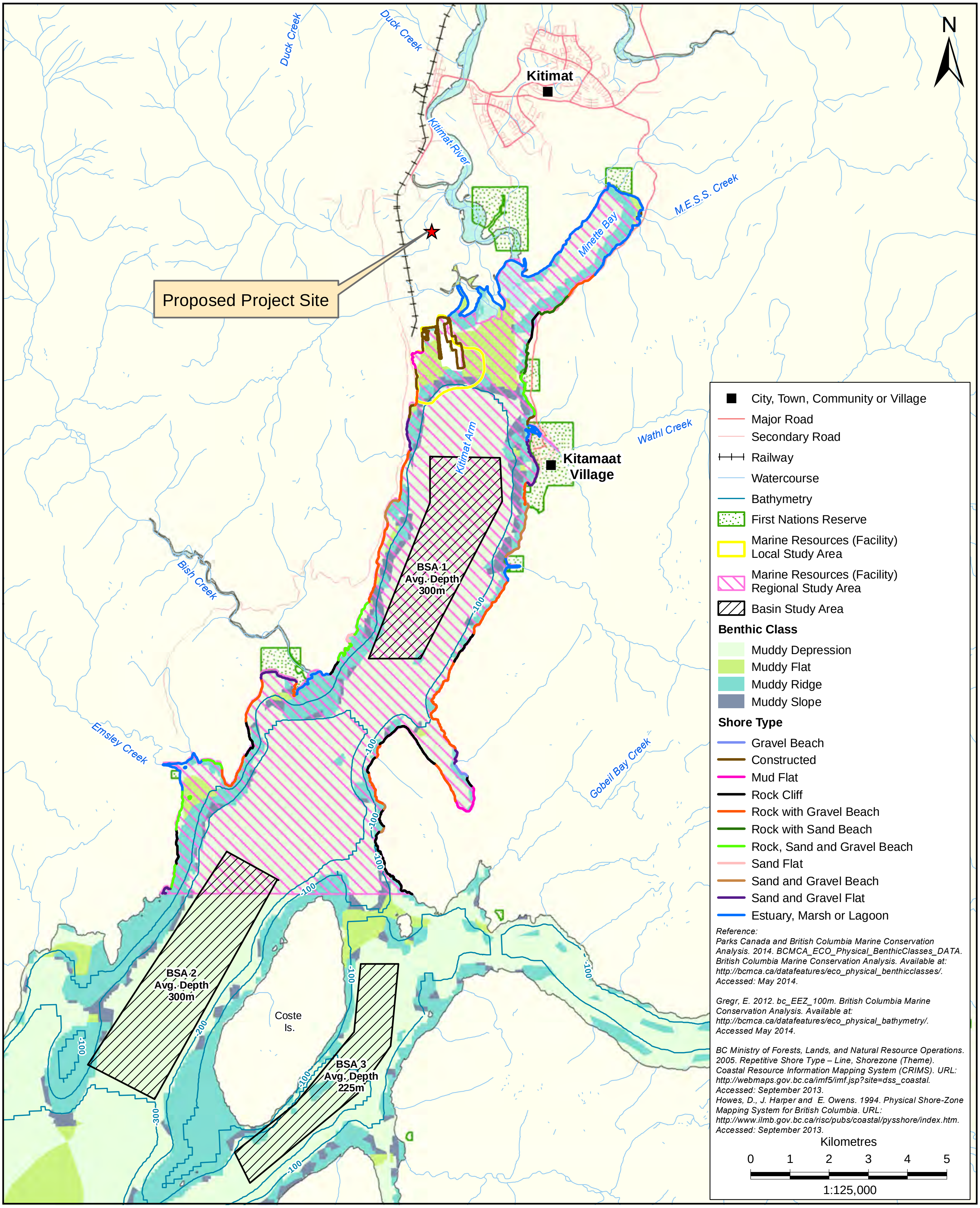
The intertidal zone is defined as the area between the higher high-water line and lower low-water line for spring tides (Williams 1993). Intertidal habitat is strongly influenced by a range of physical and biological factors, including substrate type, slope, wave exposure, shore width, tidal range, salinity, light, temperature, and species assemblages (Howes et al. 1994; Jamieson and Davies 2004; Williams 1993). Common intertidal species groups in BC include marsh plants, seagrasses, algae, invertebrates, and fish.

Intertidal habitat types that are likely to be found in the facility RSA include the sheltered soft-substrate habitat type and the rocky, semi-sheltered intertidal habitat type (Jamieson and Davies 2004). The sheltered soft-substrate habitat type is typically found in inlets, passages, and channels with sheltered beaches consisting of mixed mud, sand, and gravel substrates (Jamieson and Davies 2004). Intertidal bivalve communities are common in this habitat type. The rocky, semi-sheltered habitat type consists of vertical rock cliffs and bedrock outcrops, and boulder-scattered intertidal zones (Jamieson and Davies 2004). This habitat type supports a wide variety of marine algae and invertebrate species.

The Government of BC has developed a Biophysical Shore-Zone Mapping System for describing the biophysical character of the province's shore zone (Howes et al. 1994; Searing and Firth 1995). Physical and biological information about the shore zone is collected during spring low tides using high-quality aerial video imagery. Geoscientists and biologists use this information to divide the shore zone into discrete sections of coastline known as shore units and biobands, which are continuous and homogenous in the alongshore direction in terms of their physical and biological characteristics (Howes et al. 1994; Searing and Firth 1995).

The distribution of shore types in the facility LSA and RSA is shown in Figure 3.2-4; the cumulative length and relative abundance of shore types are listed in Table 3.2-5. The total length of shoreline in the LSA is approximately 5.7 km. Constructed (man-made)[4] shore types are the most common in the LSA, comprising 81% of the total length of shoreline (MFLNRO 2005). The total length of shoreline in the RSA is approximately 75.7 km. Estuary, marsh or lagoon, and rock with gravel beach shore types are the most common in the RSA, comprising 35% and 21% of the total length of shoreline, respectively (MFLNRO 2005).

[4] The BC Biophysical Shore-Zone Mapping System uses the term "man-made" to describe constructed shore types. Henceforth, the term "constructed" will be used in place of "man-made."



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Stantec	LNG CANADA Opportunity for British Columbia. Energy for the world	*MARINE RESOURCES TECHNICAL DATA REPORT* **SHORE TYPES AND BENTHIC CLASSES** LNG CANADA EXPORT TERMINAL KITIMAT, BRITISH COLUMBIA	PROJECTION UTM9	DRAWN BY SS
			DATUM NAD 83	CHECKED BY SW
			DATE 03-JUL-14	FIGURE NO. **3.2-4**

Table 3.2-5: Length and Relative Abundance of Shore Types in the Facility LSA and RSA

Shore Type	LSA - Length (km)	LSA - % Total Length	RSA - Length (km)	RSA - % Total Length
Estuary, marsh or lagoon	0.03	0.5	26.08	34.5
Gravel beach	0	0	0.49	0.6
Constructed	4.62	81.4	6.56	8.7
Mud flat	0.72	12.7	1.92	2.5
Rock cliff	0	0	9.63	12.7
Rock with gravel beach	0.31	5.4	15.86	21.0
Rock, sand, and gravel beach	0	0	5.76	7.6
Rock with sand beach	0	0	1.86	2.5
Sand and gravel beach	0	0	2.81	3.7
Sand and gravel flat	0	0	4.34	5.7
Sand flat	0	0	0.38	0.5
Total	**5.68**	**100.0**	**75.69**	**100.0**

SOURCE: MFLNRO (2005)

Levings (1976) found that intertidal communities and habitats of the Kitimat River estuary, including portions of the facility LSA, were characterized by low species diversity, noting that a number of the most common invertebrate species, including polychaetes, blue mussels (*Mytilus* spp. complex), and common acorn barnacles (*Balanus glandula*), were rare or absent from the estuary. As a result of these findings, Levings (1976) concluded that freshwater processes and input have a strong influence on intertidal habitats in the estuary. Bell and Kallman (1976) also attributed the low species diversity in the LSA to freshwater influences.

Subtidal Habitat

The subtidal zone is defined as the area below the mean lower, low-water line for spring tides to the seabed (Williams 1993). Subtidal habitat is strongly influenced by physical factors of the seabed, including topography (macro relief), roughness (micro relief), sediment type and distribution, grain size and shape, patchiness, rock composition, and sediment thickness (Levings et al. 1983; Fader et al. 1998; Todd and Kostylev 2010). Oceanographic factors, such as oxygen saturation, temperature variability, water stratification, and chlorophyll-*a* concentration, also influence subtidal habitat (Todd and Kostylev 2010). Benthic substrates provide habitat for a diverse range of infauna, epifauna, and bottom-dwelling fish. Subtidal species assemblages in BC may include seagrass, algae, invertebrates, and fish (Williams 1993).

The benthic subtidal habitat types most likely to be found in the facility RSA include the sheltered, shallow sandy substrate habitat type and the deep, soft-bottom habitat type (Jamieson and Davies 2004). Common species occurring in sheltered, shallow sandy substrate habitat types include clams, Dungeness crab, and eelgrass (Jamieson and Davies 2004). In deep, soft-bottom habitat types, common species include groundfish, sea stars, anemones, Dungeness crab, sea cucumbers, and pandalid shrimp (Jamieson and Davies 2004).

The seabed can be classified based on landscape features and substrate to identify areas of similar benthic characteristics, which may be related to habitat types and different species assemblages (Parks Canada and BCMCA 2014). The distribution of benthic classes in the facility LSA and RSA, and BSAs is shown in Figure 3.2-4; and, the relative abundance of benthic classes is listed in Table 3.2-6. Benthic classes in the LSA, RSA, and BSAs include muddy flat, muddy ridge, muddy slope, and muddy depression (Parks Canada and BCMCA 2014).

Table 3.2-6: Relative Abundance of Benthic Classes in the Facility LSA and RSA, and BSAs

Benthic Class	LSA – Area (km^2)	LSA - % Total Area	RSA – Area (km^2)	RSA - % Total Area	BSAs – Area (km^2)	BSAs - % Total Area
Muddy depression	0.3	15.3	42.1	70.6	25.0	98.1
Muddy flat	1.3	58.3	4.1	6.8	0.0	0.0
Muddy ridge	0.3	15.2	10.4	17.4	0.5	1.9
Muddy slope	0.2	11.3	3.1	5.3%	0.0	0.0
Total	**2.2**	**100.0**	**59.7**	**100.0**	**25.5**	**100.0**

SOURCE: Parks Canada and BCMCA (2014)

Estuaries and Salt Marshes

Another important marine habitat type on BC's north coast is soft-bottom estuarine and salt marsh habitats, which are found in the shallow soft-bottom subtidal zones of protected waters at the mouths of freshwater rivers and streams that flow into the ocean (Jamieson and Davies 2004). These highly productive habitats support fish, bird, and mammal species. Anadromous fish species use estuaries during their juvenile stages for foraging, rearing, and refugia from predators (MacKenzie et al. 2000). Some species of shellfish, such as Dungeness crab and pandalid shrimp, depend on estuaries for all, or portions of, their lifecycles (MacKenzie et al. 2000).

The largest estuaries in BC's north coast occur at the head of the fjords that flow through the mountains of the Kitimat and Pacific ranges, and are fed by large rivers, glacial melt, rain, and local snow pack melt (MacKenzie et al. 2000). North coast estuaries are dominated by mixed mud, sand, and gravel substrates (Jamieson and Davies 2004). Estuaries typically have low total species diversity, but high turnover diversity because species composition changes over relatively short distances as a result of habitat heterogeneity and variability in species tolerance to salinity (Jamieson and Davies 2004). Jamieson and Davies (2004) list some common species of marine invertebrates in north coast estuaries as harpacticoid copepods, amphipods, polychaete and oligochaete worms, burrowing anemones, lugworms, barnacles, bivalves, rock crabs (*Cancer gracillis*), and shore crabs (*Hemigrapsus* spp.). A review of plant communities in north coast estuaries identified the most common plant species as Lyngbye's sedge, tufted hair-grass, common spike-rush (*Eleocharis palustris*), hemlock water-parsnip (*Sium suave*), seaside arrowgrass, sea-milkwort (*Glaux maritima*), and silverweed (MacKenzie et al. 2000; Jamieson and Davies 2004).

Salt marshes occur in sheltered estuaries in BC. Salt marshes form below the mean higher high-water where they can be inundated by high tides on most days. Salinities in these marshes can range from 5 to 35 parts per thousand (Weinmann et al. 1984). These habitats are highly productive and provide habitat for waterfowl and juvenile fish (Jamieson and Davies 2004).

The facility LSA and RSA encompass portions of the Kitimat River estuary and salt marshes. Kitimat River, which flows south approximately 75 km from the southwestern slope of Mount Davies, discharges into Kitimat Arm from the north. Kitimat River and creeks that flow into Kitimat Arm provide spawning and rearing habitat for a variety of anadromous fish species, including all species of Pacific salmon and eulachon (MacDonald and Shepherd 1983; Jamieson and Davies 2004). Additional information on the Kitimat River estuary is provided in the technical data reports for freshwater and estuarine fish and fish habitat, vegetation resources, and wildlife resources (Triton Environmental Consultants Ltd. 2014; Stantec Consulting Ltd. 2014a, 2014b).

Kelp and Eelgrass Beds

Hundreds of marine plant species occur on the BC north coast. These may be divided into brown, green, and red algae, which are seaweeds, and seagrasses, which are estuarine and marine seed plants (Lucas et al. 2007a). Certain structure-providing plants create biogenic habitats that are used by marine organisms for spawning, rearing, foraging, and protection from predators (DFO 2006). Two main groups of habitat-forming marine plants occur on BC's north coast: kelp and seagrasses (Lucas et al. 2007b). These species form nearshore habitats for a large number of other organisms, including marine fish, invertebrates, and birds (Lucas et al. 2007b).

Kelp, the common name for species of brown algae (order Laminariales), vary in their tolerance to temperature, salinity, light intensity, desiccation, and water motion, which results in horizontal (geographic) and vertical (shore zone) distributions (Lucas et al. 2007a). Species diversity usually increases from high to low in the intertidal zone, and then decreases again as water depth increases (Lucas et al. 2007a). Twenty-seven species of kelp have been reported on the BC coast, with most occurring in the low intertidal to subtidal zone (Lucas et al. 2007a). Kelp beds are typically found in exposed, shallow (less than 30 m), rocky habitats comprised of a dense overstorey, including giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis luetkeana*), and an understorey, including *Laminaria* spp. and *Pterygophora* spp. (Jamieson and Davies 2004). Kelp beds serve as spawning and nursery areas for a variety of invertebrate and fish species, including juvenile salmon and spawning Pacific herring (Jamieson and Davies 2004; Lucas et al. 2007b).

Seagrasses are flowering marine plants that live in the marine environment. One species of seagrass, common eelgrass, provides essential habitat for birds, crabs, herring, and juvenile salmon (Jamieson and Davies 2004; Lucas et al. 2007b). Common eelgrass beds form in soft sediments in the lower intertidal and shallow intertidal zones of sheltered coasts and estuaries in BC (Weinmann et al. 1984; Jamieson and Davies 2004; Lucas et al. 2007b). Eelgrass beds add structural complexity above and below the substrate and have very high levels of primary production, ranking among the most productive ecosystems (DFO 2009). Eelgrass is sensitive to environmental change; the size of eelgrass beds can vary over time depending on the influence of environmental factors (Lucas et al. 2007a). Fisheries and Oceans Canada has declared common eelgrass an ecologically significant species (DFO 2009). Ecologically significant species are those that, if perturbed severely, will incur ecological consequences that are substantially greater than an equal perturbation of most other species associated with the ecological community (DFO 2009).

Eelgrass is known to occur in the facility RSA and has been documented in Minette Bay, Minette Channel, near Hospital Beach, and Emsley Cove (Bell and Kallman 1976; Jacques Whitford 2005; Kitimat Valley Naturalists 2011). Extensive eelgrass beds occurred historically in outer delta areas and along the western shore of Minette Bay, with the most extensive beds located in the channel entrance to Minette Bay (Bell and Kallman 1976; Hay 1976; Cottrell and Hall 1981). Less than 10% of the area of eelgrass that existed in the mid-1970s is estimated to remain in the Kitimat River delta (Kitimat Valley Naturalists 2011). Kelp beds are very likely to occur in the facility RSA, but have not been mapped.

3.2.2.1.11 Cold-Water Sponges

Sponges (phylum Porifera) are primitive aquatic animals, which lack organs, but have specialized cells and a collagenous matrix (Campbell and Simms 2009). Approximately 250 species of cold-water sponges occur in BC waters (DFO 2010c). Adult sponges are largely sessile and live in an attached position where a firm substrate is provided, such as rocky ocean bottom (Campbell and Simms 2009). Cold-water sponges provide structural habitat for a number of marine fish and invertebrate species and have been shown to enhance species richness and to support biodiversity (Austin et al. 2007; Campbell and Simms 2009; DFO 2010c). Cold-water sponges tend to be long-lived, slow growing, sensitive to physical disturbances, and subject to a variety of stressors (DFO 2010c).

The facility RSA overlaps with an IA for cloud sponges that extends from the head of Kitimat Arm to the mouth of Douglas Channel (Figure 3.2-3; DFO 2013j). A 2011 study of cold-water sponges in the RSA identified glass sponges (class Hexactinellida), including cloud sponges, goblet sponges (*Heterochone calyx*), boot sponges (family Rossellidae), and demosponges (class Demospongiae) (Stantec Consulting Ltd. 2012). Sponges were distributed along the western side of Kitimat Arm, north of Emsley Cove, and the eastern side of Kitimat Arm between Clio Bay and Kitamaat Village. The highest sponge densities were observed on bedrock substrate in water depths of 31 m to 60 m. No sponge reefs were identified, but individual sponges were commonly observed growing near one another.

3.2.2.2 Marine Mammal Acoustic Thresholds

Marine mammal hearing frequency range and sensitivity differs between species. Southall et al. (2007) identified four marine mammal functional hearing groups and their associated hearing frequency ranges:

- low-frequency cetaceans (hearing frequencies of 7 Hz to 22 kHz; baleen whales, including humpback whales, grey whales, and fin whales)

- mid-frequency cetaceans (hearing frequencies of 150 Hz to 160 kHz; various odontocetes, including killer whales and Pacific white-sided dolphins)
- high-frequency cetaceans (hearing frequencies of 200 Hz to 180 kHz; various odontocetes, including harbour porpoise and Dall's porpoise), and
- pinnipeds in water (hearing frequencies of 75 Hz to 75 kHz; pinnipeds, including Steller sea lions, and harbour seals).

Underwater sound levels, above certain received levels, have been predicted to cause permanent auditory injury (i.e., permanent threshold shifts [PTS]), or temporary changes in hearing abilities (i.e., temporary threshold shifts [TTS]) in marine mammals. The onset level of TTS has been measured for some marine mammal species (Southall et al. 2007), and PTS-onset thresholds are based on extrapolations from TTS-onset levels.

Underwater noise from impulsive noise (such as pile driving) is commonly expressed as sound pressure level (SPL), measured in dB re: 1 µPa, and sound exposure level (SEL), a measure of energy in dB re: 1 $\mu Pa^2 s$. The SPL can be an instantaneous value, whereas the SEL is the total noise energy over a given time period, typically one second for pulse sources (Theobald et al. 2009). The SPL and SEL are further described using:

- peak SPL (SPL_{peak}): the maximum sound pressure at any given moment produced by a particular activity, capturing 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, and
- cumulative SEL (SEL_{cum}): cumulative energy exposure over multiple pulses for a given period of time.

Thresholds that may induce PTS in marine mammals have been estimated by Southall et al. (2007) and NOAA (2013b). Auditory injury thresholds have been estimated using different metrics, some weighted by marine mammal functional hearing group to emphasize frequencies of greatest sensitivity. NOAA has recently released a draft version of new thresholds (NOAA 2013b); these are not directly comparable to the Southall et al. (2007) thresholds because they use different weighting criteria. Table 3.2-7 summarizes the thresholds for PTS onset (i.e., auditory injury levels) as suggested by Southall et al. (2007), and both previous and current NOAA guidance.

Table 3.2-7: Permanent Auditory Injury Thresholds (Received Level) for Marine Mammals (PTS)

Functional Hearing Group (hearing range)	NOAA Draft Acoustic Threshold[a] for PTS		NOAA Interim Threshold[b] for PTS	Southall et al. 2007 Threshold[c]	
	Pulse	Non-pulse		Pulse	Non-pulse
Phocid pinnipeds (75 Hz–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–40 kHz)	235 dB_{peak} and 215 dB SEL_{cum}	235 dB_{peak} and 220 dB SEL_{cum}			
Low-frequency cetaceans (7 Hz–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–160 kHz)	230 dB_{peak} and 187 dB SEL_{cum}	230 dB_{peak} and 198 dB SEL_{cum}			
High-frequency cetaceans (200 Hz–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 Criteria released in December 2013; because 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)

3.2.2.3 Marine Mammals

Several marine mammal species are known to occur in the North Pacific Ocean and in the shipping RSA, both seasonally and year round. The species noted in the literature review as commonly observed in the RSA are described here. Mysticeti species, or baleen whales, that may occur in the RSA include humpback whales, minke whales (*Balaenoptera acutorostrata*), grey whales (*Eschrichtius robustus*), and fin whales (*Balaenoptera physalus*). Odontoceti, or toothed whales, that may occur in the RSA include harbour porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), and Bigg's (transient) and northern resident killer whales (*Orcinus orca*). Two pinniped species, harbour seals (*Phoca vitulina richardii*) and Steller sea lions (*Eumetopius jubatus*), occur in the RSA. The northern extent of the range of sea otters (*Enhydra lutris*) reaches just south of the RSA. They are included here because of their continuing range expansion (Nichol et al. 2009) and potential habitat in and around the RSA (Gregr et al. 2008). A confirmed sighting of a North Pacific right whale (*Eubalaena japonica*) off the west coast of Haida Gwaii was recorded in June 2013 for the first time in 62 years in BC waters (CBC News 2013). Because of its rarity in BC waters and its unlikeliness to be sighted in the RSA, this species is not included in this report.

All marine mammal species that may occur in the shipping RSA and their respective status under SARA, COSEWIC, and the BC Conservation Data Centre (BCCDC) are listed in Table 3.2-8. Five of the 12 marine mammals that may occur in the study area are considered species of *special concern* by

COSEWIC and are listed on Schedule 1 of SARA (Table 3.2-8): humpback whale, grey whale, harbour porpoise, Steller sea lion, and sea otter. Fin whale and killer whale (Bigg's and northern resident) are listed as *threatened* by COSEWIC and on Schedule 1 of SARA (Table 3.2-8). Sea otter is the only marine mammal officially listed under the BC *Wildlife Act*; the Act lists it as *threatened.*

Table 3.2-8: Marine Mammal Conservation Status

Common Name	Species Name	Provincial Status[a]	COSEWIC Status[b]	SARA Status[c]
Fin whale	*Balaenoptera physalus*	*red*	*threatened*	Schedule 1, *threatened*
Humpback whale	*Megaptera novaeangliae*	*blue*	*special concern*	Schedule 1, *special concern*
Grey whale	*Eschrichtius robustus*	*blue*	*special concern*	Schedule 1, *special concern*
Minke whale	*Balaenoptera acutorostrata*	*yellow*	*not at risk*	No status
Northern resident killer whale	*Orcinus orca*	*red*	*threatened*	Schedule 1, *threatened*
Bigg's (transient) killer whale	*Orcinus orca*	*red*	*threatened*	Schedule 1, *threatened*
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	*yellow*	*not at risk*	No status
Dall's porpoise	*Phocoenoides dalli*	*yellow*	*not at risk*	No status
Harbour porpoise	*Phocoena phocoena*	*blue*	*special concern*	Schedule 1, *special concern*
Harbour seal	*Phoca vitulina richardii*	*yellow*	*not at risk*	No status
Steller sea lion	*Eumetopias jubatus*	*blue*	*special concern*	Schedule 1, *special concern*
Sea otter	*Enhydra lutris*	*blue*	*special concern*	Schedule 1, *special concern*

SOURCES: [a] BCCDC (2014), [b] COSEWIC (2013), [c] Government of Canada (2012)

The following species are described in more detail because of their likely occurrence in the shipping RSA. Information on distribution, population status, estimated abundance, vocalization, and auditory range is provided.

3.2.2.3.1 Humpback Whale

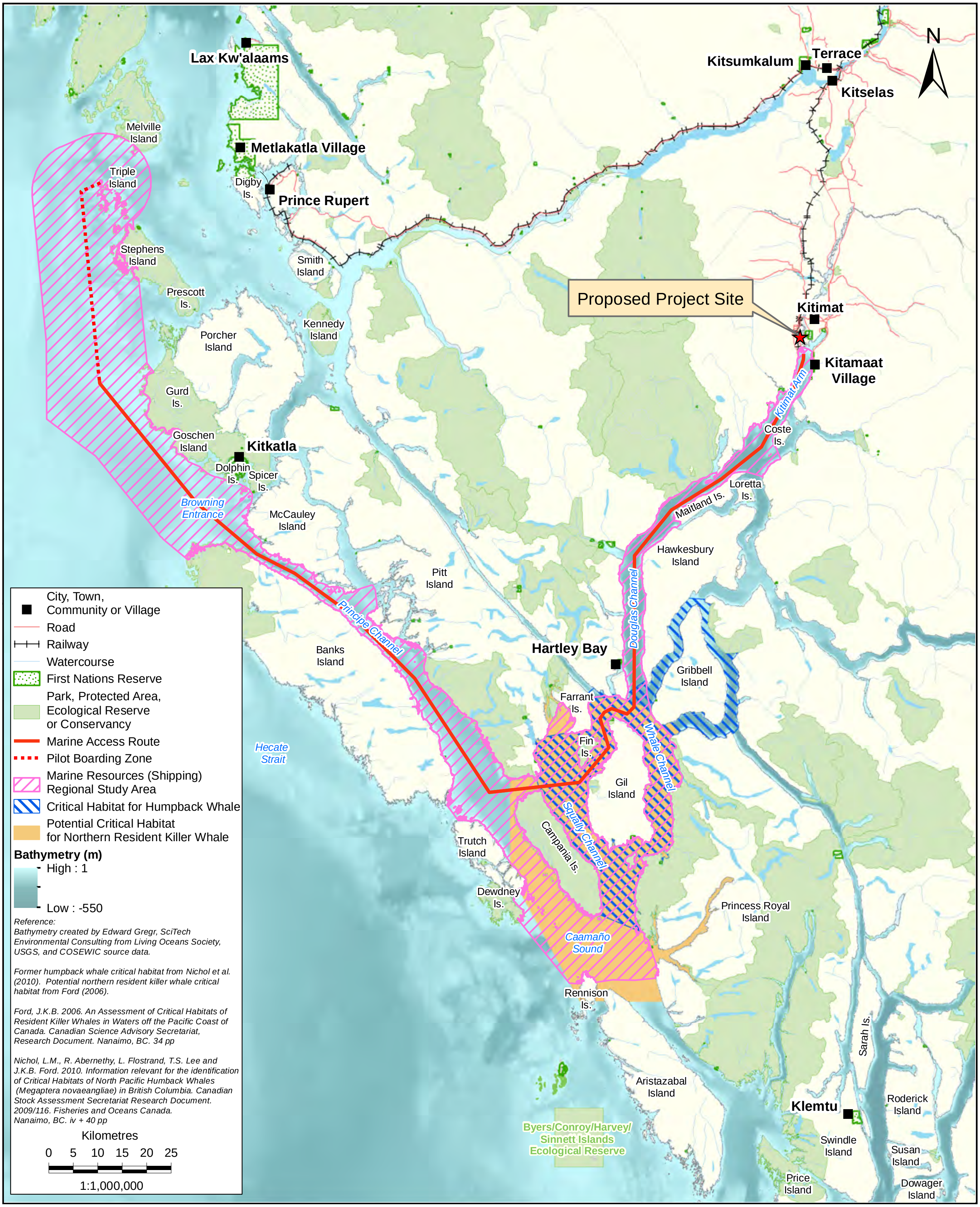
In May 2014, the Minister of Fisheries and Oceans recommended the status of the North Pacific humpback whale be amended from *threatened* to *special concern* (Government of Canada 2014). This recommendation is based on upward trends in population growth rates and increased abundance (COSEWIC 2011a; DFO 2013i). At the time of writing, the Governor in Council has not made a decision on this recommendation; and therefore the humpback whale is listed as *threatened* on Schedule 1 of SARA. The humpback whale is currently on the provincial Blue List (BCCDC 2014). In 2006, approximately 18,000 to 22,000 humpback whales were estimated to occupy the North Pacific (Calambokidis et al. 2008; Ford et al. 2009; Barlow et al. 2011). In BC waters, there are approximately

1,500 to 3,900 humpback whales (Rambeau 2008); of these, an estimated 1,000 to 1,400 individuals occur in Queen Charlotte Basin, which is in the shipping RSA (Best and Halpin 2011).

Humpback whales are globally distributed and can be observed in a wide variety of marine habitats, from fjords to offshore areas (Ford et al. 2010a). They generally spend the winter months breeding in warm low-latitude waters, such as Hawaii and Mexico (Calambokidis et al. 2008), and migrate to high latitudes to feed from spring to fall (Ford et al. 2010a). In BC waters, they are most abundant from May to October (Rambeau 2008), although some humpback whales are considered to be year-round residents.

This species is common in the shipping RSA, with seasonal peaks in concentrations in some areas. Acoustic data suggest there is a peak in humpback feeding calls in Caamaño Sound in July through August (Nichol et al. 2010). In addition, one of the four critical habitats for humpback whales, near Gil Island, is located in the shipping RSA (Figure 3.2-5) and is based on high seasonal use by humpback whales in October and November (Nichol et al. 2010). Fisheries and Oceans Canada has also defined an IA for humpback whales in the shipping RSA (Figure 3.2-6) based on expert opinion, historical whaling data, and sightings. Further, local ecological knowledge has identified Douglas Channel, Whale Channel, Squally Channel, Caamaño Sound, and west of Porcher Island in Hecate Strait as areas frequented by humpback whales (Figure 3.2-6) (DFO and BC Ministry of Sustainable Resource Management 2007). Many sightings (Ford et al. 2010a; Wheeler et al. 2010; Best and Halpin 2011; Wray et al. 2011) and numerous reports to the BCCSN (BCCSN Data 2013) of humpback whales have been recorded in the shipping RSA (Figure 3.2-7).

Humpback whales are vocal animals, producing a wide variety of sounds. These vocalizations include *megapclicks*, with peak frequencies of approximately 800 Hz and 1,700 Hz (Stimpert et al. 2007), and a variety of sounds, including grunts and moans, with frequencies ranging from 20 Hz to 2,000 Hz and source levels from 162 dB to 192 dB re 1 μPa (Thompson et al. 1986). When singing, humpback whales may hear as high as 24 kHz and produce source levels from 151 dB to 173 dB re 1 μPa (Au et al. 2006).



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MARINE RESOURCES TECHNICAL DATA REPORT

REGIONAL STUDY AREA (SHIPPING), MARINE ACCESS ROUTE, AND DESIGNATED AND POTENTIAL CRITICAL HABITAT

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KITIMAT, BRITISH COLUMBIA

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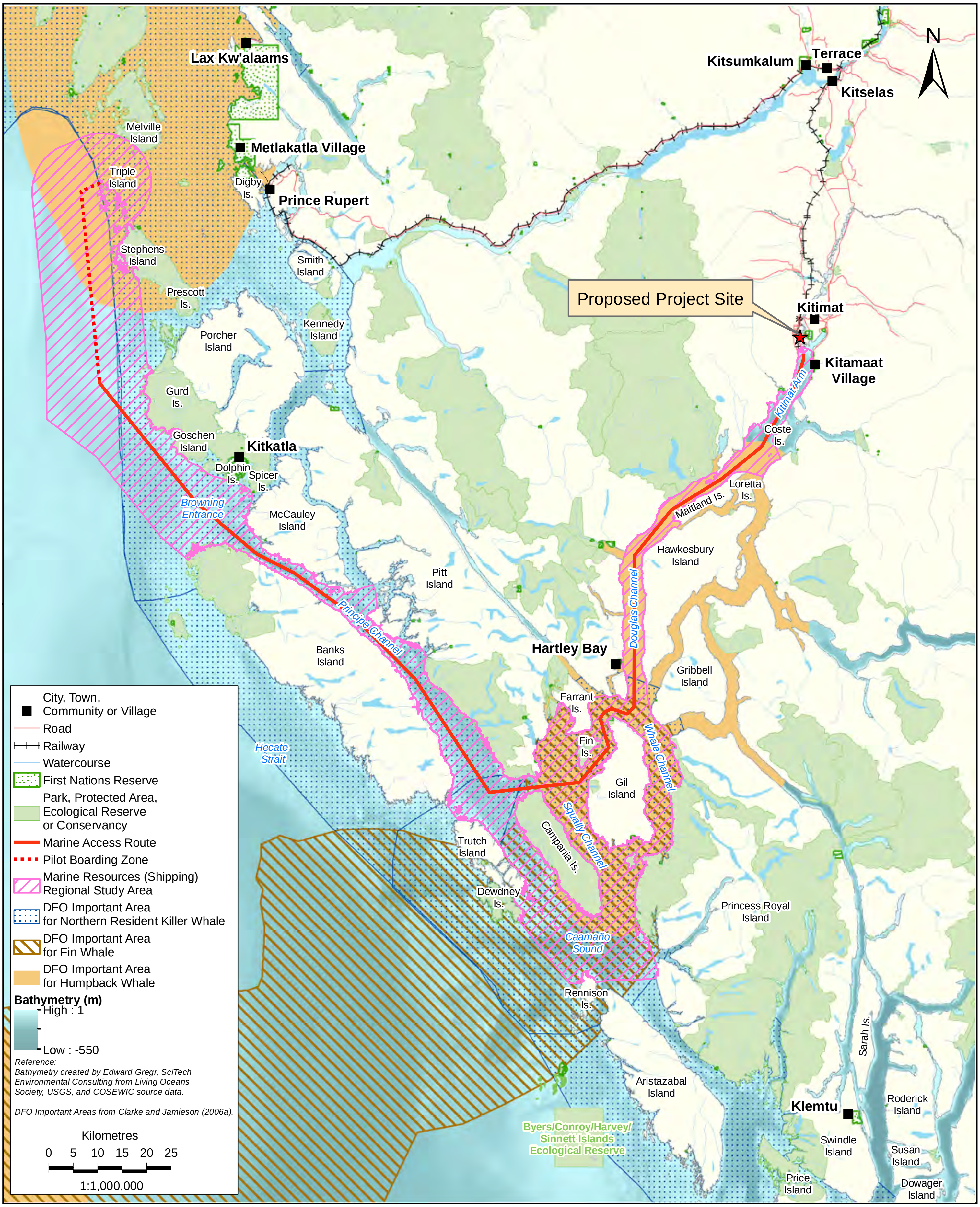

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MARINE RESOURCES TECHNICAL DATA REPORT

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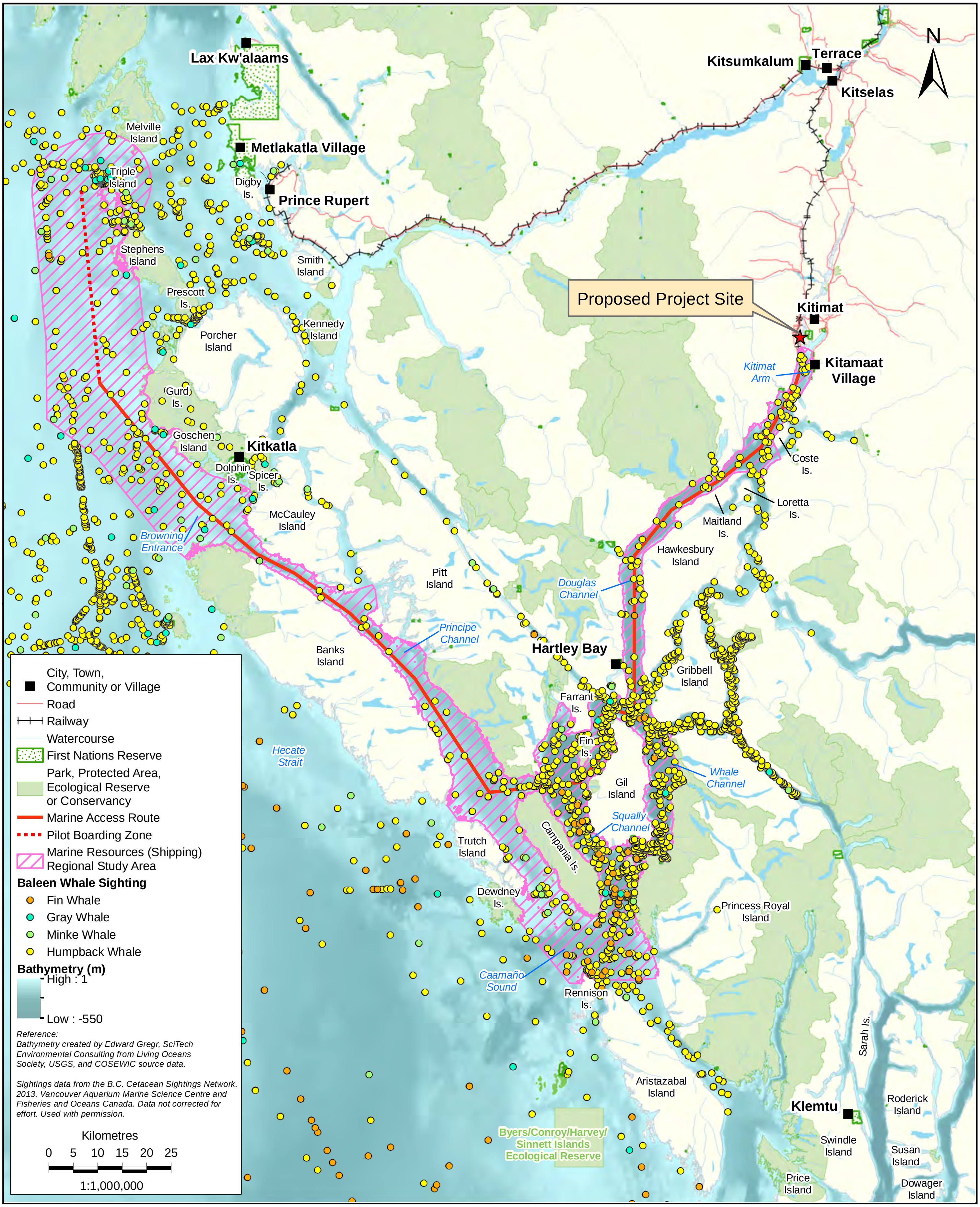

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MARINE RESOURCES TECHNICAL DATA REPORT

BC CETACEANS SIGHTINGS NETWORK BALEEN WHALE SIGHTINGS

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KITIMAT, BRITISH COLUMBIA

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3.2.2.3.2 Fin Whale

The fin whale was one of the most abundant baleen whales on the BC coast before commercial whaling in the 1900s, with pre-whaling abundance estimates of 40,000 to 45,000 whales (COSEWIC 2005; Ford et al. 2010a). An estimated 250 to 750 individuals are thought to remain in BC coastal waters, most of which occur in the Queen Charlotte Basin (Best and Halpin 2011). Because of this drastic population decline, the species is listed as *threatened* by COSEWIC (2005) and on Schedule 1 of SARA (Government of Canada 2012), and is on the provincial Red List (BCCDC 2014).

Although the population structure of fin whales in the eastern North Pacific is unclear, they are known to frequent Canadian Pacific waters year round, with most sightings recorded during the summer months (Gregr et al. 2006). It is suspected that fin whales migrate between high-latitude summer feeding grounds and low-latitude winter breeding grounds (Gregr et al. 2000, 2006; Mizroch et al. 2009). In summer, fin whales likely enter BC waters to feed along the shelf edge and on-shelf waters, taking advantage of consistent euphausiid (shrimp-like, planktonic crustaceans) aggregations (Flinn et al. 2002; COSEWIC 2005). Modelled recommended critical habitat (based on historical whaling data) suggests that the coastal waters are important for fin whales, primarily in July and August (Gregr and Trites 2001). Whale Channel, Squally Channel, and Caamaño Sound, in the shipping RSA, are identified as IAs for fin whales (Figure 3.2-6; Clarke and Jamieson 2006b). There have been recent sightings of fin whales in the shipping RSA (Table 3.2-9, Figure 3.2-7; Wheeler et al. 2010; Best and Halpin 2011; Pilkington et al. 2011b; BCCSN Data 2013).

Fin whales appear to make low-frequency calls during feeding and breeding. Call source levels have been recorded from 159 dB to 196 dB re 1 µPa at 1 m over the 15 Hz to 28 Hz band (Watkins et al. 1987; Charif et al. 2002; Širović et al. 2007; Weirathmueller et al. 2013). During the breeding season, male fin whales produce powerful low-frequency vocalizations (15 Hz to 30 Hz) that may be breeding display calls (Watkins et al. 1987; Croll et al. 2002).

3.2.2.3.3 Minke Whale

Minke whales are widespread and abundant in the North Pacific. The species is currently listed as *not at risk* by COSEWIC (2006) and, therefore, has not been designated under SARA. It is on the provincial Yellow List (BCCDC 2014).

Although the migration patterns of minke whales are not well understood, they are thought to migrate to higher latitudes in the summer months to feed (Zerbini et al. 2006) and to lower latitudes during the winter to breed (Rankin and Barlow 2005). Minke whales are generally found in shallow coastal waters where they primarily feed on small schooling fish (Ford et al. 2010a). They occur in BC waters year round, but are more prevalent in the spring, summer, and fall months, albeit in low abundances (Ford et al. 2010a). The most recent abundance estimates for minke whales in BC are 400 to 500 whales in nearshore waters (Best and Halpin 2011). They are primarily observed in Hecate Strait (Ford et al. 2010a; Best and Halpin 2011), with a few sightings reported to BCCSN (BCCSN Data 2013) (Table 3.2-9, Figure 3.2-7).

Table 3.2-9: British Columbia Cetacean Sightings Network Data (1979 to 2013) in the Marine Resources Shipping RSA

Month	Humpback Whale	Fin Whale	Minke Whale	Grey Whale	Killer Whale	Dall's Porpoise	Harbour Porpoise	Pacific White-sided Dolphin
January	0	0	0	1	1	18	1	12
February	0	0	0	0	4	9	0	11
March	22	1	0	0	2	22	1	24
April	38	1	0	1	20	15	21	7
May	56	0	2	0	29	26	8	5
June	83	0	1	0	55	48	12	8
July	174	15	4	1	49	70	14	6
August	212	12	3	4	20	43	8	6
September	188	7	1	6	11	48	2	7
October	149	1	1	5	10	39	2	8
November	38	1	0	0	11	24	1	6
December	7	0	0	0	2	23	0	5
Total	967	38	12	18	214	385	70	105

NOTE:
A sighting can be of more than one individual.
SOURCE: BCCSN Data (2013)

Minke whales make a wide range of sounds, some of which appear to be seasonally and geographically specific. "Boing" sounds have been recorded seasonally in the North Pacific, with primary frequencies from 1 kHz to 1.8 kHz (extending to 9 kHz), and have been recorded primarily from October to February (Rankin and Barlow 2005; Oswald et al. 2011; Delarue and Martin 2013). They also vocalize over a wide range of frequencies, including sounds in the 50 Hz to 9.4 kHz frequency range and at source levels between 150 dB and 165 dB re 1 µPa at 1 m (Gedamke et al. 2001).

3.2.2.3.4 Grey Whale

The grey whale is listed as *special concern* by COSEWIC (COSEWIC 2004) and on Schedule 1 of SARA (Government of Canada 2012) because of declines in the population between 1998 and 2002 (COSEWIC 2004). The species is on the provincial Blue List (BCCDC 2014). Abundance estimates (based on data from 2006 to 2007) are between approximately 19,000 to 20,000 individuals (Rugh et al. 2008; Laake et al. 2012) and suggest that the current population trajectory is relatively constant (Laake et al. 2012).

Grey whales are exclusively found in the North Pacific, migrating between summer feeding grounds in the Bering, Chuckchi, and Beaufort seas to winter breeding grounds in Mexico and southern California (Ford et al. 2012). Non-breeding animals (i.e., pregnant females, mature males, and juveniles) migrate through BC waters from approximately March through April and appear to preferentially migrate along the eastern side of Hecate Strait, although some individuals have been recorded along the western side of the strait

(Ford et al. 2012). Cow-calf pairs migrate later and have been observed closer to shore along California and Oregon; however, their route through BC remains unknown (Herzing and Mate 1984; Poole 1984). Grey whales have been recorded in the RSA by Ford et al. (2010a) and BCCSN (BCCSN Data 2013) (Table 3.2-9, Figure 3.2-7).

Recordings of grey whale vocalizations range from 13 Hz to 258 Hz (Stafford et al. 2007). These vocalizations may be used for reproduction, communication among individuals, or during migration (Watkins et al. 1987; Crane and Lashkari 1996).

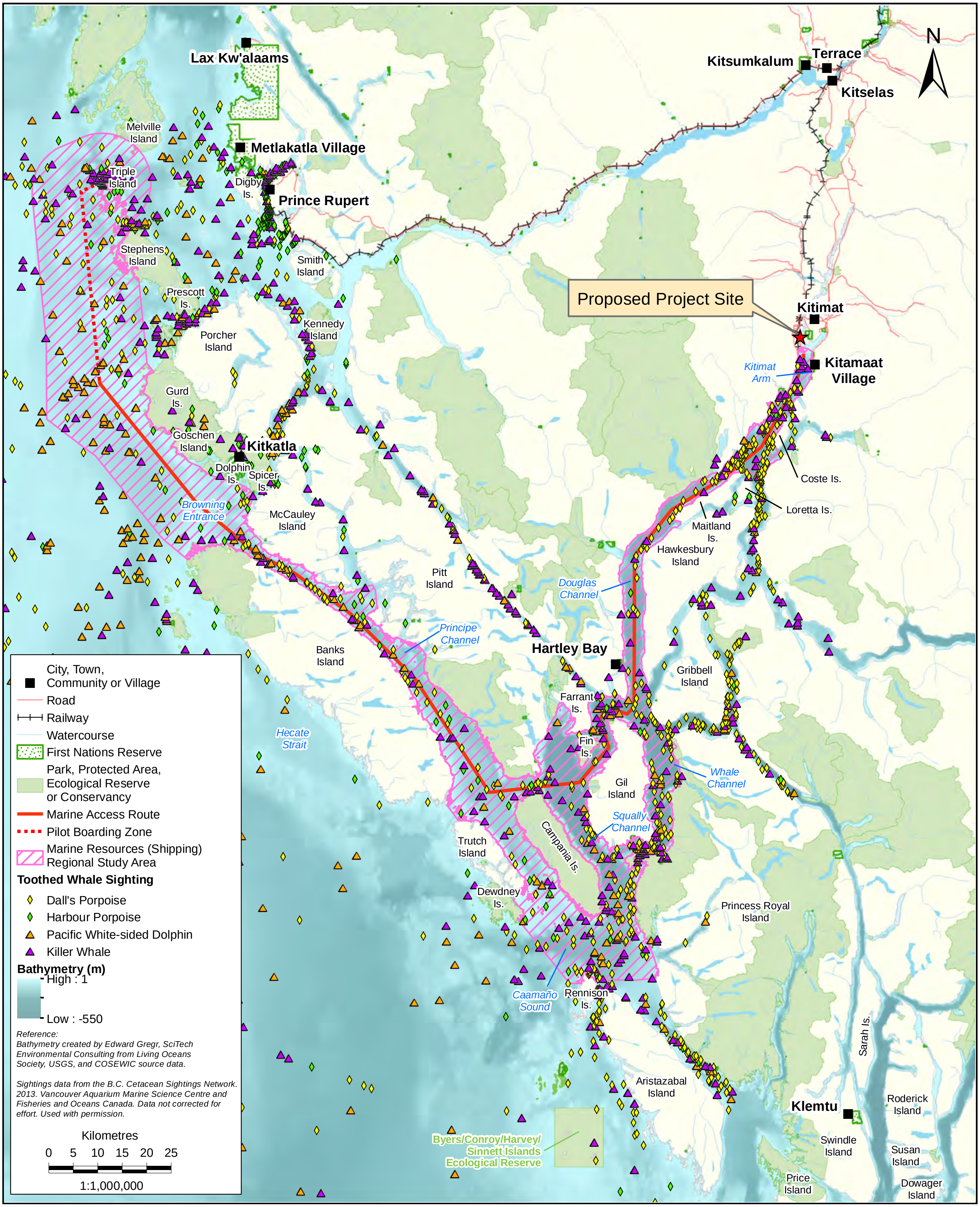
3.2.2.3.5 Northern Resident Killer Whale

Northern resident killer whale is a fish-eating subspecies of *Orcinus orca* (Ford et al. 1998; Baird 2001b; Barrett-Lennard and Ellis 2001). This is a relatively well-studied group, with a small but increasing population. From 1997 to 2006, population studies recorded an 11% increase in the number of northern resident killer whales in BC, with 244 individuals recorded in 2006, up from 220 in 1997 (COSEWIC 2008). Based on data collected in 2004 and 2005, an estimated 128 whales exist in the Queen Charlotte Basin (Williams and Thomas 2007). Because of its small population size, dietary specialization, and low reproductive rate, the population is designated as *threatened* by COSEWIC (DFO 2011a), is listed on Schedule 1 of SARA (Government of Canada 2012), and is on the provincial Red List (BCCDC 2014).

In BC, the distribution of northern resident killer whales is highly seasonal and largely depends on prey availability. Their preferred prey is spawning salmon returning to their natal streams (Ford et al. 2010a). They are primarily observed from Dixon Entrance to central Vancouver Island from June to October (DFO 2011a). From May to early-July, northern resident killer whales frequent the north coast of BC, primarily feeding on migrating chinook salmon (Ford 2006; Ford and Ellis 2006; Ford et al. 2010a). They then move down the coast to feed on other aggregations of migrating salmon (Ford and Ellis 2006).

Northern resident killer whales have been observed in the shipping RSA (Ford et al. 2010a; Wheeler et al. 2010; Pilkington et al. 2011a). BCCSN also reported sightings of killer whales in the RSA (BCCSN Data 2013); however, these sightings were not separated by ecotype (Table 3.2-9, Figure 3.2-8). IAs for northern resident killer whales include the western portions of the shipping RSA (Figure 3.2-6) (Clarke and Jamieson 2006b). These IAs were identified as areas used for socialization and migration and were labeled as “high” and “‘moderate” in importance, depending on the area. Potential critical habitat for northern resident killer whales has also been identified by DFO, extending from Caamaño Sound and around Campania Island and Gil Island (Figure 3.2-6; Ford 2006).

Northern resident killer whales appear to use vocalization to communicate (Miller 2006). Their hearing extends to at least 120 kHz, with the greatest sensitivity at 36 dB re 1 µPa at 20 kHz (Szymanski et al. 1999).



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MARINE RESOURCES TECHNICAL DATA REPORT

BC CETACEANS SIGHTINGS NETWORK
TOOTHED WHALE SIGHTINGS

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3.2.2.3.6 Bigg's (Transient) Killer Whale

Transient killer whales were renamed Bigg's killer whales in 2012. Bigg's killer whale is currently on the provincial Red List (BCCDC 2014), is designated as *threatened* by COSEWIC, and is on Schedule 1 of SARA (Government of Canada 2012) because of its small population size. Three populations of Bigg's killer whales exist, with the west coast Bigg's population extending from Washington State to southeast Alaska (Ford and Ellis 1999). In 2006, the west coast Bigg's population was estimated at 243 individuals (Ford et al. 2007), with no estimates of the number of individuals in the Queen Charlotte Basin or in the immediate area around the RSA.

Bigg's killer whales are difficult to detect because of their reliance on stealth to forage upon acoustically sensitive marine mammals, such as seals and sea lions (DFO 2007a). Bigg's killer whales travel and cover a large spatial range searching for highly mobile and evasive marine mammal prey, which makes it harder to determine their habitat requirements and year-round distribution (DFO 2007a). They can be found in BC waters year round, with possible preferential areas or home ranges where they have successfully hunted in the past (Ford and Ellis 1999). Bigg's killer whales have been recorded in the shipping RSA (Ford et al. 2010a; Wheeler et al. 2010; Best and Halpin 2011). Sightings of killer whales have been reported to BCCSN, but are not separated by type (Table 3.2-9, Figure 3.2-8; BCCSN Data 2013).

Killer whale hearing extends to at least 120 kHz, with the greatest sensitivity at 36 dB re 1 µPa at 20 kHz, the highest recorded for all odontocetes (Szymanski et al. 1999).

3.2.2.3.7 Dall's Porpoise

Dall's porpoise occurs only in the North Pacific and is abundant year round along the coast of BC (Jefferson 1990). It has been designated as *not at risk* by COSEWIC and, therefore, has not been listed under SARA (Government of Canada 2012). The species is on the provincial Yellow List (BCCDC 2014).

Dall's porpoises are often observed in deep water (700 m average depth) in both nearshore and offshore areas, and frequently in groups of four to five individuals (Ford et al. 2010a). They have been recorded in the shipping RSA throughout the year (Table 3.2-9, Figure 3.2-8; Ford et al. 2010a; Wheeler et al. 2010; Best and Halpin 2011; BCCSN Data 2013). Predictions of distribution suggest that their abundance will be higher in areas east of the Queen Charlotte Islands and central Hecate Strait (Best and Halpin 2011). Abundance estimates in the nearshore waters of BC range from 5,500 to 6,200 individuals. Of these, 4,000 to 4,500 individuals are estimated to occur in the Queen Charlotte Basin (Best and Halpin 2011).

Echolocation used by Dall's porpoise for prey detection is considered narrow band high frequency (clicks that are above 100 kHz in energy). Their echolocation mean sound source level has been recorded at 187 ± 7 dB re 1 µPa (peak to peak) with a mean frequency of 137 ± 3 kHz (Kyhn et al. 2013).

3.2.2.3.8 Harbour Porpoise

Limited information is available on population trends for harbour porpoises because they tend to avoid vessels, making them difficult to document. They are known to be sensitive to human activity (such as vessel traffic) and pollution and are often caught in fishing nets as bycatch (Baird 2003). The species is designated as *special concern* by COSEWIC (COSEWIC 2003a), is listed on Schedule 1 of SARA (Government of Canada 2012), and is on the provincial Blue List (BCCDC 2014). An estimated 6,600 to 8,000 harbour porpoises occupy the nearshore waters of BC; of these, approximately 2,500 to 3,500 are in the Queen Charlotte Basin (Best and Halpin 2011).

Harbour porpoises can be observed year round along the BC coast. Harbour porpoises are not believed to migrate; however, seasonal changes in abundance have been documented, with possible movement of porpoises to deeper, offshore waters during winter (Carretta et al. 2009). Harbour porpoises are typically found in groups of three or less, in shallow waters, and close to the shore; however, some sightings have been recorded in deeper offshore waters (Ford et al. 2010a). They are primarily sighted around Vancouver Island, Haida Gwaii, and the mainland inlets (Ford et al. 2010a; Best and Halpin 2011). The species has also been observed in the shipping RSA and surrounding waters (Table 3.2-9, Figure 3.2-8; Wheeler et al. 2010; Best and Halpin 2011; BCCSN Data 2013).

Harbour porpoises can detect low-frequency offshore sounds (Koschinski et al. 2003), and are known to use echolocation for foraging, navigation, and spatial orientation. They also use clicks for communication (Clausen et al. 2010). Hearing sensitivity is between 16 kHz and 140 kHz, with maximum sensitivity from 100 kHz to 140 kHz (at 33 dB re 1 µPa) and reduced sensitivity at 64 kHz (Kastelein et al. 2002). Echolocation clicks used for prey detection have mean source levels of 178 ± 4 dB re 1 µPa with a centroid frequency of 141 ± 1 kHz (NOAA 2013b). Clicks used for communication may be as high as 180 dB re 1 µPa (peak to peak), with similar frequency as echolocation clicks (Clausen et al. 2010).

3.2.2.3.9 Pacific White-sided Dolphin

Pacific white-sided dolphins frequent the North Pacific and BC coastal waters year round, with an estimated abundance of 22,000 to 32,500 individuals; of these, 20,000 to 29,000 individuals occur in Queen Charlotte Basin (Best and Halpin 2011). Because of its large population, the species is considered *not at risk* by COSEWIC (Government of Canada 2013b), is not listed under SARA (Government of Canada 2012), and is on the provincial Yellow List (BCCDC 2014).

Offshore, Pacific white-sided dolphins are typically observed in large groups, sometimes exceeding 1,000 individuals, but smaller groups may be observed in nearshore waters (Heise et al. 2007; Ford et al. 2010a). Evidence of seasonal movements have been recorded, with the dolphins occupying offshore waters during the spring and summer, and occupying inshore waters during the fall through spring (Stacey and Baird 1991). This species has been frequently recorded in the shipping RSA and along other parts of the coast (Table 3.2-9, Figure 3.2-8; Ford et al. 2010b; Wheeler et al. 2010; Best and Halpin 2011; BCCDC 2014).

Hearing sensitivity of Pacific white-sided dolphins ranged between 2 kHz and 128 kHz (less than 90 dB re 1 µPa) during behavioural response tests; they did not appear to be sensitive to low-frequency noise (e.g., 145 dB at 100 Hz to 106 dB at 1 kHz) (Tremel et al. 1996). They are extremely vocal and are known to whistle during the day and click during the night (Wiggins et al. 2013).

3.2.2.3.10 Harbour Seal

Harbour seals are frequently observed along the BC coast. After undergoing exponential increases between the 1970s and 1980s, the population appears to have stabilized, displaying moderate growth through the 1990s (DFO 2010a). During a survey of the Queen Charlotte Basin, harbour seals were recorded as the most frequently sighted marine mammal, with abundance estimates from 17,400 to almost 25,000 individuals, with an estimated 2,500 to 4,000 seals in the Queen Charlotte Basin (Best and Halpin 2011). Because of the species' large, stable population, it is considered *not at risk* by COSEWIC (Baird 2001a; Government of Canada 2013b), is not listed under SARA (Government of Canada 2012), and is on the provincial Yellow List (BCCDC 2014).

Along the BC coast, harbour seals haul out on rocks, islets and islands, and sand bars. Some of these haulout sites are also used for pupping (Heise et al. 2007). Although harbour seals are known to undergo extensive movements, they are not considered migratory and will often return repeatedly to specific sites or areas, demonstrating considerable site fidelity (Baird 2001a). They are typically observed in nearshore waters (Best and Halpin 2011). In the water, they are typically solitary or occur in small groups; whereas, they occur in larger groups on land (Baird 2001a). Several haulout sites and in-water observations of harbour seals have been recorded in the shipping RSA (DFO 2010a; Wheeler et al. 2010; Best and Halpin 2011).

Male harbour seals appear to use underwater vocalizations as reproductive displays and for male-male competition (Hanggi and Schusterman 1994; Hayes et al. 2004). Hearing sensitivity of harbour seals ranges from 1 kHz to 40 kHz, with sensitivity falling outside of this range (Kastelein et al. 2009).

3.2.2.3.11 Steller Sea Lion

The Steller sea lion has recently been divided into two subspecies: the western Steller sea lion (*E. j. jubatus*) and Loughlin's northern sea lion (*E. j. monteriensis*) (Phillips et al. 2009; Committee on Taxonomy 2011). Both subspecies can occur in Canadian waters. In Canada, its conservation status is currently based on the species as a whole. The species is designated as *special concern* by COSEWIC (COSEWIC 2003b), is on Schedule 1 of SARA (Government of Canada 2012), and is on the provincial Blue List (BCCDC 2014). Estimated abundance in BC is approximately 20,000 to 28,000 individuals (DFO 2008), with 2,500 to 4,000 in the Queen Charlotte Basin (Best and Halpin 2011).

The eastern stock of Steller sea lion (i.e., Loughlin's northern sea lion) is distributed throughout southeastern Alaska, BC, Washington, and Oregon. Along the coast of BC, there are four breeding sites (rookeries) and several established haulouts, occupied in the winter or year round (DFO 2010b). Two haulout sites exist in the shipping RSA: Warrior Rock, a year-round haulout just west of Triple Island, and Ashdown Island at the southern end of Whale Channel (DFO 2010b). Steller sea lion sightings have been reported in the shipping RSA at haulouts and in the water (Wheeler et al. 2010; Best and Halpin 2011).

In-air vocalizations by mature male sea lions allow them to maintain their breeding territories; whereas, those by adult females allow them to reunite with their pups at busy rookeries (Muslow and Reichmuth 2010). Peak frequencies for female calls range from 150 Hz to 1,000 Hz, with an overall call range of 30 Hz to 3,000 Hz (Campbell et al. 2002). Steller sea lions exhibit a hearing range of 1 kHz to 25 kHz, with sensitivity falling outside of these ranges (Kastelein et al. 2005). A more recent study identified an overall hearing range of 0.250 kHz to 30 kHz, with the best hearing sensitivity between 5 kHz and 14.1 kHz in a one-year-old male Steller sea lion (Muslow and Reichmuth 2010).

3.2.2.3.12 Sea Otter

Historically, sea otters were observed along the North Pacific coast from Japan to California; whereas, their current distribution is far more limited. As a result of the fur trade, they were facing extinction by the mid-1800s. Following a reintroduction in the 1970s along the north coast of Vancouver Island, they have been successfully re-established (Bigg and MacAskie 1978). In 2008, the BC population of sea otters was estimated at 4,712 individuals, with 602 individuals occurring along the central coast (Nichol et al. 2009). From 1990 to 2008, the population of sea otters along the central coast has increased by an estimated 11.4% (Nichol et al. 2009). The species is currently listed as *special concern* by COSEWIC (COSEWIC 2007), is on Schedule 1 of SARA (Government of Canada 2012), and is on the provincial Blue List (BCCDC 2014).

The range of sea otters has changed drastically since their reintroduction; they are now sighted from central Vancouver Island to the northern tip of Aristazabal Island, just south of the shipping RSA (Nichol et al. 2009). Predicted optimum habitat for sea otters includes habitat in the shipping RSA along the western side of Campania Island, the southern portion of Dewdney Island, areas of the western side of Pitt Island, the western side of McCauley Island and Porcher Island, and the islands west of Porcher Island (Gregr et al. 2008). At present, most of the RSA is thought to be beyond their range.

Little information is available on the auditory functions of sea otters. However, past studies on in-air vocalizations of California sea otters (*Enhydra lutris nereis*) suggest that the species may be capable of vocal recognition, with vocalization patterns thought to be used during communication between known individuals in close range (McShane et al. 2013). Sound production and reception in California sea otters suggest an in-air hearing range of 0.125 kHz to 32 kHz for the species (Ghoul and Reichmuth 2012).

3.2.3 Discussion

A review of existing TK, relevant literature, previous and current relevant environmental assessments, and historical data on marine resources in the facility and shipping RSAs reveals that Kitimat Arm is home to a diverse range of marine habitats and organisms.

In the facility LSA, PAHs in sediment have been identified as the contaminant of concern when existing sediment is disturbed. Concentrations have decreased in surface sediments since the 1970s and have decreased with distance from the RTA smelter. Recent sampling in the proposed dredge area indicates that PAH concentrations are contained within the top 6 m of sediment, and mainly in the top 3 m of sediment. The PAHs have low bioavailability, attributed to the nature of emissions from the smelter. There is evidence of PAH-induced DNA damage in flatfish from sites in the LSA, although the prevalence of damage decreased over five years of sampling, indicating a gradual improvement in sediment quality. A negative correlation was found between PAH concentration and benthic community richness in Alcan Harbour in the 1990s, but PAH concentrations have declined considerably since then.

Metals concentrations above sediment guidelines have been noted, both in localized areas in the dredge area (copper, cadmium, and zinc), suggesting human sources, and throughout the facility RSA (copper). In most locations, the elevated copper levels appear to reflect natural conditions because they are similar in all depths sampled and in many areas of Kitimat Arm.

Over 75 species of marine fish and 100 species of marine invertebrates from 12 phyla are known to occur in Kitimat Arm (see Appendix B, Table B-1). A number of these species are captured in CRA fisheries, including groundfish, pelagic fish, salmon, crabs, and pandalid shrimp (Lucas et al. 2007b). In general, more information is available in the literature about species targeted in fisheries than non-fishery species. At least 12 species of marine mammals are known to occur in the marine resources shipping LSA and RSA.

The facility RSA overlaps with IAs for eulachon, tanner crab, cloud sponge, and encompasses Pacific salmon spawning rivers, eulachon spawning rivers, and Pacific herring spawning areas (Hay and McCarter 2000; Clarke and Jamieson 2006b; Jefferson et al. 2009; DFO 2013c). Eight marine fish and invertebrate species at risk may occur in both the facility and shipping RSAs, including the bluntnose sixgill shark, spiny dogfish, canary rockfish, yelloweye rockfish, quillback rockfish, eulachon, green sturgeon, and northern abalone. Another seven marine fish species at risk may occur in the shipping RSA, including bocaccio, darkblotched rockfish, longspine thornyhead, rougheye rockfish, yellowmouth rockfish, tope, and Olympia oyster. Further, seven marine mammal species at risk are known to occur in the shipping RSA: humpback whale, fin whale, killer whale (Bigg's and northern resident), harbour porpoise, Steller sea lion, and sea otter. The shipping RSA overlaps with DFO IAs for fin whale, northern resident killer whale, and humpback whale.

Marine fish habitat types on BC's north coast include marine riparian habitat, intertidal habitat, subtidal habitat, estuaries and salt marshes, and kelp and eelgrass beds (Jamieson and Davies 2004; Lucas et al. 2007a; Lucas et al. 2007b). The facility RSA encompasses portions of the Kitimat River estuary and Kitimat Arm. This area has been used for a variety of industrial activities since the 1950s, including an aluminum smelter, a pulp and paper mill, a methanol plant, and log storage and handling facilities (Levings 1976; MacDonald and Shepherd 1983). "Estuary, marsh or lagoon" and "rock with gravel beach" are the most common shore types in the RSA, whereas "constructed" is the most common shore type in the facility LSA (MFLNRO 2005). Mud is the dominant subtidal substrate in the facility LSA, RSA, and BSAs (Parks Canada and BCMCA 2014). Eelgrass is known to occur in the facility RSA and has been documented in Minette Bay, near Hospital Beach, and Emsley Cove (Jacques Whitford 2005; Kitimat Valley Naturalists 2011). Several species of cold-water sponges are also known to occur in the RSA (Stantec Consulting Ltd. 2012; Golder Associates Ltd. 2014b).

A relatively large body of knowledge exists about fish and fish habitat in the facility RSA. While this information provides a strong foundation for the assessment of potential effects on marine resources from the Project, more detailed site-specific information about the biophysical characteristics of marine fish and fish habitat in the facility LSA was required to assess potential Project effects. Three marine field studies were conducted in the LSA to address this knowledge gap (see Section 4).

Information available on the distribution and sightings of marine mammals is either sparse for the north coast, or not corrected for effort and, therefore, does not accurately reflect marine-mammal habitat use in the shipping RSA. Abundance estimates are available for some species, but are given for a much broader area (e.g., Queen Charlotte Sound), with limited coverage in the nearshore inlets and fjords of the area. Additional information on the distribution, abundance, and seasonal use of the area by marine mammals in the shipping RSA was required to assess potential Project effects. Twelve marine mammal surveys were conducted in the shipping RSA to address this knowledge gap (see Section 4).

4 FIELD STUDIES

Field studies were conducted to collect baseline information on marine fish and fish habitat, and marine mammals. Three field studies were conducted to characterize marine fish and fish habitat in the facility LSA, including an intertidal survey, a salt marsh survey, and a subtidal survey. Data tables from these surveys are provided in Appendix C. A subtidal survey was also conducted by Golder Associates Ltd. to characterize fish and fish habitat and to identify potential glass sponge assemblages in the BSAs (see Appendix D and Appendix E). Twelve marine mammal surveys were conducted in the marine resources shipping LSA and RSA to provide additional information on the distribution, abundance, and seasonal use of these areas by marine mammals. An underwater noise field study was conducted in the shipping RSA by JASCO Applied Sciences to measure baseline ambient noise levels and their variability, to quantify existing vessel traffic through acoustic detections, and to describe the spatial and temporal acoustic presence of select marine mammal species along the marine access route (see Appendices F and G).

4.1 Intertidal Survey

The objective of the intertidal survey was to collect baseline data and information about the marine fish habitat and marine biota in the intertidal zone of the facility LSA.

4.1.1 Methods

Two intertidal surveys were conducted at the facility LSA: August 30 through September 2, 2012, and June 22 through 27, 2013. The surveys were completed during the best available low-tide sequences in August and September 2012 and June 2013 to maximize the surface area of the intertidal zone exposed for sampling.

The intertidal zone was surveyed using transect methods based on the marine habitat information requirements and recommended survey procedures established by DFO (Williams 1993; DFO 2004, 2011b). The survey design included quadrat sampling to gather quantitative data on marine species and to estimate their relative density in the facility LSA. Transects were distributed to provide adequate coverage of all habitat types in the study area.

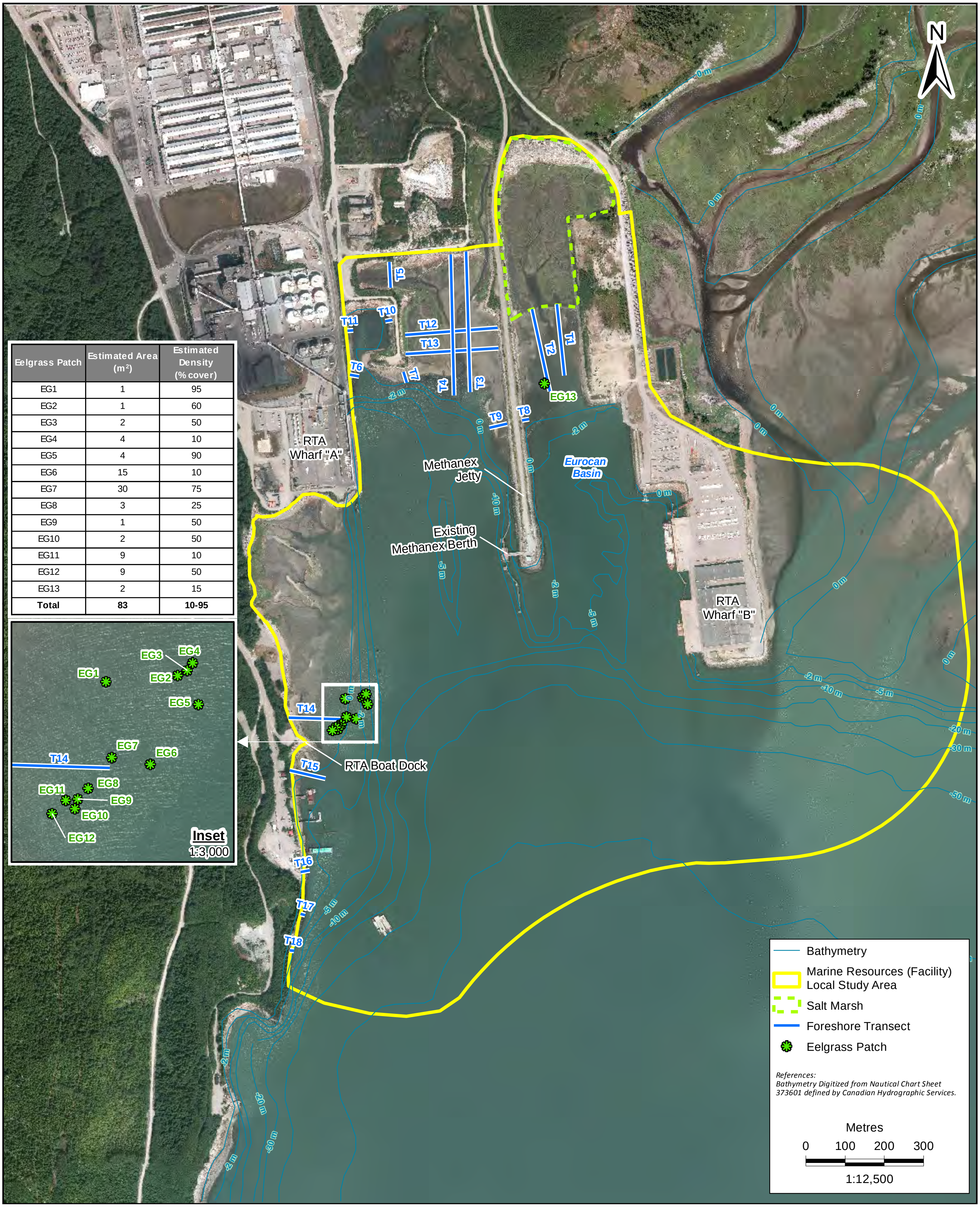
Transect surveys consisted of a tape measure extending from the highest high-water mark to the mean lower low-water mark, perpendicular to the waterline. In instances where tide levels were above the mean lower low-water mark, transects extended from the highest high-water mark to the waterline. Surveys were conducted within two hours of low tide to survey the full extent of the intertidal zone. Coordinates of the landward and seaward ends of each transect were marked using hand-held global positioning system (GPS) units. Detailed notes and photographs of the general physical and biological conditions of each area sampled were taken.

A total of 18 transects were placed in the intertidal zone of the facility LSA (Figure 4.1-1 and Photo 4.1-1). For each transect, the intertidal zone was divided into low, mid, and high intertidal zones based on the biotic assemblages present and professional judgment of the field team. The length and slope of each zone (high, mid, low) was measured using a tape measure and clinometer, respectively. Substrates were classified by substrate type (Table 4.1-1) for each transect following standard methods in Williams (1993). A visual survey of the backshore and subtidal zones was also conducted at each transect, and detailed notes were taken on the biological and physical characteristics of these zones.

Table 4.1-1: Classification of Substrate Types

Substrate Type	Definition
Bedrock	Continuous solid rock exposed by the scouring forces of water
Boulder	Rocks greater than 256 mm in diameter
Cobble	Moderate- to small-sized rocks 64 mm to 256 mm in diameter
Pebble	Small stones between 2 mm to 64 mm in diameter
Sand	Fine deposits frequently found on margins of streams or between rocks and stones, ranging from 0.06 mm to 2 mm in diameter
Mud/clay	A material of organic origin with a greasy feel between the fingers and no apparent structure, less than 0.06 mm in diameter
Organics/detritus	A soft material composed of silt and clay and containing 85% or more organic materials, such as sticks, leaves, and remnants of decayed aquatic plants
Shell debris	Calcareous remains of shellfish or invertebrates containing shells

SOURCES: Williams (1993); DFO (2007b)



Eelgrass Patch	Estimated Area (m²)	Estimated Density (% cover)
EG1	1	95
EG2	1	60
EG3	2	50
EG4	4	10
EG5	4	90
EG6	15	10
EG7	30	75
EG8	3	25
EG9	1	50
EG10	2	50
EG11	9	10
EG12	9	50
EG13	2	15
Total	**83**	**10-95**

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MARINE RESOURCES TECHNICAL DATA REPORT

INTERTIDAL TRANSECTS AND EELGRASS MAPPING

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION: UTM9	DRAWN BY: SS
DATUM: NAD 83	CHECKED BY: SW
DATE: 20-AUG-14	FIGURE NO. **4.1-1**

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Photo 4.1-1: Intertidal Transects in Facility Local Study Area

Alongshore transects (i.e., parallel to the waterline) were placed along each vertical transect in the approximate middle of each intertidal zone (i.e., low, mid, high) (Figure 4.1-2). The alongshore transects were 25 m long and intersected the vertical transects at their mid-point (12.5 m). Five randomly selected quadrat locations were sampled along each of the alongshore transects. Quadrat dimensions were 0.25 m x 0.25 m. Species in each quadrat were identified and quantified using percent cover or individual counts. Species were identified using field guides (Druehl 2000; Lamb and Hanby 2005; Lamb and Edgell 2010; Harbo 2011). Organisms that could not be identified to the species level with certainty were identified to the lowest taxonomic level possible. For each quadrat, the following information was collected:

- a photograph of each quadrat in position
- substrate type – recorded as percent cover per quadrat following general substrate classification methods (as per Table 4.1-1); substrate types were cumulative and recorded as percentages out of a total of 100%
- vegetation (Table 4.1-2) – recorded as estimates of percent cover per quadrat
- sessile invertebrates (e.g., barnacles, mussels, sponges) – recorded as estimates of percent cover per quadrat
- motile invertebrates and fish – recorded as number of individuals per quadrat; individuals were counted, or if numbers were too large to count, abundance was estimated as an approximate count per quadrat.

Incidental observations of less common marine species that were not observed by quadrat sampling were recorded.

Table 4.1-2: Description of Vegetation Types

Vegetation Type	Definition
Brown algae	Common name for species from the phylum Phaeophyta; typically brown, with a large broad-bladed thallus attached to the substrate by a tough stalk and holdfast; brown algae may be light olive-green, brown, yellow, golden, or almost black in colour
Green algae	Common name for species from the phylum Chlorophyta; green algae are green in colour because of the dominant chlorophyll pigment
Red algae	Common name for species from the phylum Rhodophyta; most seaweed species are found in this phylum; red algae may be green, yellow, brown, red, pink, or purple in colour
Seagrass	Flowering plants that evolved on land, but have adapted to the marine environment; found in the low intertidal and shallow subtidal zone; common on mud flats that are exposed at low tide, in estuaries, and shallow, protected bays; species found in BC include the native eelgrass, *Zostera marina*, and an exotic species, *Zostera japonica*
Vascular plants	Vascular plant species are typically present at elevations that are seldom inundated by tidal waters; some marsh plants can tolerate higher salinity

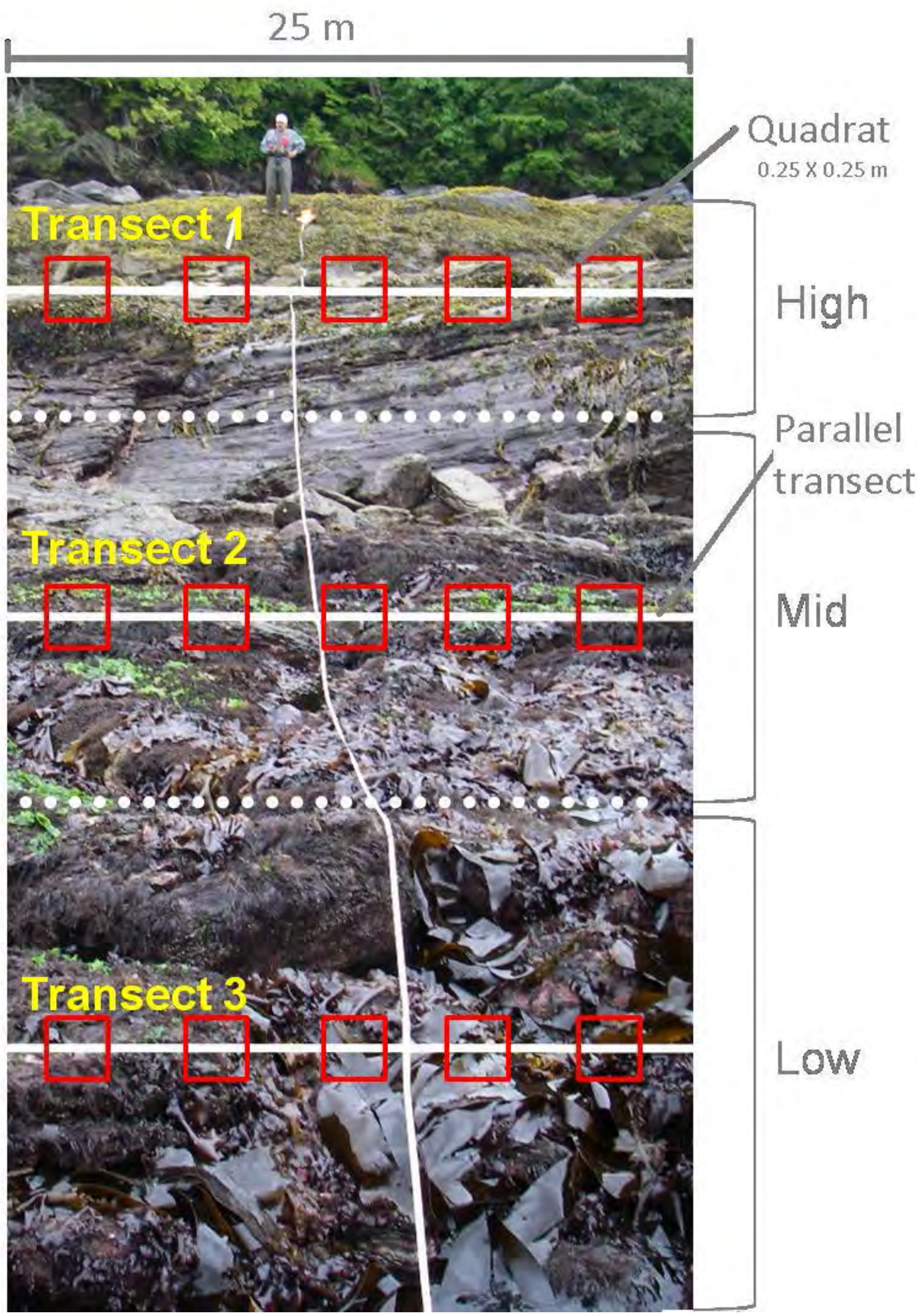


Figure 4.1-2: Intertidal Transect Layout

Two transects (12 and 13) were placed in the mid intertidal zone of the large tidal flat located between the RTA Wharf "B" to the east and Methanex jetty to the west. These transects were intended to gather additional information about this large zone. A tape measure was extended across the tidal flat from west to east. A coordinate for the start and end point of each transect was marked using hand-held GPS units. Detailed notes and photographs of the general physical and biological conditions along each transect were taken every 50 m and at every transition between dominant biophysical features (e.g., vegetation, substrate type).

In addition to transect surveys, a general site survey using visual observations was conducted to identify rare or sensitive species and habitats that might be present in the intertidal zone of the facility LSA (i.e., eelgrass, species at risk, invasive aquatic species). Rare or sensitive species and habitats were photographed, their location recorded with a hand-held GPS unit, and, for eelgrass, the area and density (percent cover) were estimated.

4.1.2 Results

4.1.2.1 Backshore Habitat

The backshore zone consists of altered marine riparian habitat associated with a variety of constructed structures and materials, including graded construction and staging areas, causeways, dikes, wharves, gravel roads, concrete and rock riprap, culverts, and wood and metal debris (Photo 4.1-1). Riparian vegetation in this area includes small- to medium-sized coniferous and deciduous trees, shrubs, sedges, and grasses. Backshore habitat at each transect is described in Table 4.1-3.

Photo 4.1-2: Backshore Habitat in Facility Local Study Area

Table 4.1-3: Description of Backshore Habitat

Transect	Description
Transects 1 and 2	▪ Narrow rock dike (boulder and cobble) ▪ Salt marsh (see Section 4.2 below)
Transects 3, 4, and 5A	▪ Riprap consisting of large concrete slabs, wood, and metal debris ▪ Gravel road ▪ Sitka spruce (*Picea sitchensis*) and black cottonwood (*Populus trichocarpa*)
Transects 6 and 11	▪ Adjacent to RTA Wharf “A” ▪ Concrete wall, riprap consisting of large angular rock (boulder size) ▪ Gravel road, chain-link fence ▪ Grasses, shrubs, bushes, Sitka spruce, and black cottonwood
Transect 7	▪ Causeway ▪ Riprap consisting of large concrete slabs, wood, and metal debris ▪ Grass, Sitka spruce, and black cottonwood
Transects 5B, 8–12	▪ Methanex jetty ▪ Riprap consisting of large concrete slabs and large angular rock (boulder), wood and metal debris ▪ 1.5 m diameter culvert through Methanex jetty between Transects 8 and 9 ▪ Grass and small trees, including pine (*Pinus* sp.), black cottonwood, alder (*Alnus* sp.), hemlock, and spruce
Transects 14–16	▪ Road, parking lot, RTA boat dock ▪ Large woody debris ▪ Sitka spruce, alder, redcedar, black cottonwood, tufted hair-grass, silverweed ▪ Concrete wall, 1 m diameter culvert, asphalt and metal debris at Transect 15
Transect 17–18	▪ Boulders, large woody debris ▪ Redcedar, Sitka spruce

4.1.2.2 Intertidal Habitat

4.1.2.2.1 Slope and Substrate Type

The slope and length of the intertidal transects are listed in Table 4.1-4 and the length of each transect is shown in Figure 4.1-3. Intertidal habitat in the facility LSA consists primarily of sand and mud tidal flats. Consequently, the slope is typically low to moderate in the low and mid intertidal zones. The slope is typically greater in the high intertidal zone because it primarily consists of steep, rock riprap.

A low zone was not defined at Transect 5 because the seabed was fully exposed at mid-tide. Transect 5 included two high zones because the vertical transect spanned both the south (Transect 5A) and north (Transect 5B) sides of the embayment. The low intertidal zone at Transects 10 and 11 was not surveyed because the mud was too deep in the low zone to be surveyed safely.

Table 4.1-4: Length and Slope of Intertidal Transects

Transect Number	Date (dd/mm/yy)	Low Tidal Height (m)	Total Length (m)	High Zone Length (m)	Mid Zone Length (m)	Low Zone Length (m)	Total Slope (%)	High Zone Slope (%)	Mid Zone Slope (%)	Low Zone Slope (%)
1	30/08/12	0.8	183.0	25.0	39.0	119.0	3	9	3	1
2	30/08/12	0.8	215.0	9.0	79.0	127.0	2	22	1	1
3	31/08/12	0.7	360.0	20.0	320.7	16.0	1	20	0	4
4	31/08/12	0.7	370.0	28.0	252.0	90.0	3	12	2	1
5A (south)	01/09/12	0.8	26.0	7.5	18.5	0	7	26	8	0
5B (north)	01/09/12	0.8	45.0	26.5	18.5	0	3	3	3	0
6	01/09/12	0.8	24.4	7.2	12.0	5.2	12	18	9	9
7	02/09/12	1.0	39.6	19.5	14.5	5.6	9	9	9	9
8	30/08/12	0.8	16.5	7.9	6.8	1.8	26	44	9	9
9	31/08/12	0.7	51.0	9.4	36.6	5.0	7	30	2	2
10	01/09/12	0.8	19.0	9.0	7.5	0	22	28	23	–
11	01/09/12	0.8	17.0	11.1	3.7	0	17	21	15	–
12	22/06/13	0.3	219.0	0	219.0	0	–	–	–	–
13	22/06/13	0.3	139.1	0	139.1	0	–	–	–	–
14	23/06/13	0.1	137.5	35.5	16.5	85.5	2	10	2	1
15	23/06/13	0.1	93.0	19.2	54.0	19.8	4	8	2	1
16	23/06/13	0.1	24.7	7.6	10.0	7.1	19	18	21	16
17	24/06/13	0.0	12.2	2.1	7.3	2.8	22	16	24	21
18	24/06/13	0.0	19.4	6.3	8.7	4.4	24	20	27	22

NOTE:

– not collected

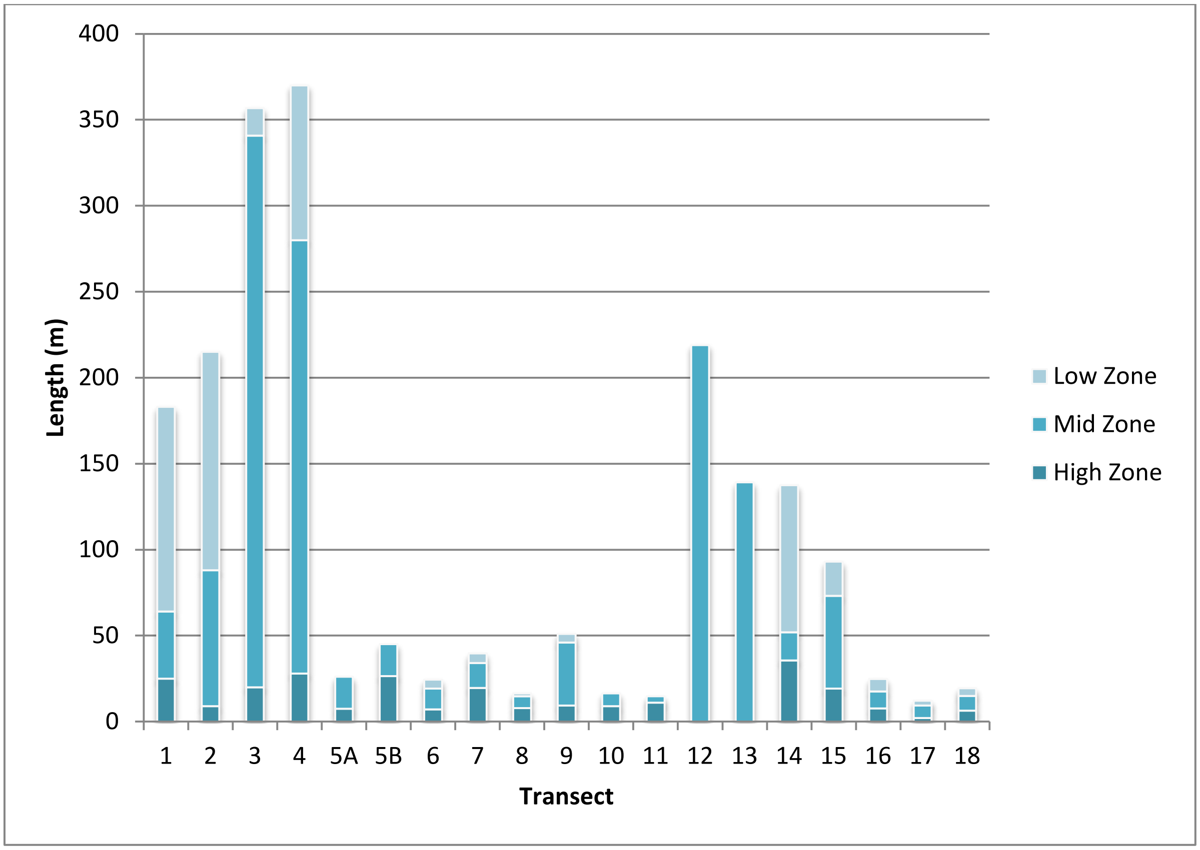


Figure 4.1-3: Intertidal Transect Length

The distribution of substrate types in the facility LSA is shown in Figure 4.1-4, and the distribution of substrate types across the low, mid, and high intertidal zones is shown in Figure 4.1-5. All three zones consisted of mixed substrate, with more coarse substrates in the high zone and more fine substrates in the mid and low zones. Boulder and cobble-sized rock riprap and concrete slabs were the most common substrates in the high zone, whereas pebble, sand, and mud were the most common substrates in the mid and low zones. Woody debris was relatively common in the high zone and uncommon in the low and mid zones.

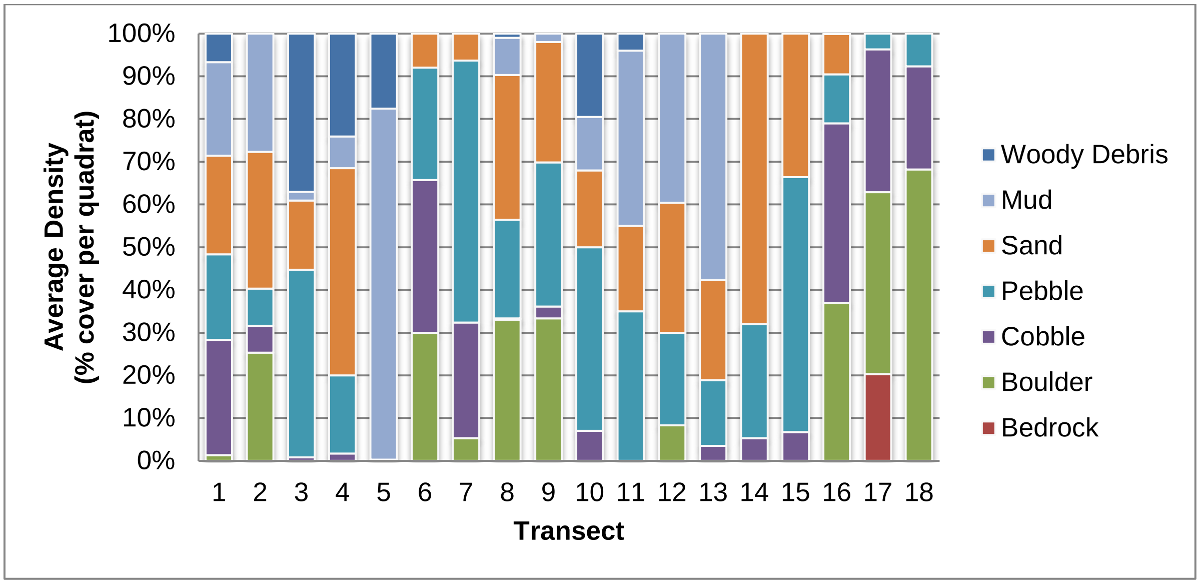


Figure 4.1-4: Average Density of Intertidal Substrate Types in the Facility Local Study Area

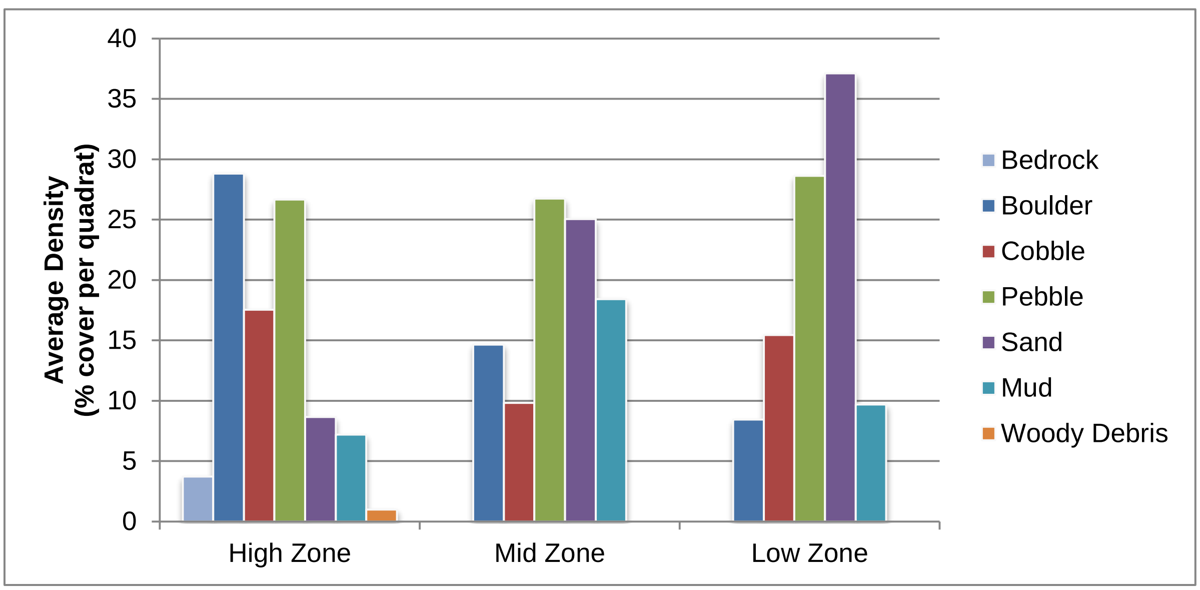


Figure 4.1-5: Average Density of Intertidal Substrate Types by Zone in the Facility Local Study Area

4.1.2.2.2 Marine Fish and Invertebrates

Four species of marine fish and 15 species of marine invertebrates were observed during the intertidal survey (Table 4.1-5). The relative density of marine fish and invertebrates observed during the intertidal surveys is listed in Appendix C, Table C-1. Three fish were observed during quadrat sampling, including a penpoint gunnel (*Apodichthys flavidus*) in Transect 10, an unidentified gunnel (family Pholidae) in Transect 9, and a sculpin (family Cottidae) in Transect 3. The decomposed carcasses of a number of spawning salmon were incidentally observed near Transects 1 to 4; but no live salmon were observed during the intertidal survey (Photo 4.1-3). A polychaete worm was observed in the high intertidal zone west of Transect 7, but was not observed during quadrat sampling.

Table 4.1-5: Intertidal Survey: Marine Fish and Invertebrates in the Facility Local Study Area

Taxon	Phylum	Description	Low Zone	Mid Zone	High Zone
Penpoint gunnel *Apodichthys flavidus*	Chordata	Fish	–	X	–
Gunnel *Pholis* sp.	Chordata	Fish	X	–	–
Sculpin Family Cottidae	Chordata	Fish	X	–	–
Pacific salmon *Oncorhynchus* sp.[a]	Chordata	Fish	–	X	X
Common acorn barnacle *Balanus glandula*	Arthropoda, Crustacea	Barnacle	X	X	X
Crangonid shrimp Family Crangonidae	Arthropoda, Crustacea	Shrimp	X	X	–
Gammarid amphipod Suborder Gammaridea	Arthropoda, Crustacea	Amphipod	X	X	X
Stubby isopod *Gnorimosphaeroma oregonensis*	Arthropoda, Crustacea	Isopod	X	X	X
Rockweed isopod *Idotea wosnesenskii*	Arthropoda, Crustacea	Isopod	X	X	–
Intertidal pseudoscorpion *Halobisium occidentale*	Arthropoda	Arthropod	–	–	X
Purple shore crab *Hemigrapsus nudus*	Arthropoda	Shore crab	X	–	–
Green shore crab *Hemigrapsus oregonensis*	Arthropoda	Shore crab	X	–	–
Red velvet mite *Neomolgus littoralis*	Arthropoda	Mite	X	X	–
Sitka periwinkle *Littorina sitkana*	Mollusca	Periwinkle	–	X	–

Taxon	Phylum	Description	Low Zone	Mid Zone	High Zone
Limpet *Lottia* sp.	Mollusca	Limpet	X	X	–
Blue mussel *Mytilus* spp. complex	Mollusca	Mussel	X	X	–
Unidentified bivalve Class Bivalvia	Mollusca	Clam	X	X	–
Ribbon worm Phylum Nemertea	Nemertea	Worm	X	–	–
Polychaete worm Class Polychaeta	Annelida	Worm	–	–	X

NOTES:
[a] No live specimens were observed during intertidal survey.
X – species observed
– species not observed

Photo 4.1-3: Salmon Carcasses in Facility Local Study Area

Two types of siphon holes were observed in sand and mud substrates. The first type was circular and approximately 1 cm to 2 cm in diameter; the second type was triangle shaped with sides approximately 3 cm to 5 cm long (Photo 4.1-4). Both types of siphon holes were excavated. Bivalve molluscs were found in the first type of siphon holes near Transects 1, 2, 14, and 15. It is not known which species are responsible for creating the second type of siphon hole; but it is likely they were created by crangonid shrimp because these species were observed near the siphon holes.

The most common invertebrates observed were amphipods (suborder Gammaridea), with an average density of 5.5 individuals per quadrat, and stubby isopods, with an average density of 2.5 individuals per quadrat. Only two gunnels, one sculpin, one crangonid shrimp, two intertidal pseudoscorpions (*Halobisium occidentale*), and one ribbon worm (phylum Nemertea) were observed during the transect surveys.

Photo 4.1-4: Siphon Holes in Facility Local Study Area

Three species of marine fish and 14 species of invertebrates were observed in the low intertidal zone, 12 in the mid zone, and 5 in the high zone (Table 4.1-6). Marine fish were rarely observed in the mid and low zones and were not observed in the high zone. Stubby isopods were the most common invertebrate species observed in the low and high zones; amphipods were the most common species in the mid zone.

4.1.2.2.3 Marine Vegetation

Twelve species of marine algae, one species of seagrass, and five species of marsh plants were observed in the intertidal zone (Table 4.1-6). The relative density of marine vegetation observed during the intertidal surveys is listed in Appendix C, Table C-2. Thirteen small patches of common eelgrass ranging from 1 m^2 to 30 m^2 in area (83 m^2 total) and 10% to 95% cover were observed in the low intertidal zone near Transect 2 and Transects 14 and 15 (Photo 4.1-5). Locations of the eelgrass patches are shown in Figure 4.1-1. Eelgrass was not observed during quadrat sampling along transects.

Table 4.1-6: Intertidal Survey: Marine Vegetation in the Facility Local Study Area

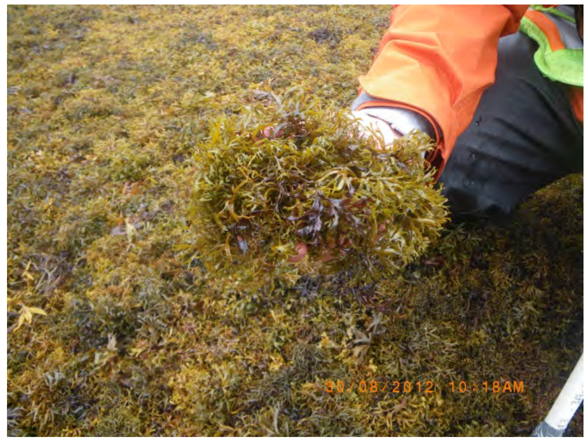
Taxon	Phylum	Description	Low Zone	Mid Zone	High Zone
Green rope *Acrosiphonia* sp.	Chlorophyta	Green algae	X	X	X
Sea moss *Cladophora* sp.	Chlorophyta	Green algae	X	X	X
Green ribbon *Ulva intestinalis*	Chlorophyta	Green algae	X	X	X
Sea lettuce *Ulva* sp.	Chlorophyta	Green algae	X	X	–
Rockweed – form A *Fucus gardneri*	Ochrophyta	Brown algae	X	X	X
Rockweed – form B *Fucus gardneri*	Ochrophyta	Brown algae	X	X	–
Sugar wrack kelp *Laminaria saccharina*	Ochrophyta	Brown algae	X	–	–
Brown filamentous algae Phylum Ochrophyta	Ochrophyta	Brown algae	X	X	X
Rusty rock *Hildenbrandia* sp.	Rhodophyta	Red algae	–	–	X
Tar spot seaweed *Mastocarpus* sp. (crust)	Rhodophyta	Red algae	X	X	X
Turkish washcloth *Mastocarpus* sp. (blade)	Rhodophyta	Red algae	X	–	–
Sea brush *Odonthalia* sp.	Rhodophyta	Red algae	X	–	–
Red ribbon *Palmaria* sp.	Rhodophyta	Red algae	X	–	–
Colonial diatoms Family Bacillariaceae	Bacillariophyta	Diatom	X	X	X
Common eelgrass *Zostera marina*	Streptophyta	Seagrass	X	–	–
Lyngbye's sedge *Carex lyngbyei*	Magnoliophyta	Plant	–	X	X
Seaside arrowgrass *Triglochin maritimum*	Magnoliophyta	Plant	–	–	X
Silverweed *Potentilla anserina* ssp. *pacifica*	Embryophyta	Plant	–	–	X
Tufted hair-grass *Deschampsia caespitose*	Spermatophyta	Plant	–	–	X
Horned pondweed *Zannichellia palustris*	Tracheophyta	Plant	–	X	–

NOTES:
X – species observed
– species not observed

Photo 4.1-5: Eelgrass Patches in Facility Local Study Area

Rockweed was present in two forms (Photo 4.1-6):

- Form A – the most common form of rockweed found attached to rocks in the mid to high intertidal zone with inflated branch tips (Druehl 2000; Lamb and Hanby 2005), and
- Form B – the unattached, non-reproductive form lacking inflated branch tips that is common in estuarine environments (Gabrielson et al. 2006).



NOTE
Left: Form A; Right: Form B

Photo 4.1-6: Rockweed Forms in Facility Local Study Area

Overall, the density of marine vegetation was low in the facility LSA (Figure 4.1-6). The most common species of algae observed was rockweed, with an average density of 15.2% cover in Form A and 12.9% cover in Form B. Green rope was also relatively common with an average density of 6.6% cover. Lyngbye's sedge was the most common of all plant species with an average density of 9.0% cover. The relative density of marine vegetation species observed during the intertidal survey is shown in Appendix C, Table C-2.

Fourteen species of marine vegetation were observed in the low intertidal zone, 10 in the mid zone, and 12 in the high zone (Table 4.1-6). Rockweed was the most common algae species in all zones. Lyngbye's sedge was the most common plant species in the high zone and was the only species present in the mid zone.

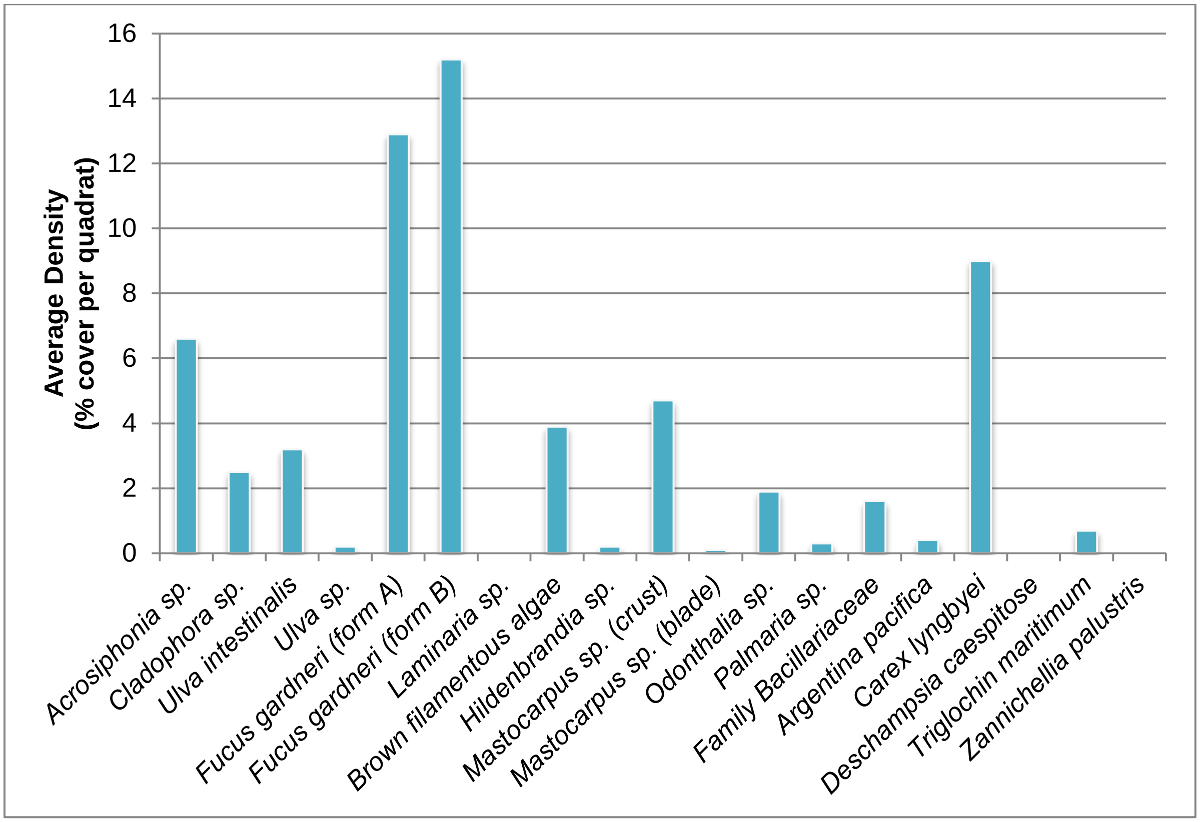


Figure 4.1-6: Intertidal Survey: Average Density of Marine Vegetation in the Facility Local Study Area

4.1.3 Discussion

Results of field surveys suggest the overall density of marine organisms in the intertidal zone of the facility LSA is low compared with other intertidal areas of BC's north coast. Even some of the most common marine algae and invertebrate species found throughout intertidal habitats in BC, such as rockweed, common acorn barnacles, and blue mussels were present in low densities in the LSA (Appendix C, Tables C-1 and C-2). Two factors likely contribute to the low diversity and density of marine organisms in the intertidal zone of the LSA. First, freshwater processes and input from Kitimat River have a strong influence on intertidal habitat in the estuary and might limit the establishment of some marine species that cannot tolerate lower salinity levels. This conclusion is supported by the fact that marine species diversity was greater at Transects 14 to 18, which are located further away from the influence of Kitimat River than the other transects. Second, the intertidal zone of the LSA consists almost entirely of constructed shore types. Coastal development and industrial activities in the LSA have likely reduced the productive capacity of marine riparian and intertidal habitats. None of the species observed in the intertidal zone have been identified by federal or provincial governments as species at risk.

The intertidal surveys were conducted during the summer when marine vegetation is assumed to be at or near its peak annual density and abundance. The data collected during the intertidal surveys are representative of the fish habitat conditions in the facility LSA during the survey period. However, seasonal and yearly variations in the distribution and abundance of marine organisms likely occur in the LSA, which are not reflected in the data.

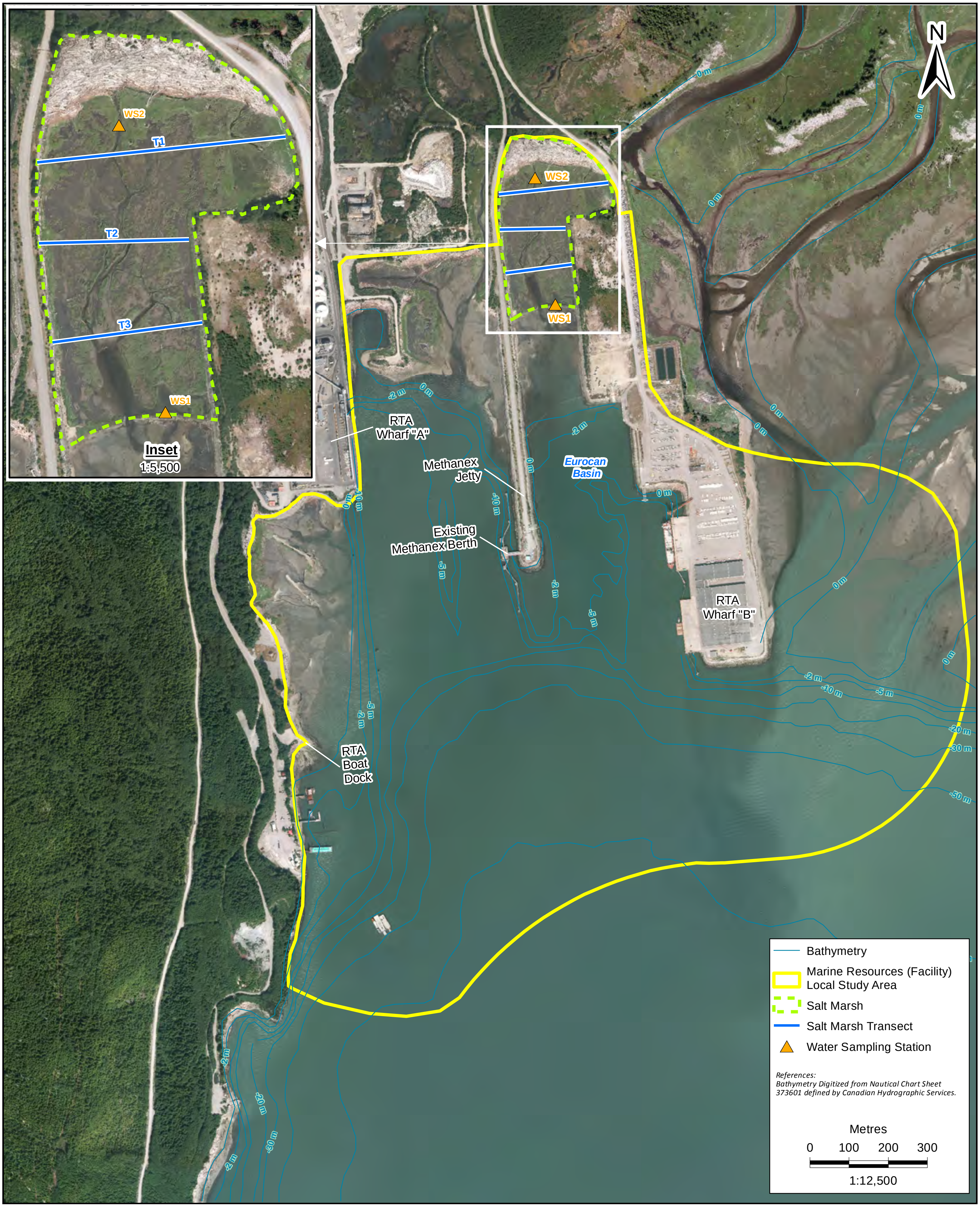
4.2 Salt Marsh Survey

The objective of the salt marsh survey was to collect baseline data and information on fish and fish habitat in the salt marsh located in the facility LSA. The salt marsh was created as compensation habitat for the Eurocan Pulp and Paper terminal expansion landfill between 1989 and 1990. A containment and protection dike consisting of quarry tailings was constructed along the southern boundary of the habitat compensation zone. Riprap was placed on top of the dike to create rocky habitat. The remainder of the habitat compensation zone was filled with sand and silt. Existing vegetation in the habitat compensation zone was removed before infill and then replanted once construction was complete. The salt marsh is isolated from Kitimat River to the east, and all surface water exchange occurs through an opening in the dike along the southern boundary of the marsh.

4.2.1 Methods

Three transects were surveyed in the salt marsh located between the RTA Wharf “B” and the Methanex jetty on August 30 through September 2, 2012, and on July 31, 2013 (Figure 4.2-1). Each transect was delineated using a tape measure extending across the salt marsh from west to east. A coordinate for the start and end point of each transect was marked using hand-held GPS units. Detailed notes and photographs of the general physical and biological conditions along each transect were taken every 25 m and at every transition between dominant biophysical features (e.g., vegetation, substrate type). The survey design included quadrat sampling to gather quantitative data on flora and fauna in the salt marsh and to estimate their relative density. Transects were distributed to provide adequate coverage of all habitat types in the salt marsh.

General water chemistry measurements were taken at two stations in the salt marsh on June 26, 2013 (Figure 4.2-1). The measurements were taken at the surface (depth of 0 m) during ebb tide using a YSI EXO1 water chemistry meter.



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MARINE RESOURCES TECHNICAL DATA REPORT

SALT MARSH TRANSECTS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
04-JUL-14	4.2-1

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4.2.2 Results

The salt marsh consists of tidal channels and marsh vegetation. The marsh is bordered by a constructed riprap revetment wall, and artificial and modified riparian habitat to the west, north, and east, and a rock dike partially open to Kitimat Arm to the south. The riparian habitat consists of black cottonwood, Sitka spruce, red alder, elderberry (*Sambucus* sp.), Lyngbye's sedge, and silverweed. To the west, the marsh is bounded by a road and the Methanex jetty. The salt marsh is flat, dominated by mud substrate (Figure 4.2-2), and characterized by a network of shallow tidal channels that drain into Kitimat Arm at low tide and flood at high tide (Photo 4.2-1). Elevation of the marsh ranges from approximately +2 m to +6.5 m CD, and many of the channels are at least partially filled with water at all stages of the tide.

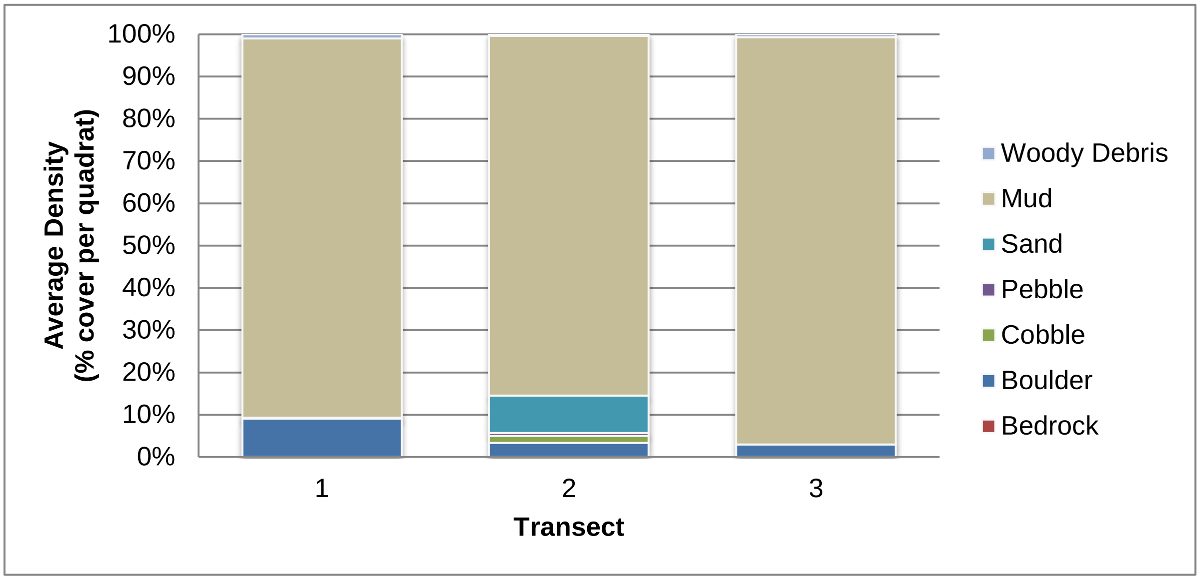


Figure 4.2-2: Salt Marsh Survey: Average Density of Substrate Types in the Salt Marsh

NOTES:

Clockwise from top left: rockweed, Lyngbye's sedge and tidal channels; rockweed Form B; tidal channel; sculpin; containment dike; Lyngbye's sedge and tidal channels

Photo 4.2-1: Salt Marsh in the Facility Local Study Area

Two species of marine algae, six species of marsh plants, two species of marine invertebrates, and two families of marine fish were observed in the salt marsh (Table 4.2-1). The salt marsh consisted primarily of Lyngbye's sedge, rockweed beds (Form B), and tidal channels (Photo 4.2-1). Stubby isopods and gammarid amphipods were observed living in and under the rockweed. Juvenile salmon and sculpin were observed swimming in the tidal channels, but were not observed during quadrat sampling.

Table 4.2-1: Salt Marsh Survey: Marine and Estuarine Biota in the Salt Marsh

Taxon	Phylum	Description
Rockweed (Form B) *Fucus gardneri*	Ochrophyta	Brown algae
Brown filamentous algae	Ochrophyta	Brown algae
Silverweed *Potentilla anserina* ssp. *pacifica*	Magnoliophyta	Plant
Lyngbye's sedge *Carex lyngbyei*	Magnoliophyta	Plant
Tufted hair-grass *Deschampsia cespitosa*	Magnoliophyta	Plant
Water mudwort *Limosella aquatica*	Magnoliophyta	Plant
Seaside arrowgrass *Triglochin maritimum*	Magnoliophyta	Plant
Horned pondweed *Zannichellia palustris*	Tracheophyta	Plant
Amphipod Suborder Gammaridea	Arthropoda, Crustacea	Amphipod
Stubby isopod *Gnorimosphaeroma oregonensis*	Arthropoda, Crustacea	Isopod
Sculpin Family Cottidae	Chordata	Fish
Pacific staghorn sculpin *Leptocottus armatus*	Chordata	Fish
Pacific salmon *Oncorhynchus* sp.	Chordata	Fish

The average density of species observed in the salt marsh is shown in Figure 4.2-3. The relative density of marine algae, marsh plants, and invertebrates observed in the salt marsh is shown in Appendix C, Table C-3. Rockweed (Form B) was the most common species observed, with an average density of 55.4% cover, followed by Lyngbye's sedge, with an average density of 24.5% cover. Amphipods and stubby isopods were moderately abundant with an average density of 12.8 and 7.1 individuals, respectively.

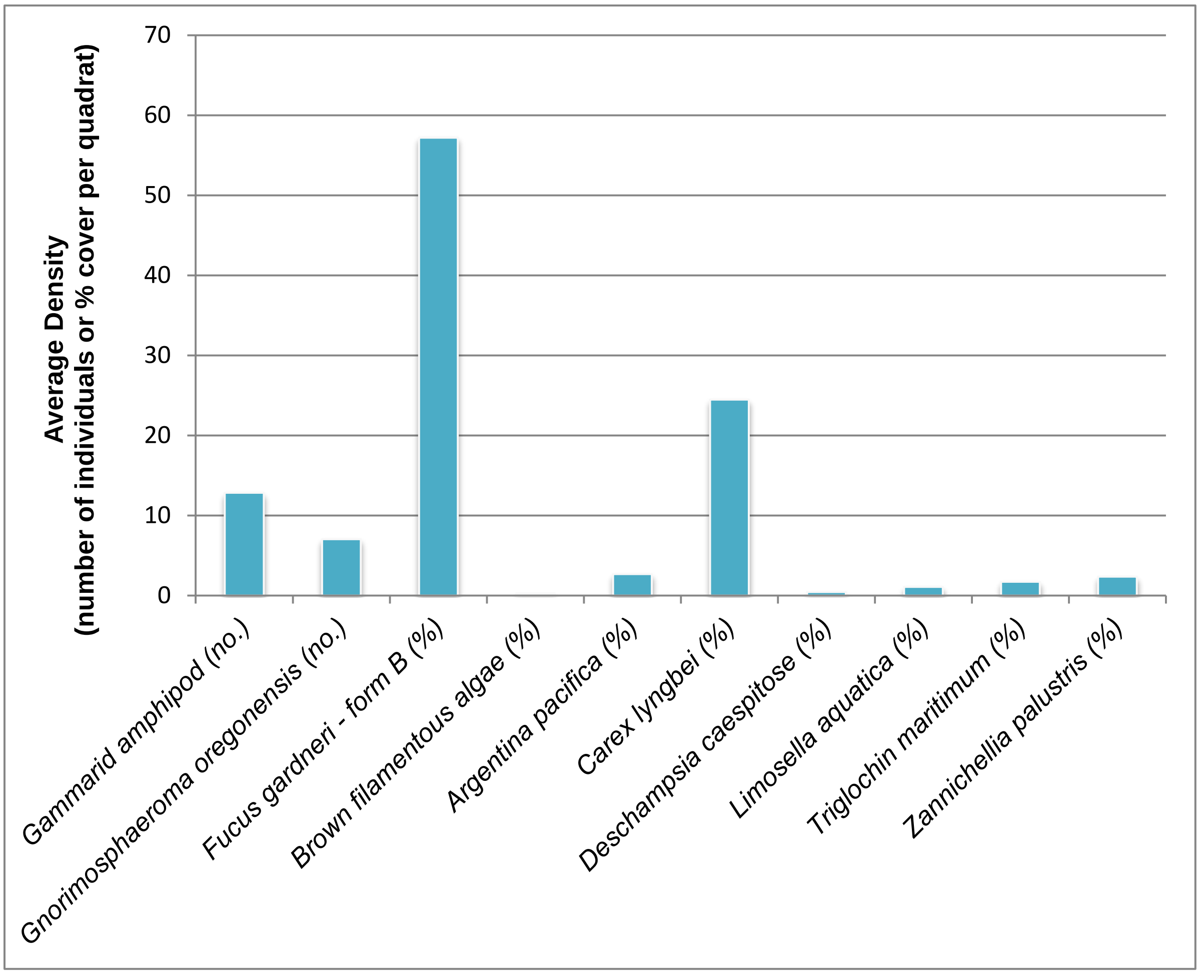


Figure 4.2-3: Salt Marsh Survey: Average Density of Marine Invertebrates and Vegetation in the Salt Marsh

General water chemistry measurements taken in the salt marsh are listed in Table 4.2-2. All measured parameters were relatively consistent at both sampling stations, with the exception of dissolved oxygen, which was about two times greater at the southern end of the marsh than the northern end. Salinity in the marsh was characteristic of estuarine waters.

Table 4.2-2: Salt Marsh Survey: General Water Chemistry Measurements

Station	Depth (m)	Temperature (°C)	Salinity (PSU)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	pH	Conductivity (µS/cm)
WQ1	0	14.1	2.46	8.02	4.22	6.27	4,570.6
WQ2	0	13.8	2.61	4.47	4.28	6.37	4,844.8

NOTES:
PSU – practical salinity unit
NTU – nephelometric turbidity unit
µS/cm – microsiemens per centimetre

4.2.3 Discussion

Rockweed, Lyngbye's sedge, and silverweed are the dominant vegetation species in the marsh. Although only two invertebrate species were observed in the salt marsh, they were relatively abundant. At all stages of the tide, the salt marsh provides habitat for marine fish, including five species of Pacific salmon and sculpin. None of the fish or invertebrate species observed in the salt marsh have been identified by federal or provincial governments as species at risk. Incidental bird observations in and around the salt marsh included Canada geese (*Branta canadensis*), great blue herons (*Ardea herodias fannini*), and bald eagles (*Haliaeetus leucocephalus*).

4.3 Subtidal Survey

The objective of the subtidal survey was to collect baseline data and information about marine fish and fish habitat in the subtidal zone of the facility LSA.

4.3.1 Methods

The subtidal survey was conducted in the facility LSA by International Underwater Surveyors Inc. (now Sea Roamer Marine Services) from October 3 to 6, 2012. The camera-mounted *Deep Ocean Phantom DHD2* remotely operated vehicle (ROV) was used to record video along transects extending across the LSA. The average flight speed was approximately 0.3 m/s, and the ROV was generally less than 1 m above the seabed. The camera provided a composite video signal to an overlay unit that stamped the GPS coordinates (latitude and longitude), together with date and time, on each video frame. The video signal was received in real-time by the vessel and was used to observe marine biota and habitat features and to avoid underwater obstacles.

A high-intensity white LED light and a tungsten-halogen light were mounted on the ROV frame to provide illumination when required. The camera was fitted with parallel scaling lasers mounted 15 cm apart to allow for accurate size estimation of organisms and objects. The camera also had zoom capability.

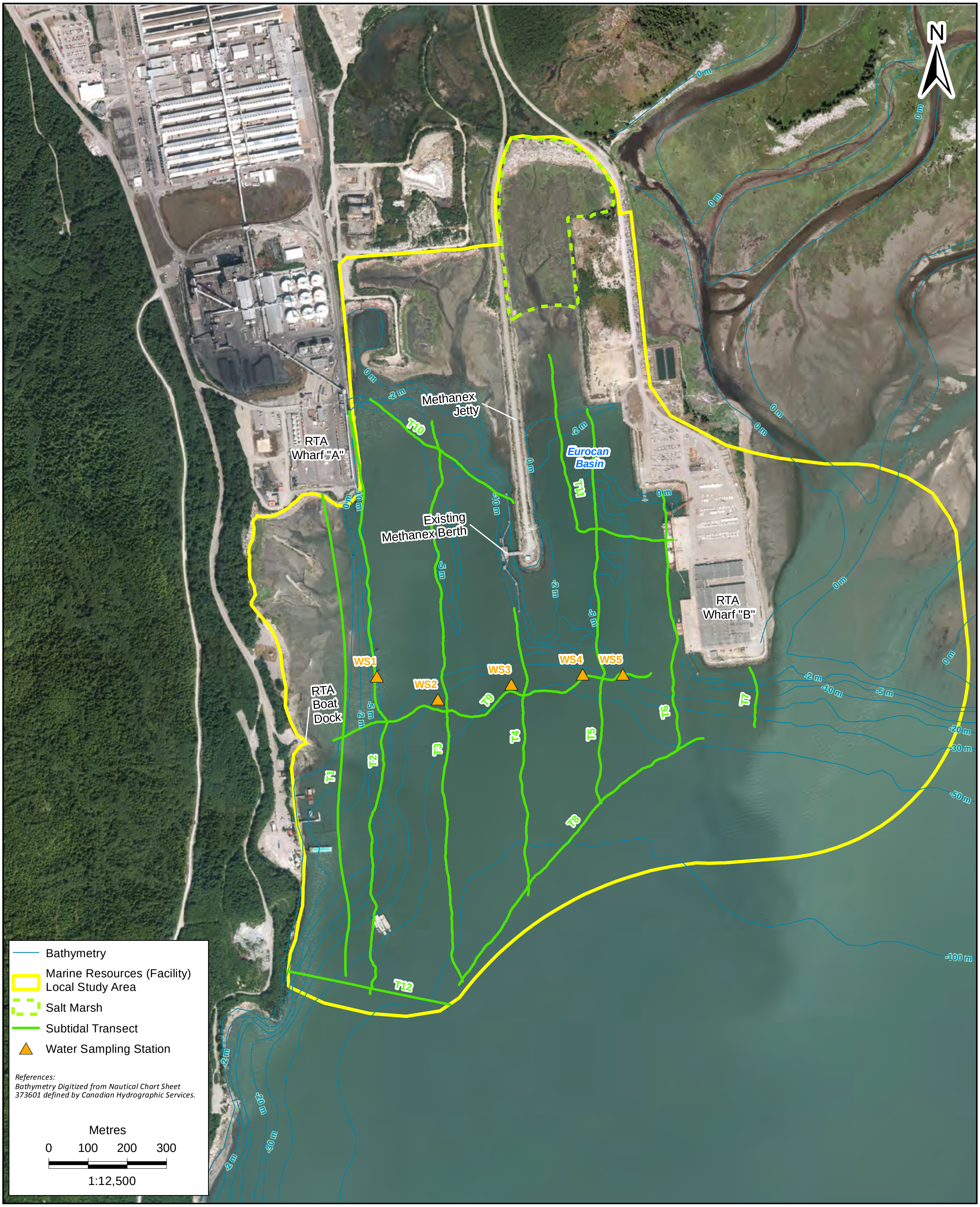
A total of 12 transects were flown with the ROV in the facility LSA (Figure 4.3-1). Transect spacing ranged from 100 m to 200 m apart for north-south transects and approximately 600 m apart for east-west transects. Transects were distributed to provide adequate coverage of all habitat types in the LSA.

Information recorded during analysis of the videos from the ROV included:

- the start and end time, start and end GPS coordinates, and start and end depth of transects
- the classification of substrate types along each transect following the standard methods in Williams (1993) and DFO (2007) (Table 4.1-1)
- the time, GPS coordinates, and depth of changes in substrate type and
- the time, GPS coordinates, and depth of each sighting of marine fish, invertebrate, and vegetation species.

Marine species were identified using field guides (Druehl 2000; Lamb and Hanby 2005; Lamb and Edgell 2010; Harbo 2011). Organisms that could not be identified to species were identified to the lowest taxonomic level possible.

General water chemistry measurements were taken at five stations in the facility LSA (Figure 4.3-1). Measurements were taken every metre from a start depth of 1 m to the seabed or to a depth of 20 m using a YSI EXO1 water chemistry meter.



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MARINE RESOURCES TECHNICAL DATA REPORT

SUBTIDAL TRANSECTS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION: UTM9	DRAWN BY: SS
DATUM: NAD 83	CHECKED BY: SW
DATE: 04-JUL-14	FIGURE NO.: **4.3-1**

4.3.2 Results

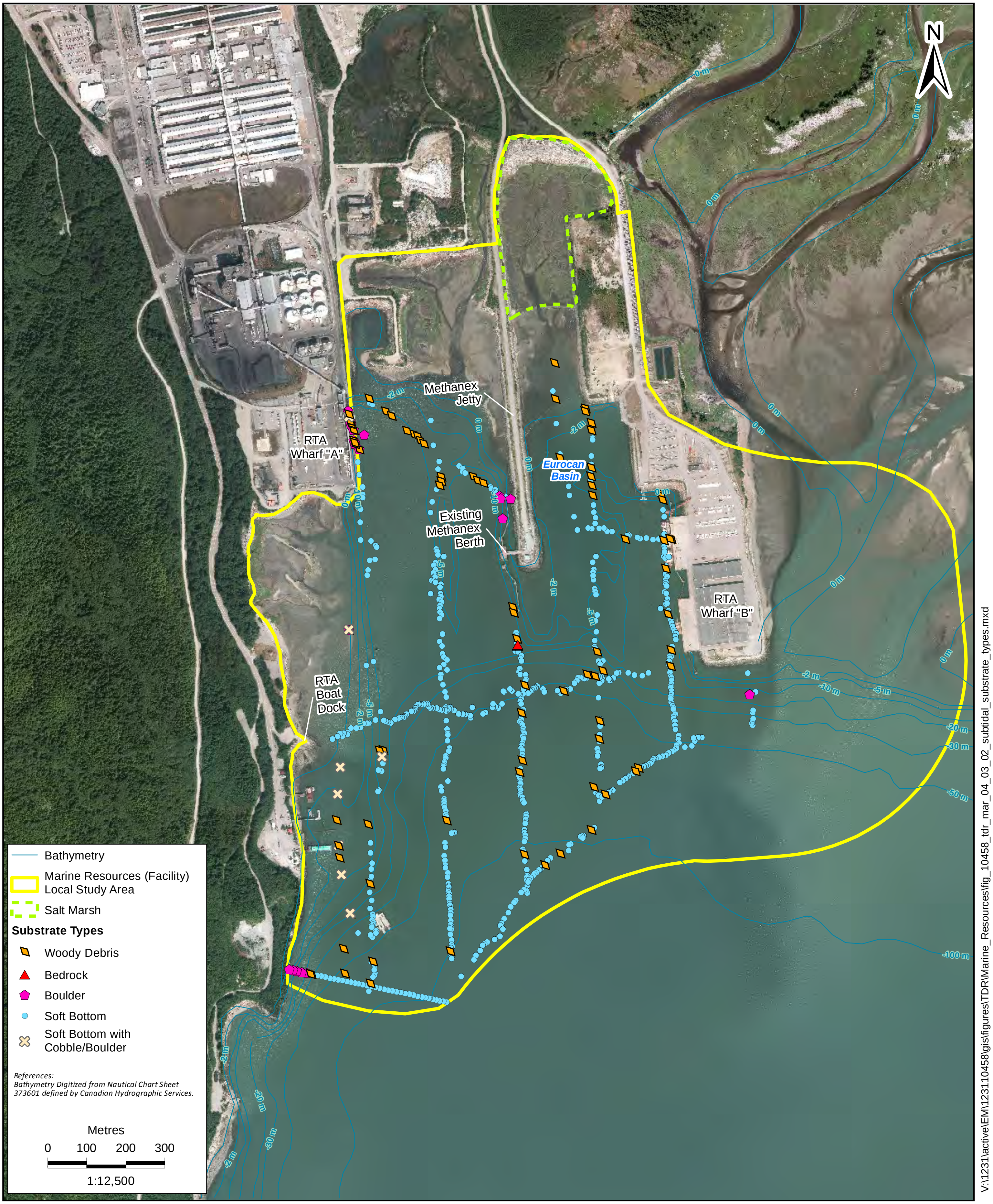
The total time, total length, and start and end depth of each subtidal transect are listed in Table 4.3-1.

Table 4.3-1: Length and Water Depth of Subtidal Transects

Transect	Total Length (m)	Start Depth (m)	End Depth (m)
1	1,237	56	3
2	1,639	12	1
3	1,480	12	81
4	746	7	118
5	1,022	17	118
6	663	2	93
7	156	4	17
8	910	17	57
9	895	38	0
10	457	58	118
11	707	18	1
12	424	4	0

4.3.2.1 Visibility, Water Depth, and Substrate Type

Overall visibility was moderate to poor during the subtidal survey. Video of the seabed indicates that it consists almost entirely of soft substrates. Figure 4.3-2 shows the distribution of subtidal substrate types at the facility LSA. Patches of boulder and cobble substrate were observed along Transects 1, 2, and 12. An area of boulder-sized riprap was observed along the northern portion of Transect 2. A small area of bedrock approximately 50 m^2 in extent was observed at a depth of 18 m along Transect 4. Areas of woody debris were observed throughout the facility LSA (Figure 4.3-2). Photo 4.3-1 shows various substrate types observed during the subtidal survey. Water depth in the facility LSA increases gradually from north to south to a maximum observed depth of 133 m along the southern boundary of the facility LSA.



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MARINE RESOURCES TECHNICAL DATA REPORT

SUBTIDAL SURVEY:
DISTRIBUTION OF SUBSTRATE TYPES IN THE FACILITY LOCAL STUDY AREA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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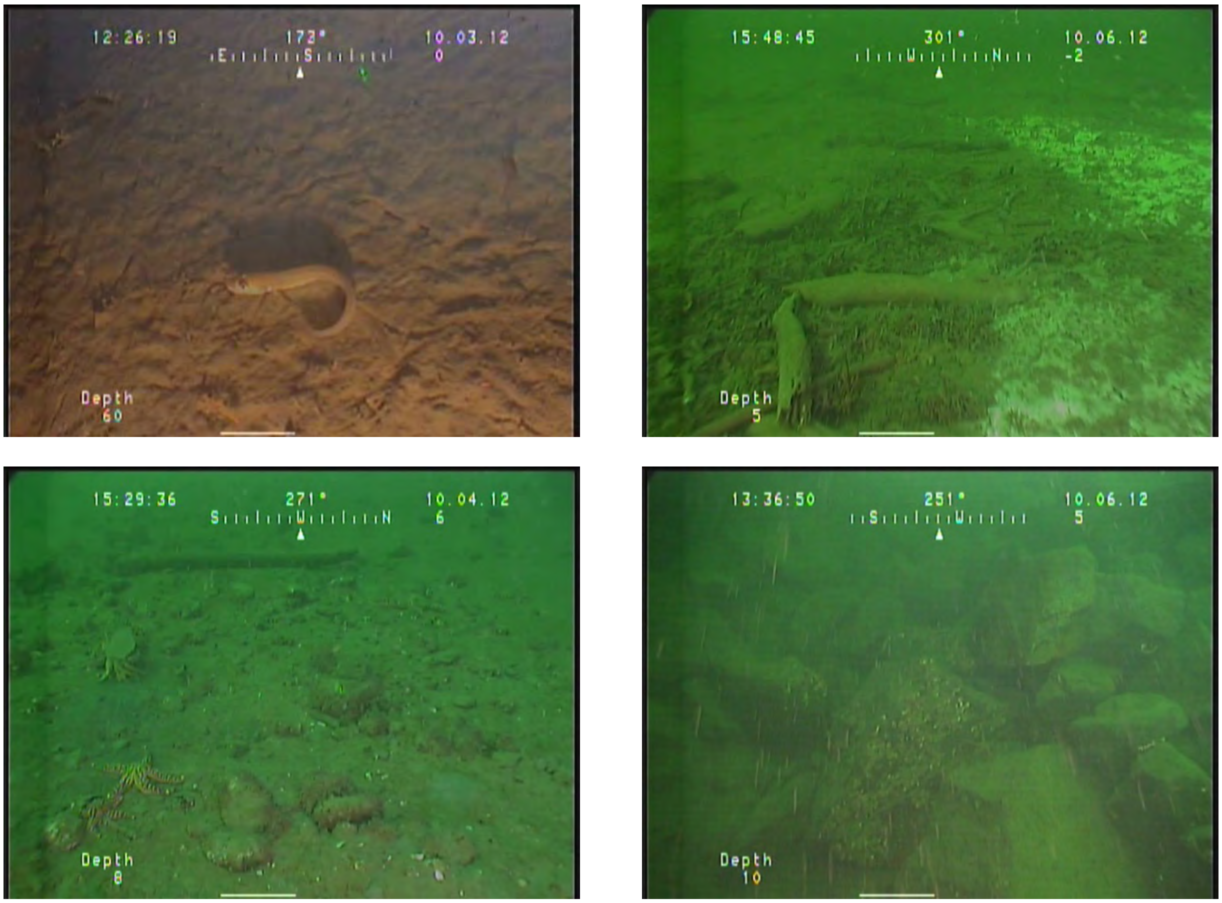


NOTES:

Clockwise from top left: soft substrate and eelpout; soft substrate with woody debris; boulder/cobble substrate; mixed substrate with sea stars and Dungeness crab

Photo 4.3-1: Subtidal Substrates in the Facility Local Study Area

4.3.2.2 Marine Fish

Marine fish species from 12 families were observed during the subtidal survey (Table 4.3-2). The average density of marine fish observed during the subtidal survey is shown in Figure 4.3-3, and their distribution is shown in Figure 4.3-4. Eelpouts (*Lycodes* spp.; 39.3 individuals per km transect), pricklebacks (family Stichaeidae; 31.1 individuals per km transect), and righteye flounders (family Pleuronectidae; 26.1 individuals per km transect) were the most common species of marine fish observed. The relative density of marine fish observed during the subtidal surveys is provided in Appendix C, Table C-4. Photo 4.3-2 shows several of the marine fish species observed during the survey, including a flounder, a black eelpout (*Lycodes diapterus*), a cod, and a spinyhead sculpin (*Dasycottus setiger*).

Table 4.3-2: Subtidal Survey: Marine Fish in the Facility Local Study Area

Taxon	Family	Description
Poacher Family Agonidae	Agonidae	Fish
Ronquil Family Bathymasteridae	Bathymasteridae	Fish
Spotted ratfish *Hydrolagus colliei*	Chimaeridae	Chimaera
Skate Family Rajidae	Rajidae	Skate
Spinyhead sculpin *Dasycottus setiger*	Cottidae	Fish
Pacific staghorn sculpin *Leptocottus armatus*	Cottidae	Fish
Sculpin Family Cottidae	Cottidae	Fish
Shiner perch *Cymatogaster aggregata*	Embiotocidae	Fish
Pile perch *Rhacochilus vacca*	Embiotocidae	Fish
Perch Family Embiotocidae	Embiotocidae	Fish
Walleye Pollock *Theragra chalcogramma*	Gadidae	Fish
Cod Family Gadidae	Gadidae	Fish
Gobie Family Gobiidae	Gobiidae	Fish
Whitespotted greenling *Hexagrammos stelleri*	Hexagrammidae	Fish
Gunnel Family Pholidae	Pholidae	Fish
Yellowfin sole *Limanda aspera*	Pleuronectidae	Fish
Dover sole *Microstomus pacificus*	Pleuronectidae	Fish
Righteye flounders Family Pleuronectidae	Pleuronectidae	Fish
Longsnout prickleback *Lumpenella longirostris*	Stichaeidae	Fish
Pacific snake prickleback *Lumpenus sagitta*	Stichaeidae	Fish
Whitebarred prickleback *Poroclinus rothrocki*	Stichaeidae	Fish
Prickleback Family Stichaeidae	Stichaeidae	Fish

Taxon	Family	Description
Shortfin eelpout *Lycodes brevipes*	Zoarcidae	Fish
Black eelpout *Lycodes diapterus*	Zoarcidae	Fish
Blackbelly eelpout *Lycodes pacificus*	Zoarcidae	Fish
Eelpout *Lycodes* sp.	Zoarcidae	Fish

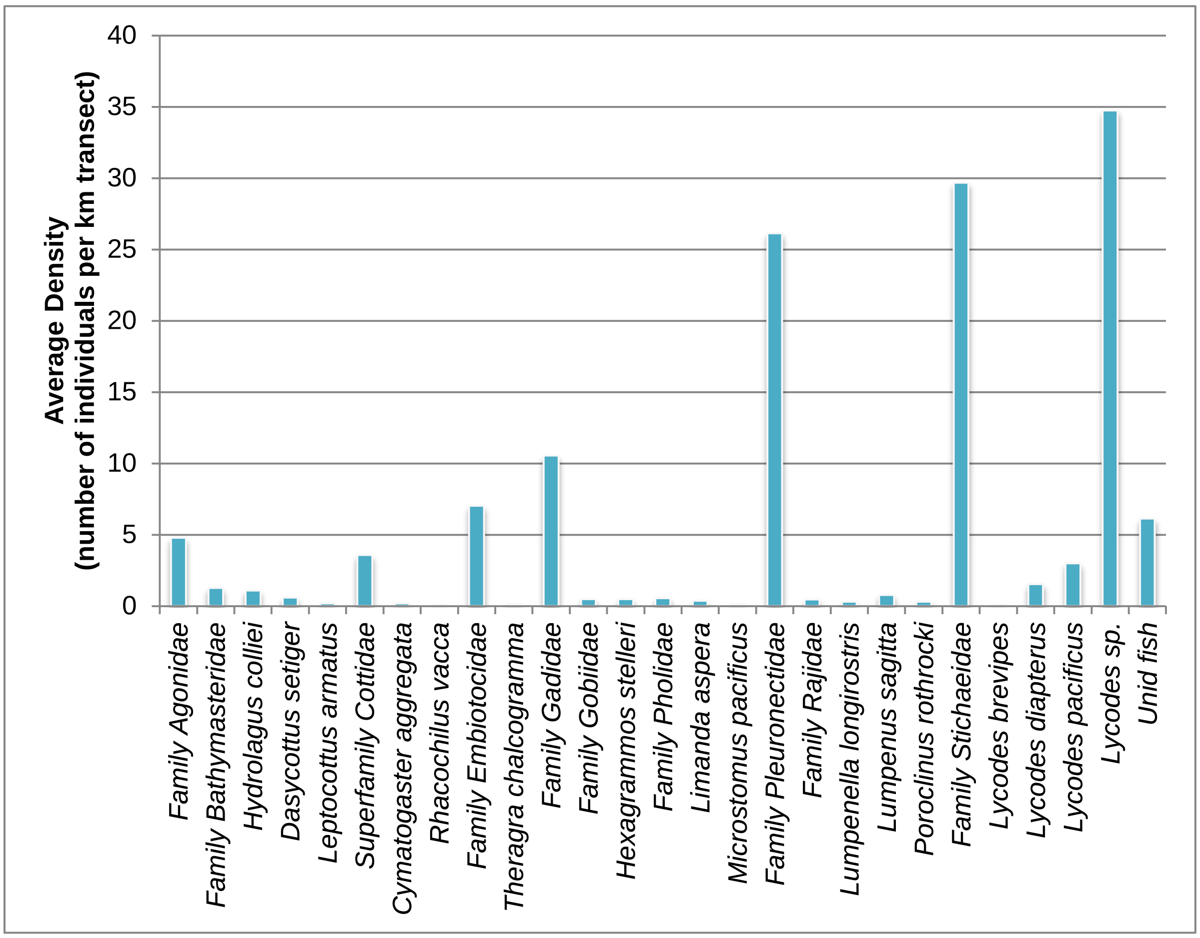
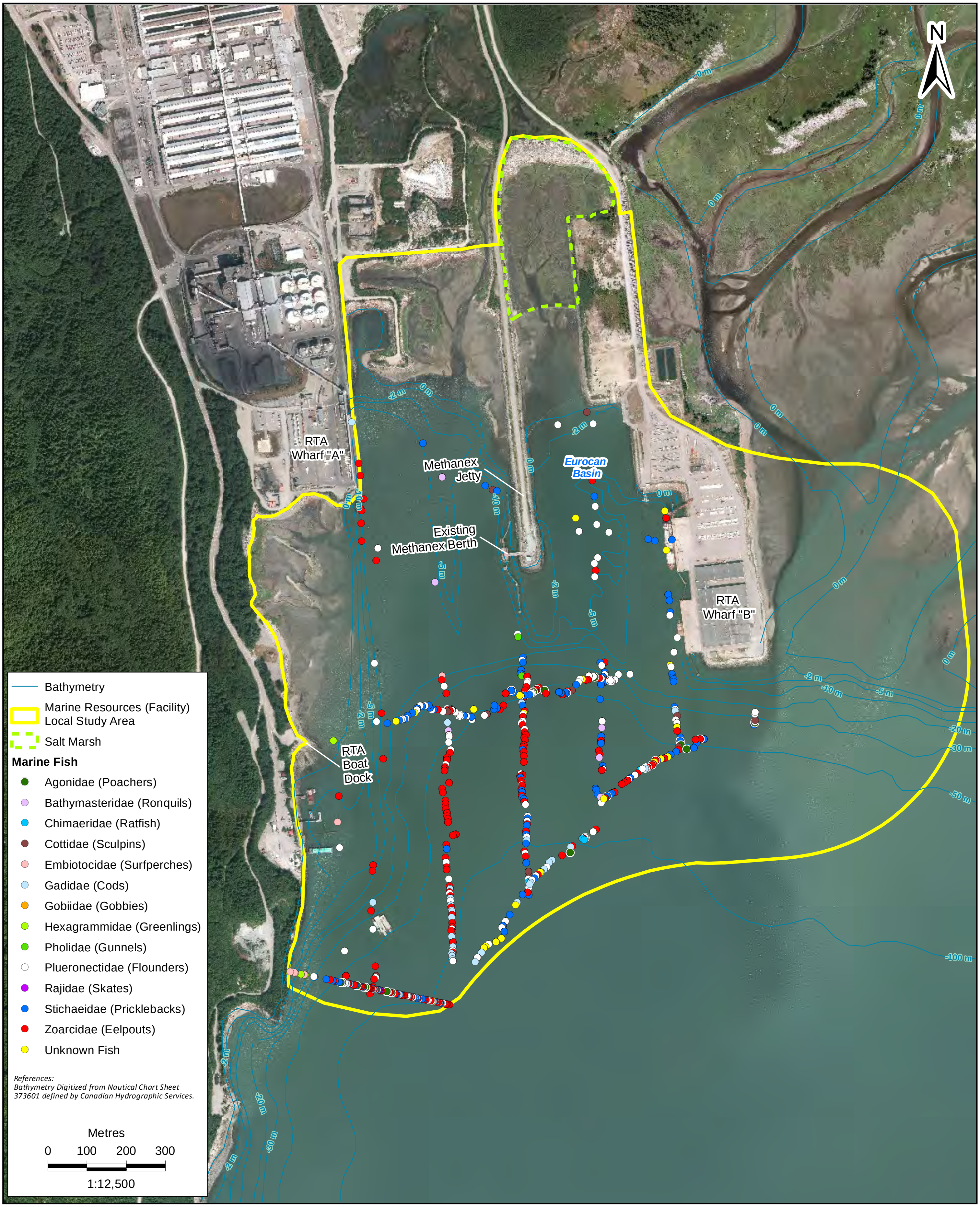


Figure 4.3-3: Subtidal Survey: Average Density of Marine Fish in the Facility Local Study Area



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MARINE RESOURCES TECHNICAL DATA REPORT

SUBTIDAL SURVEY:
DISTRIBUTION OF MARINE FISH OBSERVATIONS IN THE FACILITY LOCAL STUDY AREA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
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DATE	FIGURE NO.
21-AUG-14	**4.3-4**

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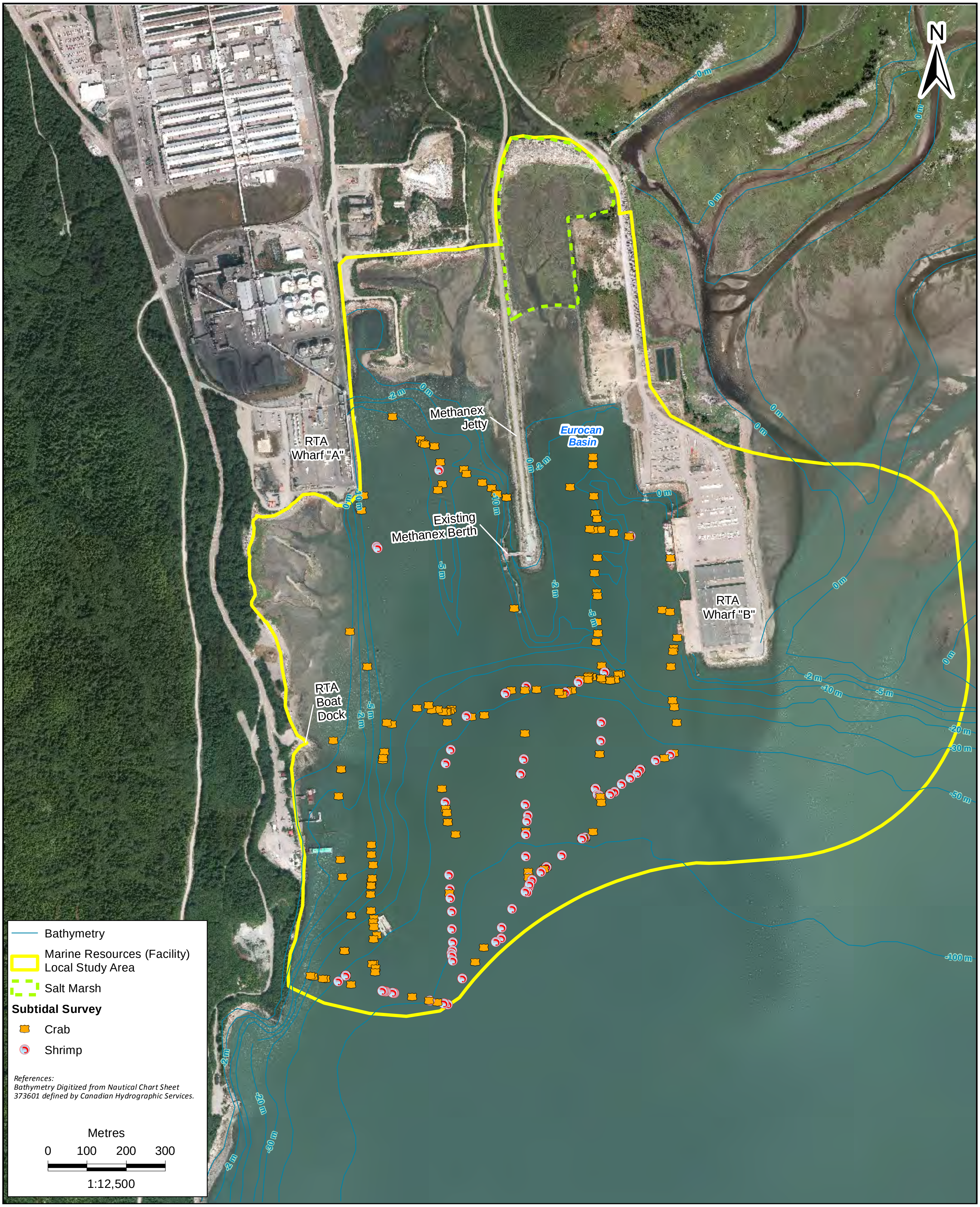
NOTES:
Clockwise from top left: righteye flounder, black eelpout, Pacific cod, spinyhead sculpin

Photo 4.3-2: Marine Fish in the Facility Local Study Area

4.3.2.3 Marine Invertebrates

Marine invertebrate species from four phyla were observed in the subtidal zone of the facility LSA (Table 4.3-3). Figure 4.3-5 shows the distribution of crab and shrimp species observed during the subtidal survey, and Figure 4.3-6 shows the distribution of other marine invertebrates. The relative density of marine invertebrates observed during the subtidal surveys is shown in Appendix C, Table C-5. White-dotted sea cucumbers (*Chiridota albatrossii*) were by far the most common marine invertebrate observed in the facility LSA. However, they were not evenly distributed throughout the facility LSA and were concentrated along Transect 9 in the centre of the facility LSA between the RTA boat dock and the southern tip of RTA Wharf "B" at depths of -20 m to -50 m CD. Orange sea pens (*Ptilosarcus gurneyi*) were the second most common marine invertebrate species observed. Photo 4.3-3 shows several species of marine invertebrates observed during the survey.



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MARINE RESOURCES TECHNICAL DATA REPORT

SUBTIDAL SURVEY: DISTRIBUTION OF CRAB AND SHRIMP OBSERVATIONS IN THE FACILITY LOCAL STUDY AREA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

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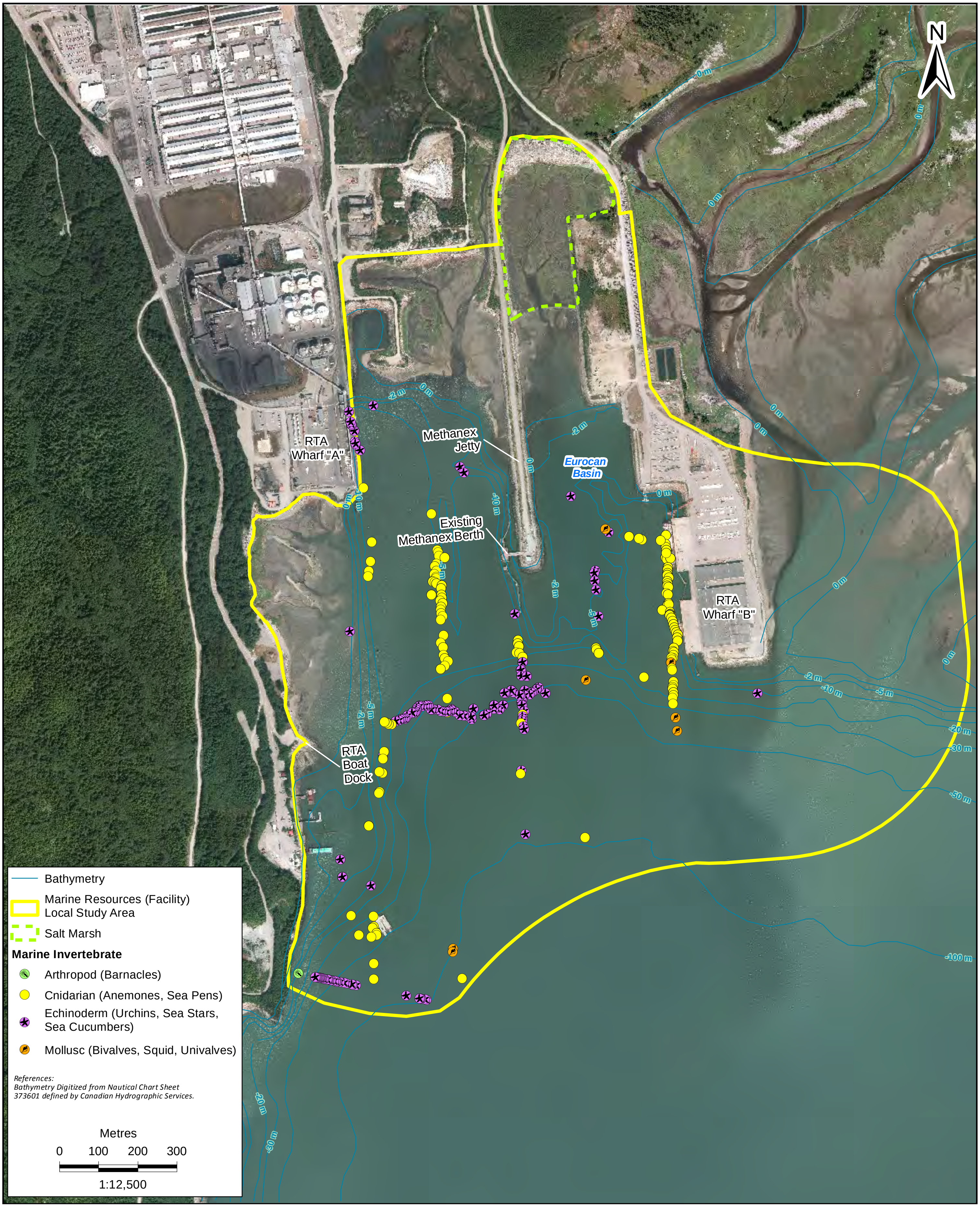

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MARINE RESOURCES TECHNICAL DATA REPORT

SUBTIDAL SURVEY: DISTRIBUTION OF MARINE INVERTEBRATE OBSERVATIONS IN THE FACILITY LOCAL STUDY AREA

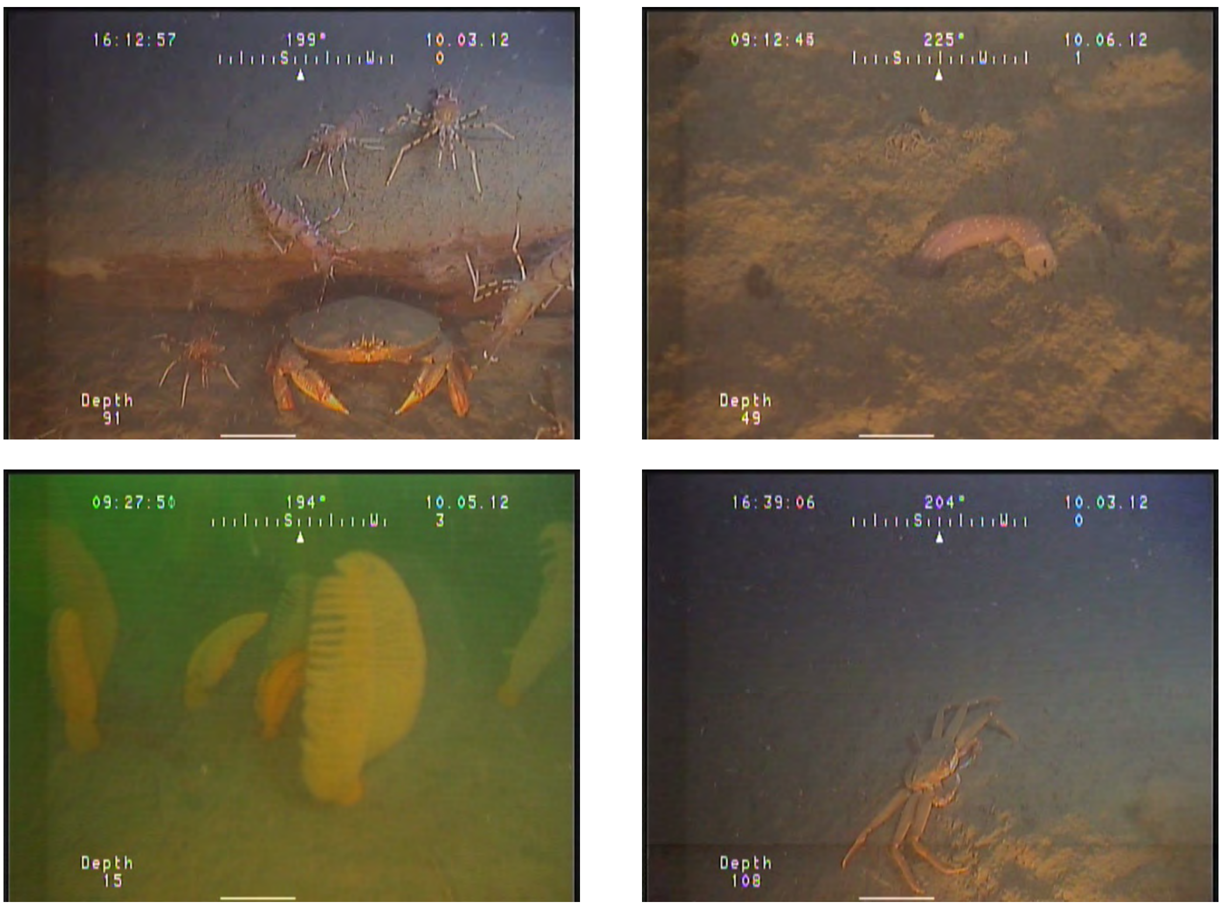
LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION UTM9	DRAWN BY SS
DATUM NAD 83	CHECKED BY SW
DATE 21-AUG-14	FIGURE NO. **4.3-6**

Table 4.3-3: Subtidal Survey: Marine Invertebrates in the Facility Local Study Area

Taxon	Phylum	Description
Common acorn barnacle *Balanus glandula*	Arthropoda	Barnacle
Dungeness crab *Metacarcinus magister*	Arthropoda	Crab
Crab *Cancer* sp.	Arthropoda	Crab
Tanner crab *Chionoecetes* sp.	Arthropoda	Crab
Grooved tanner crab *Chionoecetes tanneri*	Arthropoda	Crab
Crab Family Majidae	Arthropoda	Crab
Crab Infraorder Brachyura	Arthropoda	Crab
Hermit crab Superfamily Paguroidea	Arthropoda	Crab
Squat lobster *Munida quadraspina*	Arthropoda	Squat lobster
Coonstripe shrimp *Pandalus danae*	Arthropoda	Shrimp
Humpback shrimp *Pandalus hypsinotus*	Arthropoda	Shrimp
Shrimp *Pandalus* sp.	Arthropoda	Shrimp
Crimson anemone *Cribrinopsis fernaldi*	Cnidaria	Anemone
Short plumose anemone *Metridium senile*	Cnidaria	Anemone
Plumose anemone *Metridium* sp.	Cnidaria	Anemone
Anemone Order Actiniaria	Cnidaria	Anemone
Orange sea pen *Ptilosarcus gurneyi*	Cnidaria	Soft coral
White-dotted sea cucumber *Chiridota albatrossii*	Echinodermata	Sea cucumber
Mottled star *Evasterias troschelli*	Echinodermata	Sea star
Rainbow star *Orthasterias koehleri*	Echinodermata	Sea star
Sea star Class Asteroidea	Echinodermata	Sea star
Green sea urchin *Strongylocentrotus droebachiensis*	Echinodermata	Urchin

Taxon	Phylum	Description
Triton *Charonia* sp.	Mollusca	Sea snail
Stubby squid *Rossia pacifica*	Mollusca	Squid
Unidentified bivalve mollusc Class Bivalvia	Mollusca	Bivalve



NOTES:
Clockwise from top left: humpback shrimp and Dungeness crab; white-dotted sea cucumber; tanner crab; orange sea pens

Photo 4.3-3: Marine Invertebrates in the Facility Local Study Area

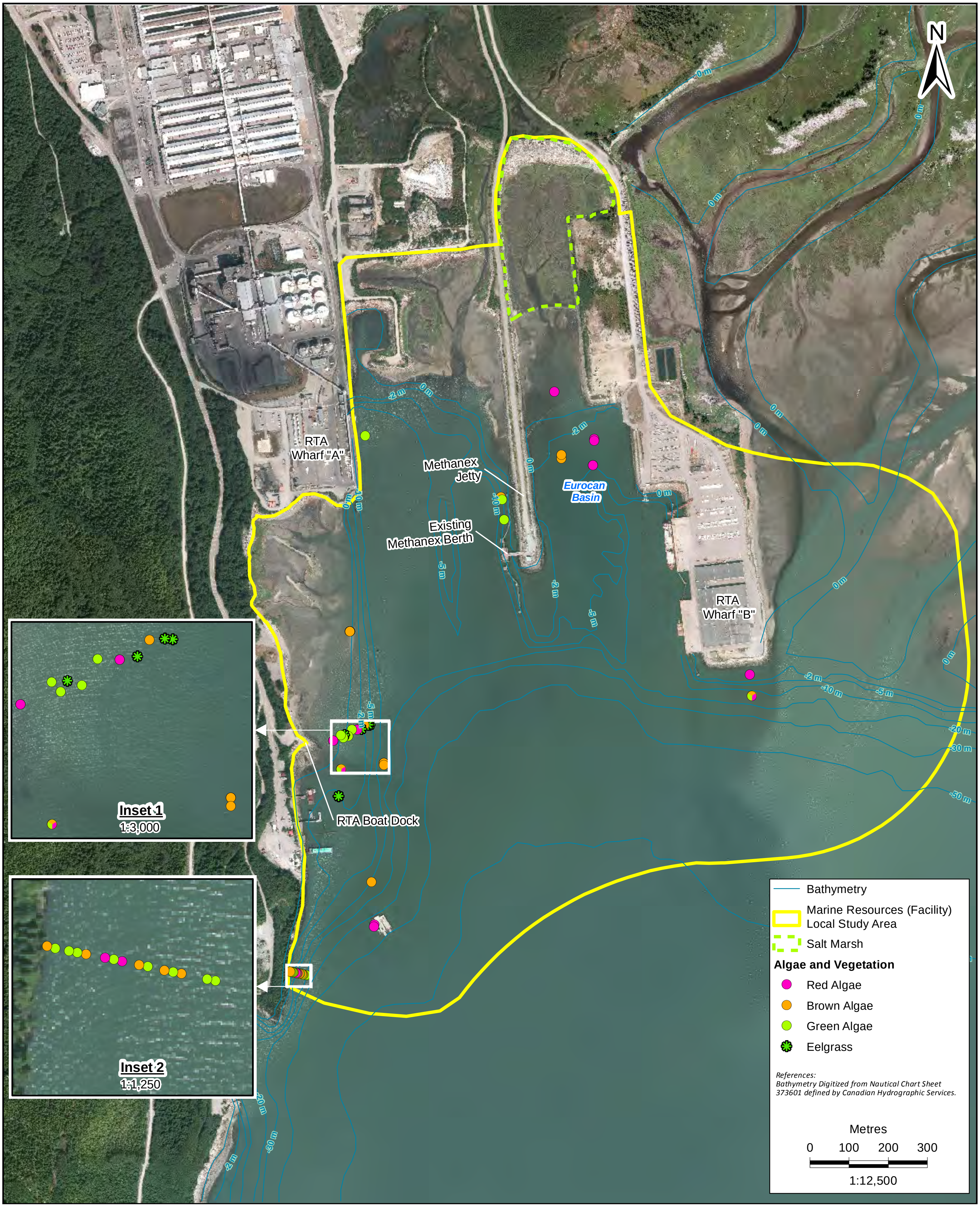
Several species of crabs were observed in the facility LSA. Dungeness crab was the most common crab species observed and was present in moderate density (14 individuals per km transect) compared with other marine invertebrate species observed (Appendix C, Table C-5). Hermit crab, decorator crab, and tanner crab were present in relatively low densities (less than four individuals per km transect) (Appendix C, Table C-5). All species of crab were observed on soft substrates. Pandalid shrimp were another commonly observed species group in the LSA and were present in moderate densities (1 to 15 individuals per km transect) on soft substrates (Appendix C, Table C-5).

4.3.2.4 Marine Vegetation

Marine vegetation species from four phyla were observed in the subtidal zone of the facility LSA (Table 4.3-4; Figure 4.3-7). Overall, marine vegetation species were present in low density in the subtidal zone. Green ribbon (*Ulva intestinalis*) and sea moss (*Cladophora* sp.) were the most common species observed, followed by rockweed and kelp (*Laminaria* spp.). Small areas of sea brush (*Odonthalia* sp.) were also observed. Algal coverage was most dense in the shallow areas of the facility LSA, typically at depths of 1 m to 5 m on rock substrate. A small patch of eelgrass approximately 20 m^2 in size was observed along the western shoreline in shallow water (less than 6 m water depth) on soft substrate (Figure 4.3-7). Because of the low coverage of marine vegetation in the subtidal zone, their relative density was not estimated during the video analysis. Photo 4.3-4 shows some of the marine vegetation species observed during the subtidal survey, including green ribbon, rockweed, and common eelgrass.

Table 4.3-4: Subtidal Survey: Marine Vegetation in the Facility Local Study Area

Taxon	Phylum/Division	Description
Green ribbon *Ulva intestinalis*	Chlorophyta	Green algae
Sea moss *Cladophora* sp.	Chlorophyta	Green algae
Rockweed *Fucus gardneri*	Phaeophyta	Brown algae
Kelp *Laminaria* sp.	Phaeophyta	Brown algae
Sea brush *Odonthalia* sp.	Rhodophyta	Red algae
Common eelgrass *Zostera marina*	Magnoliophyta	Seagrass



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MARINE RESOURCES TECHNICAL DATA REPORT

SUBTIDAL SURVEY: DISTRIBUTION OF MARINE VEGETATION OBSERVATIONS IN THE FACILITY LOCAL STUDY AREA

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION UTM9	DRAWN BY SS
DATUM NAD 83	CHECKED BY SW
DATE 21-AUG-14	FIGURE NO. 4.3-7

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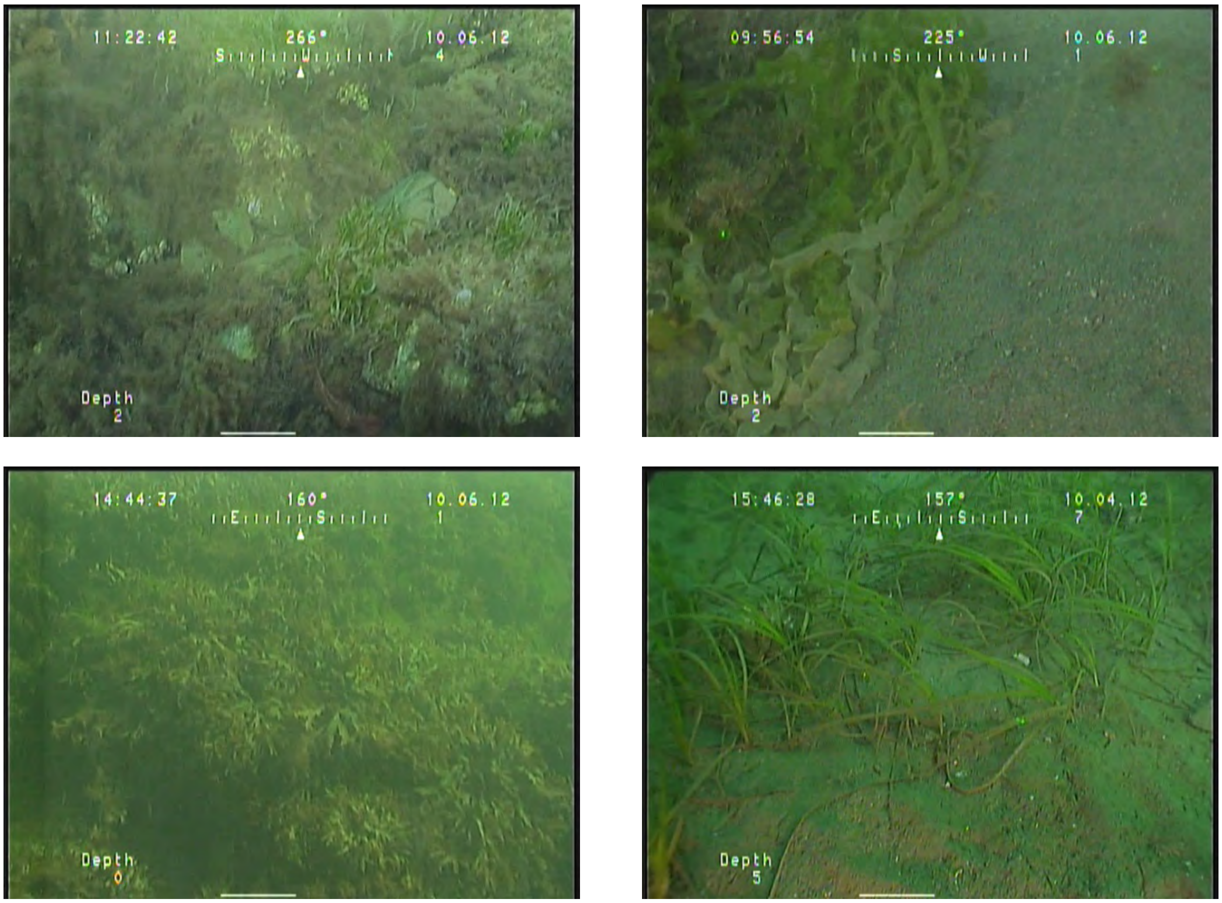


NOTE:
Clockwise from top left: mixed algae; green ribbon; eelgrass; rockweed

Photo 4.3-4: Marine Vegetation in the Facility Local Study Area

General water chemistry measurements taken in the facility LSA show that the upper 20 m of the water column was characterized by a weak halocline, with a gradual increase in salinity with increasing water depth (Appendix C, Table C-6). Temperature and dissolved oxygen decreased with increasing water depth. Turbidity averaged 0.3 NTU across all sampling stations and water depths.

4.3.3 Discussion

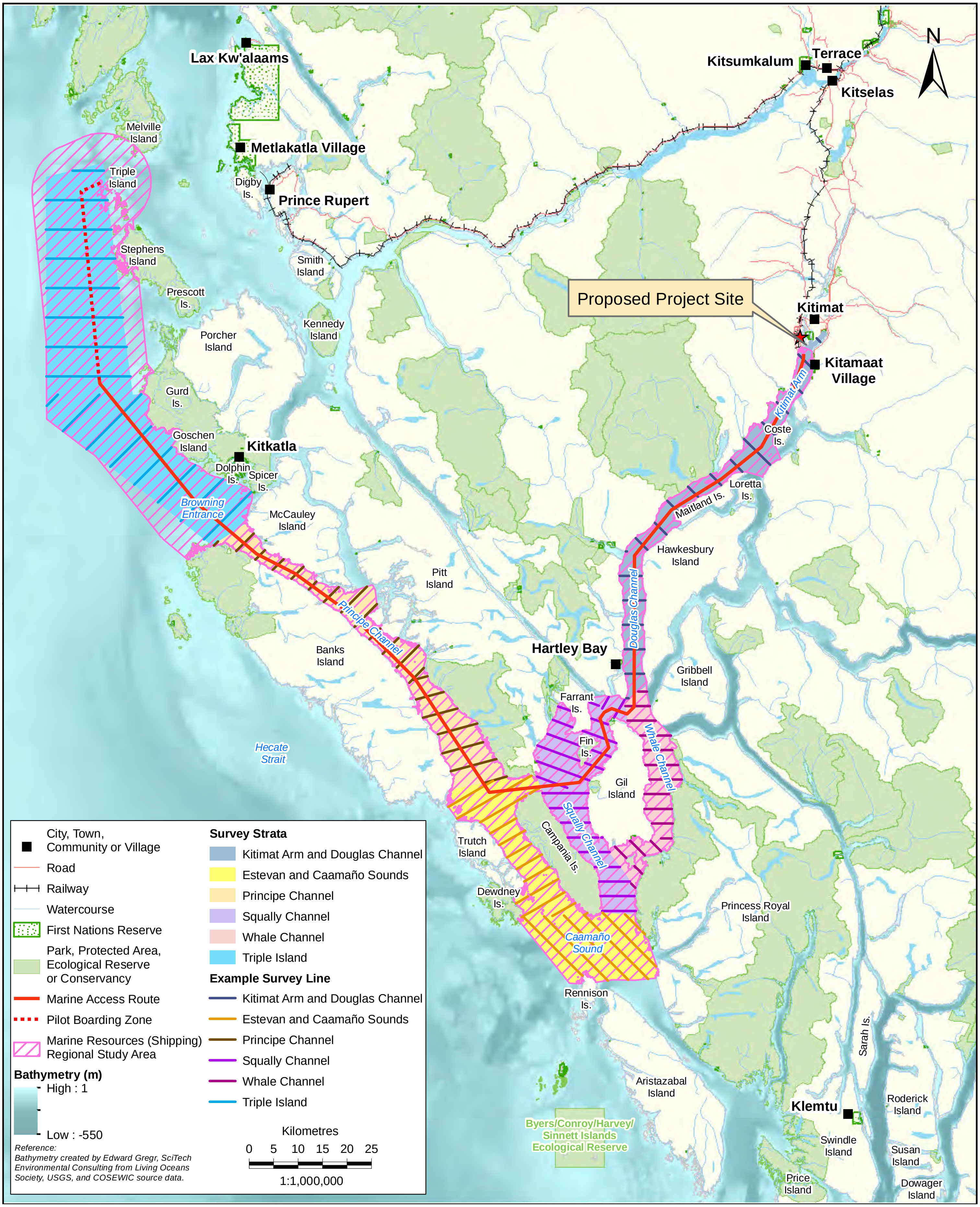
Subtidal habitat in the facility LSA is characterized by soft substrates with limited structural complexity. A diverse range of marine fish and invertebrate species (*n* = 51 species) were observed in the LSA during the subtidal survey (Appendix C, Tables C-4 and C-5). None of the species observed in the subtidal zone have been identified by federal or provincial governments as species at risk. Marine species targeted by CRA fisheries observed during the survey include flounders, cod, greenlings, perch, sculpin, Dungeness crab, pandalid shrimp, sea urchins, bivalve molluscs, sea stars, sea cucumbers, and sea anemones. The diversity and density of marine vegetation observed during the subtidal survey were low. This is likely attributable to the limited occurrence of hard substrates suitable for colonization by algae, and light attenuation attributable to turbidity and water depth.

The ROV video analysis is biased towards larger, non-motile organisms because of restrictions in camera articulation, limitations in camera resolution, and, in this survey, poor underwater visibility. The ROV survey is also biased towards benthic and demersal fish species; therefore, it may not have captured pelagic fish species present in the facility LSA at the time of the survey. Furthermore, it is possible that some highly motile benthic and demersal fish species may have been present in the facility LSA during the survey, but were not recorded because they have the ability to avoid the ROV. The subtidal survey was conducted during early fall when marine vegetation is assumed to be at or near its peak annual density and abundance. The data collected during the subtidal survey represented the fish habitat conditions in the facility LSA during the survey period. However, short and long-term temporal variations exist in the distribution and abundance of marine organisms in the LSA, which are not reflected in the data.

4.4 Marine Mammal Surveys

Twelve marine mammal line transect surveys were conducted along the marine access route in the shipping RSA and in surrounding waters (Figure 4.4-1). Distance sampling methods were used during surveys and analysis to estimate the number of animals in a given area (relative population abundance) for commonly observed species.

Distance sampling methods are commonly used to estimate marine mammal abundance. For example, they have been used to estimate marine mammal abundance in BC waters (Williams and Thomas 2007; Best and Halpin 2011) and to estimate abundance of whales along the coasts of Washington, Oregon, and California (Calambokidis and Barlow 2004). These methods have also been used to determine density and distribution of baleen and toothed whales in Alaskan waters (Zerbini et al. 2005; Zerbini et al. 2006).



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MARINE RESOURCES TECHNICAL DATA REPORT

SURVEY STRATA AND AN EXAMPLE OF LINE TRANSECTS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
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DATE	FIGURE NO.
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4.4.1 Methods

4.4.1.1 Survey Design

Marine mammal line transect surveys were designed using the software package Distance 6.0 (Thomas et al. 2010) following standard methods suggested by Buckland et al. (2001). Distance sampling methods measure the distances to animal sightings, use those distances to predict the number of animals that are not observed during surveys, and then estimate the abundance of a species (Buckland et al. 2001). The complex coastline of the survey area was also considered during the survey design by including methods suggested by Thomas et al. (2007) and Dawson et al. (2008).

The study area included the marine access route and surrounding waters and was divided into six strata (or regions) (Figure 4.4-1):

- Kitimat Arm/Douglas Channel
- Whale Channel
- Squally Channel
- Caamaño Sound/Estevan Sound
- Principe Channel, and
- Triple Island.

The strata boundaries were based on critical habitat for humpback whales (Nichol et al. 2010), potential critical habitat for northern resident killer whales (Ford 2006), and different waterbodies in the study area. Designated and potential critical habitats are based on areas of high use by their relevant species and are, therefore, expected to have higher encounter rates for those species than other regions of the study area. Dividing strata in this way helps to produce areas with encounter rates that are relatively homogeneous for these species, thereby preventing over- or underestimation of density (Buckland et al. 2001). Dividing the study area into strata also allowed for proper orientation of transect lines. Orienting the transect lines perpendicular to the coast line avoids over- or under-sampling and provides for uniform coverage of the area, which is an important principle in distance sampling methods and analysis (Buckland et al. 2001; Thomas et al. 2007; Dawson et al. 2008). Transect lines were also oriented in a direction that reduced the effect of environmental variables, such as sea state or swell, which can reduce the ability of observers to make sightings (Thomas et al. 2007; Dawson et al. 2008). Using strata provided fine-scale estimates of marine mammal population abundance in each strata (when appropriate numbers of sightings were made), rather than one estimate for the entire study area, allowing for more detailed interpretation of habitat use by each species.

The number of transect lines per strata varied between 10 and 20 lines, with a goal of approximately 15 line transects per strata, which is considered “good survey design” by Thomas et al. (2007). Equally spaced parallel transect lines, with random start points, were used to maximize coverage probability in each strata. An example of the survey design is shown in Figure 4.4-1.

4.4.1.2 Survey Timing

Surveys were planned to capture high density and low density periods of marine mammal abundance and to overlap with biologically important times for certain species in the region. Each survey period included two surveys, with start dates that were spaced by approximately two weeks. The surveys started in Kitimat Arm and then moved through the strata southwest to Caamaño Sound and then north towards Principe Channel and Triple Island (Figure 4.4-1).

4.4.1.2.1 February – Winter Survey Period

A survey period in February was selected to represent a low-density period for most marine mammals in the study area. Species present year round on the north coast of BC and expected to be recorded during this survey period are identified below.

- Steller sea lions occupy BC coastal waters throughout the year, and sightings have been reported throughout the study area (Best and Halpin 2011). Known haulout sites occur south of Gil Island and near Triple Island (DFO 2010b).
- Harbour seals have many haulout sites that are used year round for resting and pupping (Heise et al. 2007). They exhibit considerable site fidelity and are, therefore, expected to be observed consistently in similar locations (Baird 2001a). They were the most commonly sighted marine mammal on the BC coast by Best and Halpin (2011) and were most frequently observed in nearshore waters.
- Bigg's (transient) killer whales have been recorded in the study area year round (Ford et al. 2010a).
- Pacific white-sided dolphins are common year round on the north coast of BC (Heise et al. 2007; Ford et al. 2010a). Some evidence suggests they move to inshore waters from fall to early spring and move offshore in the spring to summer (Stacey and Baird 1991). Best and Halpin (2011) did not report any sightings of Pacific white-sided dolphins in the study area; however, Ford et al. (2010a) recorded several sightings in Whale Channel, Principe Channel, and Caamaño Sound, and many have been reported to the BCCSN (BCCSN Data 2013).
- Harbour porpoises frequent the BC coast year round and are commonly observed within 20 km of shore (Ford et al. 2010a; Best and Halpin 2011).
- Dall's porpoises are present year round on the BC coast and have been sighted frequently throughout the study area (Ford et al. 2010a; Best and Halpin 2011).

4.4.1.2.2 April – Spring Survey Period

A survey period in April was chosen to represent a shoulder season (when species abundance is starting to increase) in marine mammal population abundance. Some marine mammals start returning to the study area from their overwintering habitat during this period; and grey whales likely migrate past the study area on their way to summer feeding grounds.

- Grey whales migrate through Hecate Strait from approximately mid-March to mid-April. Most animals appear to use the deeper eastern half of Hecate Strait (Ford et al. 2012), which is potentially beyond the study area.
- Humpback whales are present in BC waters, primarily from spring through fall, and show high site fidelity to localized foraging areas (Ford et al. 2009; Nichol et al. 2010). Sightings are expected to be lower at this time of year than during the fall (Nichol et al. 2010).
- Pinnipeds (i.e., seals and sea lions) and toothed cetaceans (i.e., killer whales, dolphins, and porpoises) are present year round.

4.4.1.2.3 June – Early Summer Survey Period

A survey period in June was expected to capture the increased presence of northern resident killer whales in the study area. Potential critical habitat for this species is located from Caamaño Sound to Wright Sound, including Squally Channel and Whale Channel (Ford 2006).

- Northern resident killer whales likely move into the study area in the early summer to forage on the earliest chinook salmon runs (Ford and Ellis 2006).
- Humpback whales should continue to be sighted until the fall.
- Pinnipeds and toothed cetaceans are present year round.

4.4.1.2.4 July – Mid Summer Survey Period

A survey period in July was selected to represent one of the peak seasons in marine mammal abundance in the study area.

- Northern resident killer whales continue to forage on the chinook salmon run as it migrates up Douglas Channel (Ford and Ellis 2006).
- Humpback whales are expected based on acoustic data, suggesting that feeding calls peak in Caamaño Sound in July through August (Nichol et al. 2010).
- Fin whales may be present based on models of potential critical habitat, suggesting increased use of shelf and sheltered waters in July and August (Gregr and Trites 2001). Historically, they occurred in Queen Charlotte Sound, Hecate Strait, Caamaño Sound, and around Gil Island (Gregr and Trites 2001).
- Pinnipeds and toothed cetaceans are present year round.

4.4.1.2.5 August – Late Summer Survey Period

The late summer survey period was chosen because continued sightings of humpbacks and fin whales were expected.

- Northern resident killer whales will likely be sighted less frequently as they move south to feed on Vancouver Island chinook and chum salmon runs (Ford and Ellis 2006).
- Humpback whales are expected to continue to forage in the area, primarily in Caamaño Sound (Nichol et al. 2010).
- Fin whales are expected to continue to use shelf and sheltered waters.
- Pinnipeds and toothed cetaceans are present year round.

4.4.1.2.6 October – Fall Survey Period

The fall survey period was selected to represent the tail end of peak whale abundance for most cetaceans in the study area, with the exception of humpback whales, which were expected to be at peak numbers.

- Humpback whales are expected based on acoustic data, suggesting a peak in occurrence in Whale Channel from October through November. Significantly higher densities of humpback whales were recorded in this area during fall than spring (Nichol et al. 2010).
- Few, if any, fin whales are expected in the area because recent surveys did not record any individuals during the fall (Ford et al. 2010a).
- Pinnipeds and toothed cetaceans are present year round.

4.4.1.3 Survey Protocol

Vessel-based line transect surveys were completed during daylight hours when weather conditions were conducive to sighting marine mammals (i.e., Beaufort sea state less than 4—small chop, defined direction, numerous whitecaps). The vessels travelled at 8 to 9 knots on all transects in order to establish a consistent temporal effort throughout the survey. Formal marine mammal observer (MMO) training sessions on the survey protocol were conducted before surveys and on board the survey vessels. Two dedicated MMOs and two data recorders (also trained as MMOs) were on shift when line transects were completed. The MMOs used 7 x 50 reticle binoculars to assist with scanning for marine mammals, confirm species identification, and measure distances to the sightings. The MMOs were positioned on high points on the vessels, one on the port and one on the starboard side. They scanned for marine mammals at varying distances from the vessel along line transects and during transit between line transects.

The surveys were conducted using standard distance sampling methods outlined by Buckland et al. (2001). These methods are designed to address three integral assumptions of distance sampling method:

1. All marine mammals on the line transect are detected ($g(0)=1$).
2. The animals do not move *or* are detected at their original location.
3. Distance to the animal is measured exactly.

Several steps were taken to satisfy the first assumption: *all marine mammals on the line transect are detected*. Two MMOs continuously scanned for marine mammals, and the data recorders assisted with scanning when an MMO had to focus on a sighting to identify the species. Having designated data recorders present also allowed the MMOs to focus on scanning while the recorders collected the information. The MMOs scanned from approximately 10° across the bow of the vessel to 90° on the other side. Scanning effort was higher on the transect line so that all animals on the transect line were detected.

For marine mammals, specific methods were required to address the second assumption: *the animals do not move* or *are detected at their original location*. If a marine mammal was in the water, its original location could not be known, and the measured distance was to the detection location of the animal. To address the assumption, vessels travelled at an average speed of 8 to 9 knots, which generally ensured the observer was moving faster than most marine mammals in the area (Dawson et al. 2008). This method helped to meet the assumption because the marine mammal was moving slower and randomly with respect to the vessel; therefore, identifying its location when it was detected was sufficient to meet the assumption (Buckland et al. 2001). Efforts were made to scan as far away from the vessel as possible, while still being able to make an accurate species identification, so that animals were sighted before any possible change in animal behaviour attributable to the vessel's presence.

Adequate training and consistent use of methods were used to satisfy the third assumption: *distance to the animal is measured exactly*. When a marine mammal was sighted, the species and the distance and angle from the line transect to the animal were recorded. The distance to the animal was measured using reticle binoculars and sight-estimated by the MMO. Distances were also corrected for bias by comparing observer estimates with estimates given to objects at known distances. The angle to the animal from the bow (i.e., the transect line) was measured using a pelorus. If several animals were seen near each other, whether they were a "group" was evaluated, the number of individuals was counted, and the distance was measured to the geographic centre of the group. An observation of a group of individuals was considered as one sighting. Marine mammals observed while the vessel transited the pre-determined line transects were recorded as "on effort" sightings. Sightings that occurred while the vessel was transiting between survey lines were recorded in the same manner but were labelled as "off effort."

Behavioural data were recorded for each sighting to provide potential information about habitat use and response to vessel presence (see Table 4.4-1 for behavioural terms applied).

Table 4.4-1: Marine Mammal Behaviours

Behaviour	Description
Breach	Whale leaps out of the water and slams its body on the surface of the water.
Fin slap/Lobtailing	Marine mammal slaps its pectoral fin or fluke against the surface of the water.
Spyhop	Marine mammal raises its head vertically out of the water.
Resting	Marine mammal is at the surface of the water and not travelling.
Milling	Marine mammal swims in no particular direction in a limited area.
Looking	Marine mammal looks at the vessel with its head out of the water.
Rafting	Group of marine mammal are in a horizontal position at the surface of the water.
Porpoising	Marine mammal leaps near the surface of the water as it travels.
Bow riding	Marine mammal swims in front of the bow of a vessel.
Wake riding	Marine mammal swims in the wake created by a vessel.
Feeding	Marine mammal is feeding.

Environmental variables were recorded throughout the surveys, approximately every half hour and whenever a sighting was recorded (Table 4.4-2). Environmental variables were used to determine sightability (i.e., the likelihood of observing an animal, if it is present at the surface, in relation to environmental conditions).

Table 4.4-2: Environmental Variables

Environmental Variable	Description Options
Weather	Clear, partly cloudy, overcast, fog, mist, light rain, moderate rain, heavy rain, or snow
Wind direction	The direction the wind is coming from
Beaufort wind speed	Wind speed in knots
Beaufort sea state	0 to 12; these numbers rank sea state based on the Beaufort Scale
Visibility	Zero; <500 m (very low visibility); 500 m–1,000 m (low visibility); 1,000 m–2,500 m (moderate visibility); 2,500 m–5,000 m (high visibility); 5,000 m–10,000 m (very high visibility); >10,000 m (excellent visibility)
Sun glare (descriptive)	No glare, weak glare, strong glare, or variable
Sun glare angle **FROM** (clock face)	The direction and portion of MMO field of view affected by glare (if any)
Sun glare angle **TO** (clock face)	Where glare stops using the clock face, as above
Sightability	Nil, poor, medium, high, or very high; this is a qualitative measure of how well the MMO can spot marine mammals based on the current visibility, weather, sea state, and sun glare

The Beaufort sea state and wind speed are standard measures used to describe sea conditions (Table 4.4-3).

Table 4.4-3: Beaufort Sea State and Wind Speed

Beaufort Sea State	Wind Speed (knots)	Descriptive Term	Effects Observed at Sea
0	less than 1	calm	Sea surface like a mirror, but not necessarily flat.
1	1–3	light air	Ripples with the appearance of scales are formed, but without foam crests.
2	4–6	light breeze	Small wavelets, still short but more pronounced. Crests do not break. When visibility is good, horizon line is always very clear.
3	7–10	gentle breeze	Large wavelets. Crests begin to break. Foam has a glassy appearance. Perhaps scattered whitecaps.
4	11–16	moderate breeze	Small waves, becoming longer. Fairly frequent whitecaps.
5	17–21	fresh breeze	Moderate waves, taking a more pronounced long form. Many whitecaps are formed. Chance of some spray.
6	22 – 27	strong breeze	Large waves begin to form. The white foam crests are more extensive everywhere. Probably some spray.
7	28–33	near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
8	34–40	gale	Moderately high waves of greater length. Edges of crests begin to break into the spindrift. The foam is blown in well-marked streaks along the direction of the wind.
9	41–47	strong gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble, and roll over. Spray may affect visibility.
10	48–55	storm	Very high waves with long overhanging crests. Dense white streaks of foam. Surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shock-like. Visibility affected.
11	56–63	violent storm	Exceptionally high waves. Sea completely covered with long white patches of foam. Visibility affected.
12	64–71	hurricane	Air filled with foam and spray. Sea entirely white with foam. Visibility seriously impaired.

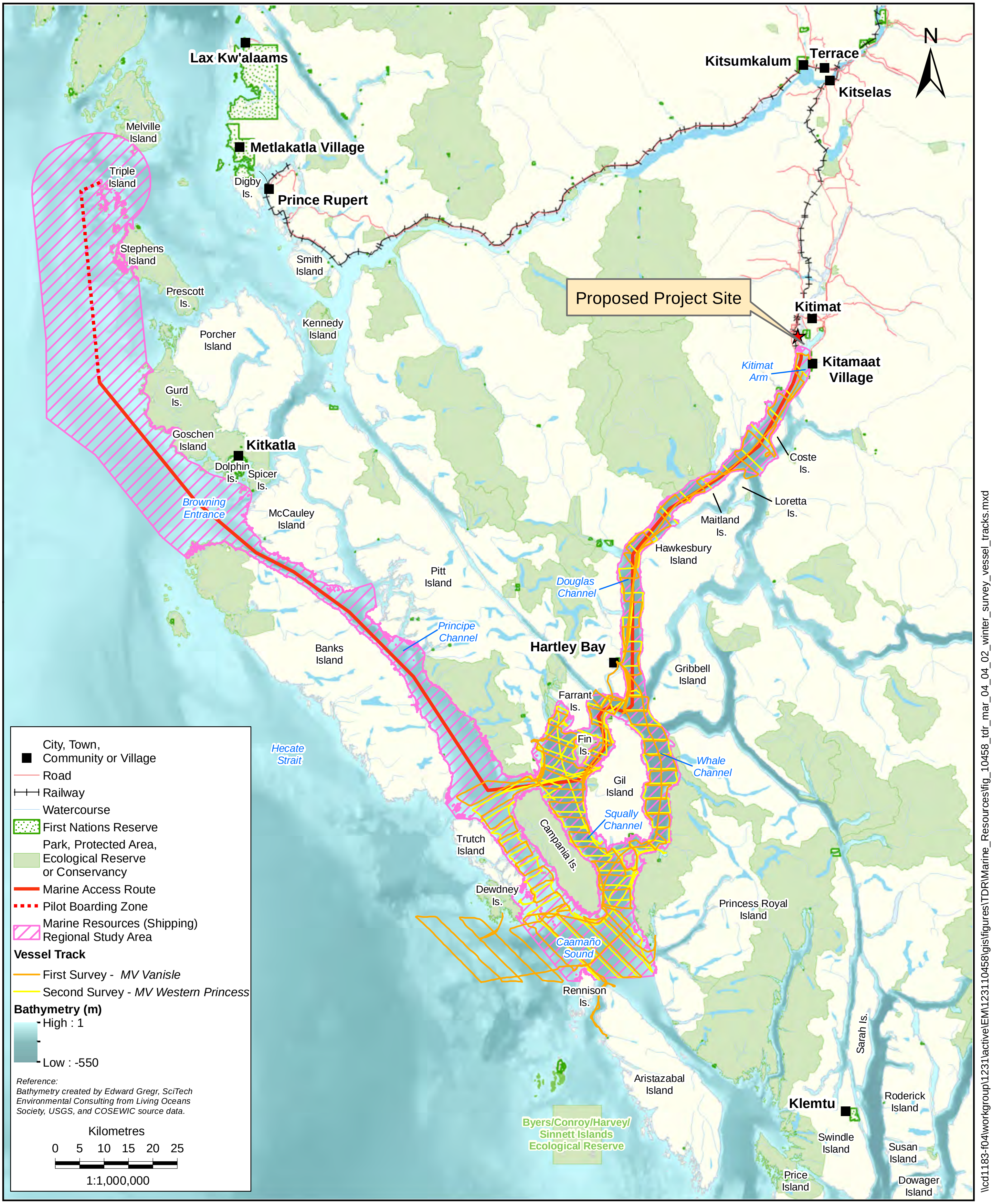
SOURCE: Environment Canada (2011)

4.4.2 Results

Two marine mammal line transect surveys were completed within each of the six planned survey periods (Table 4.4-4). The surveys completed at the end of January and into February for the winter survey period did not cover the entire study area. These surveys included traditional territories of Haisla Nation and Gitga'at First Nation and excluded Gitxaala Nation traditional territory because of access limitations. The area surveyed included Kitimat Arm/Douglas Channel, Squally Channel, Whale Channel, and Estevan Sound/Caamaño Sound (Figure 4.4-2). The remaining surveys included all three traditional territories, including Principe Channel and the portion of the study area extending to Triple Island (Figure 4.4-3 to Figure 4.4-7). Between 13 and 19 line transects were completed for each strata except for the portion of the late summer survey (August 2 to 10) between Browning Entrance and Triple Island, which was cancelled because of weather conditions. The realized survey effort (distance spent "on transect") and the area of each strata are listed in Table 4.4-5. Temporal effort was consistent through the surveys because of vessel speeds of 8 to 9 knots on all line transects.

Table 4.4-4: Survey Summary

Survey Period	Date (2013)	Number of Weather Days	Vessel	Total Distance Travelled (km)	On Effort Distance Travelled (km)
Winter	January 28–February 11	2	MV *Vanisle*	1,190	476
	February 10–20	2	MV *Western Princess*	953	360
Spring	March 26–April 4	0	MV *Ocean Achiever*	1,369	577
	April 8–24	2.5	MV *Ocean Royal*	1,700	627
Early summer	June 1–13	0	MV *Ocean Royal*	1,226	624
	June 14–25	0	MV *Ocean Royal*	1,345	628
Mid-summer	July 2–12	0.5	MV *Ocean Royal*	1,256	592
	July 17–27	0.5	MV *Ocean Royal*	1,381	627
Late summer	August 2–10	3	MV *Ocean Royal*	943	392
	August 16–27	1.5	MV *Ocean Royal*	1,332	644
Fall	October 2–13	1.5	MV *Ocean Royal*	1,199	609
	October 18–29	1.5	MV *Ocean Royal*	1,367	629
Total		**15**		**15,261**	**6,785**



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MARINE RESOURCES TECHNICAL DATA REPORT

WINTER SURVEY VESSEL TRACKS

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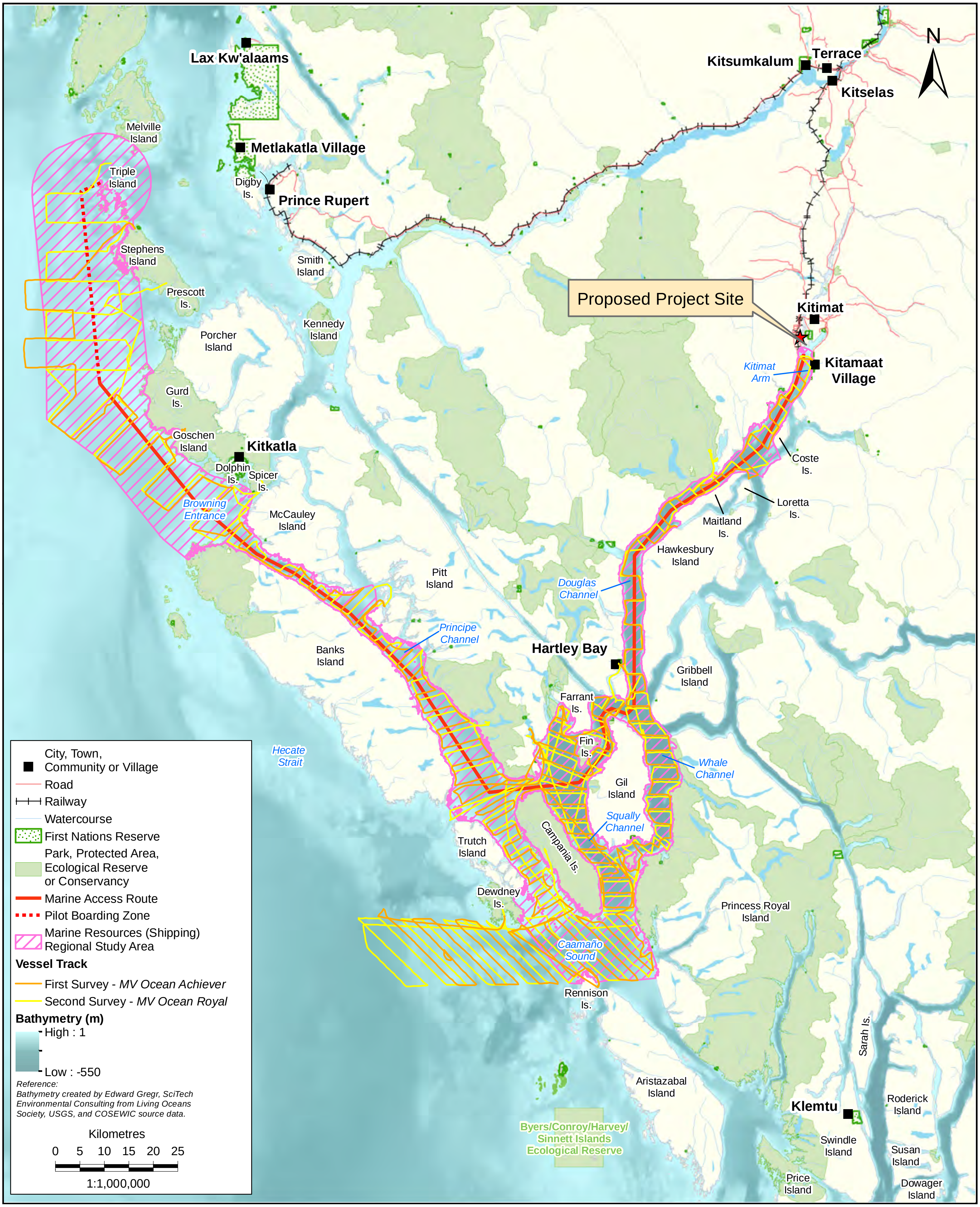
DATE: 04-JUL-14	FIGURE NO. **4.4-2**



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MARINE RESOURCES TECHNICAL DATA REPORT

SPRING SURVEY VESSEL TRACKS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
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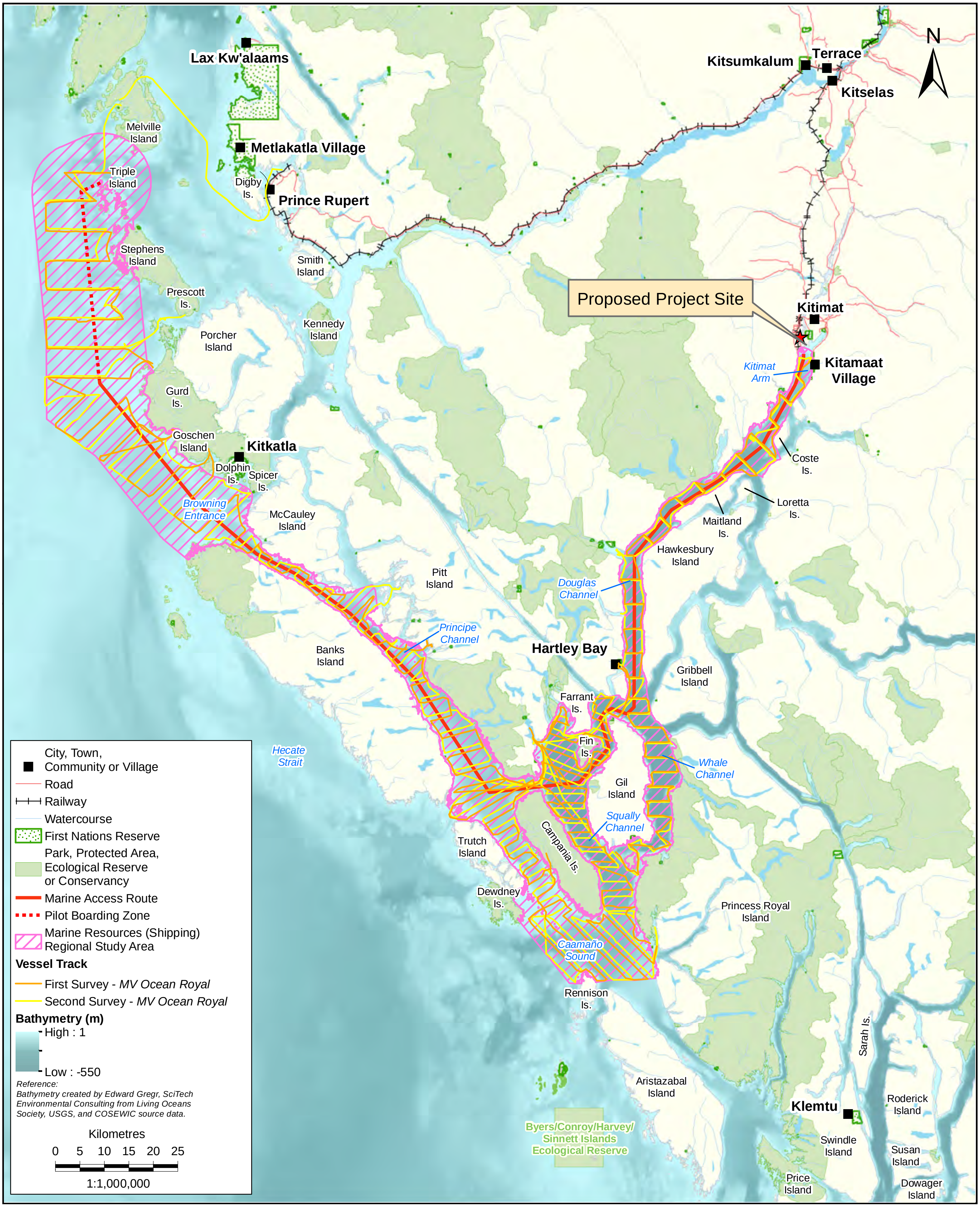

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MARINE RESOURCES TECHNICAL DATA REPORT

EARLY SUMMER SURVEY VESSEL TRACKS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION UTM9	DRAWN BY SS
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DATE 04-JUL-14	FIGURE NO. 4.4-4

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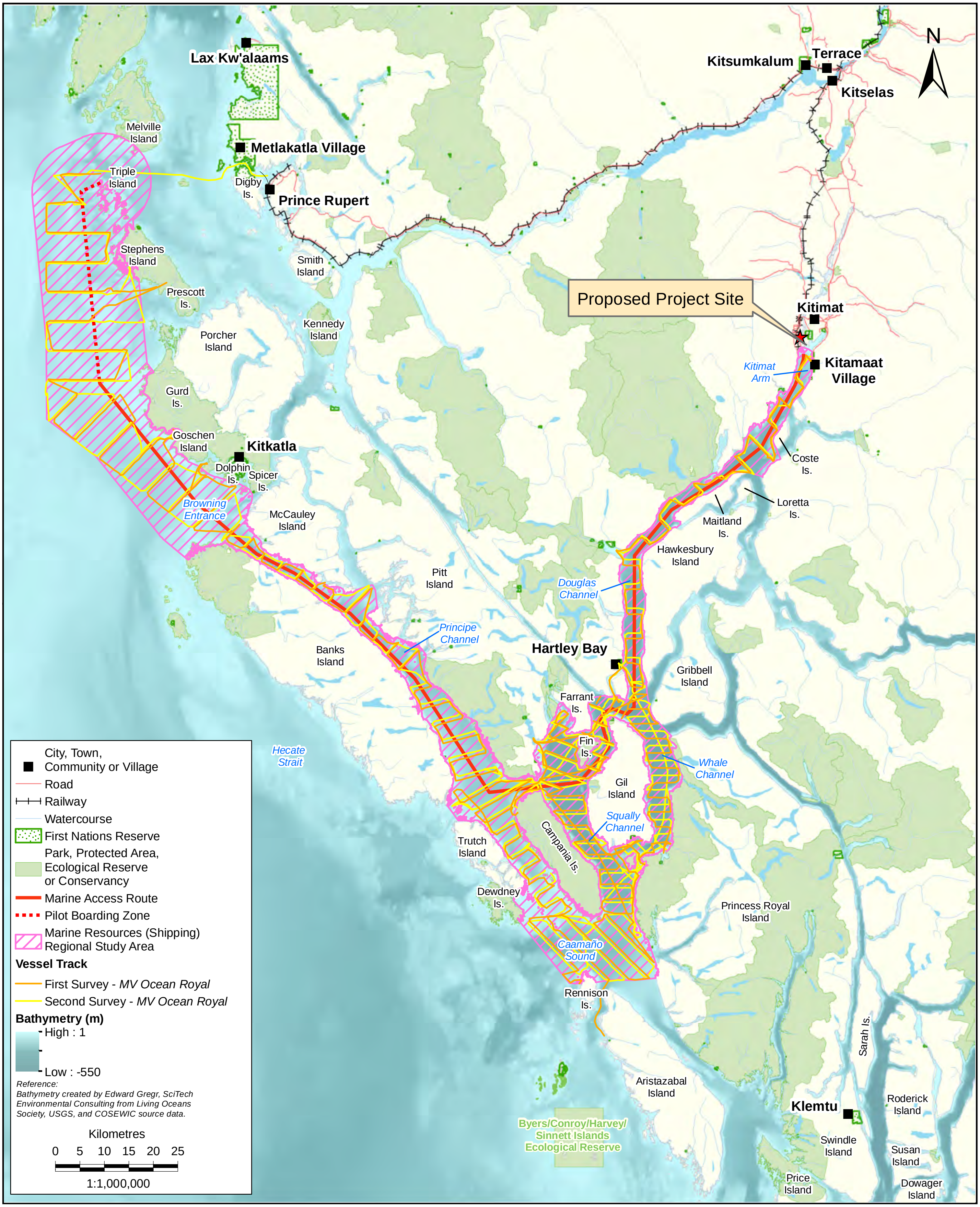

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		LNG CANADA EXPORT TERMINAL KITIMAT, BRITISH COLUMBIA	DATE 04-JUL-14 / FIGURE NO. **4.4-5**

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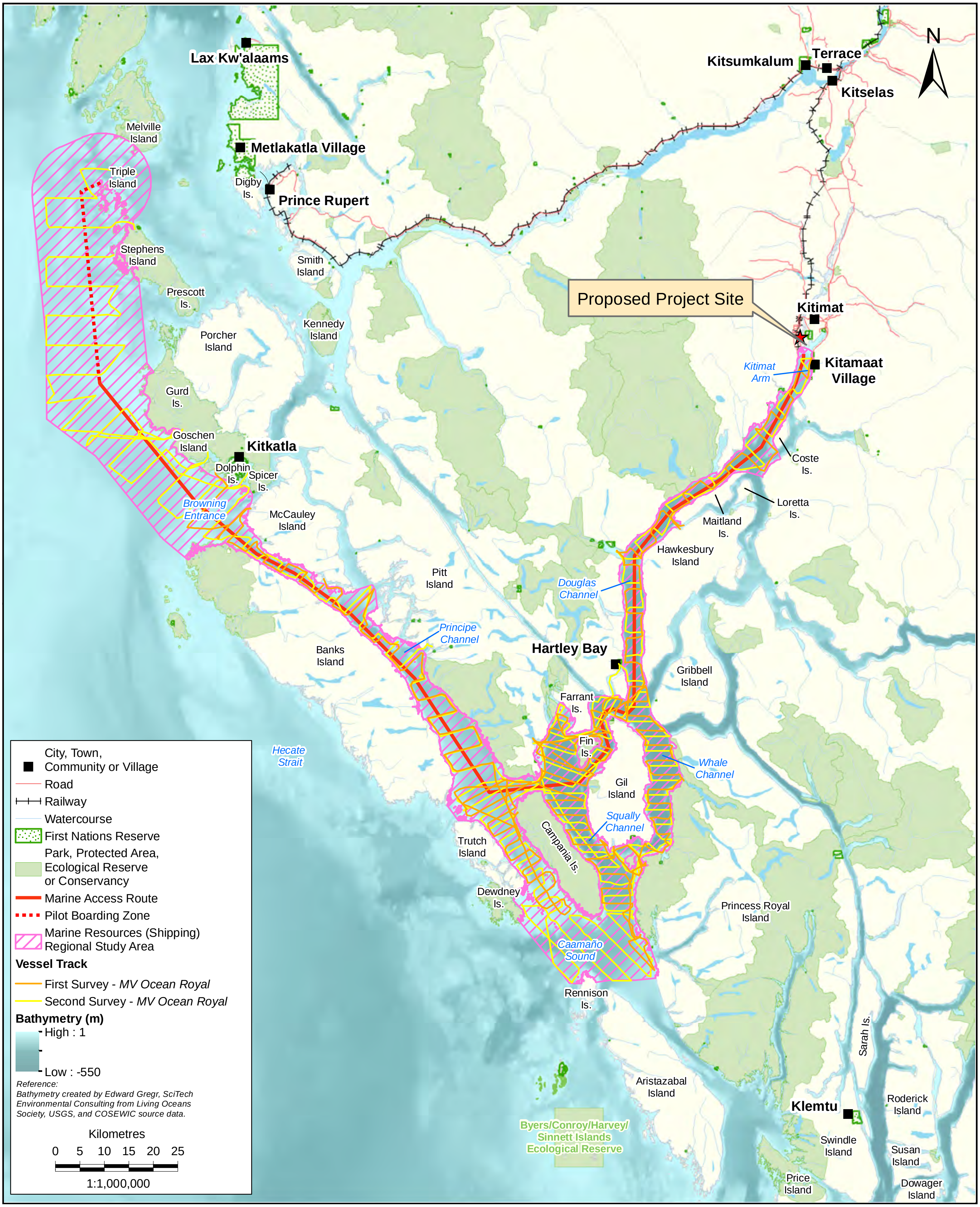

MARINE RESOURCES TECHNICAL DATA REPORT

LATE SUMMER SURVEY VESSEL TRACKS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION UTM9	DRAWN BY SS
DATUM NAD 83	CHECKED BY SW
DATE 04-JUL-14	FIGURE NO. **4.4-6**

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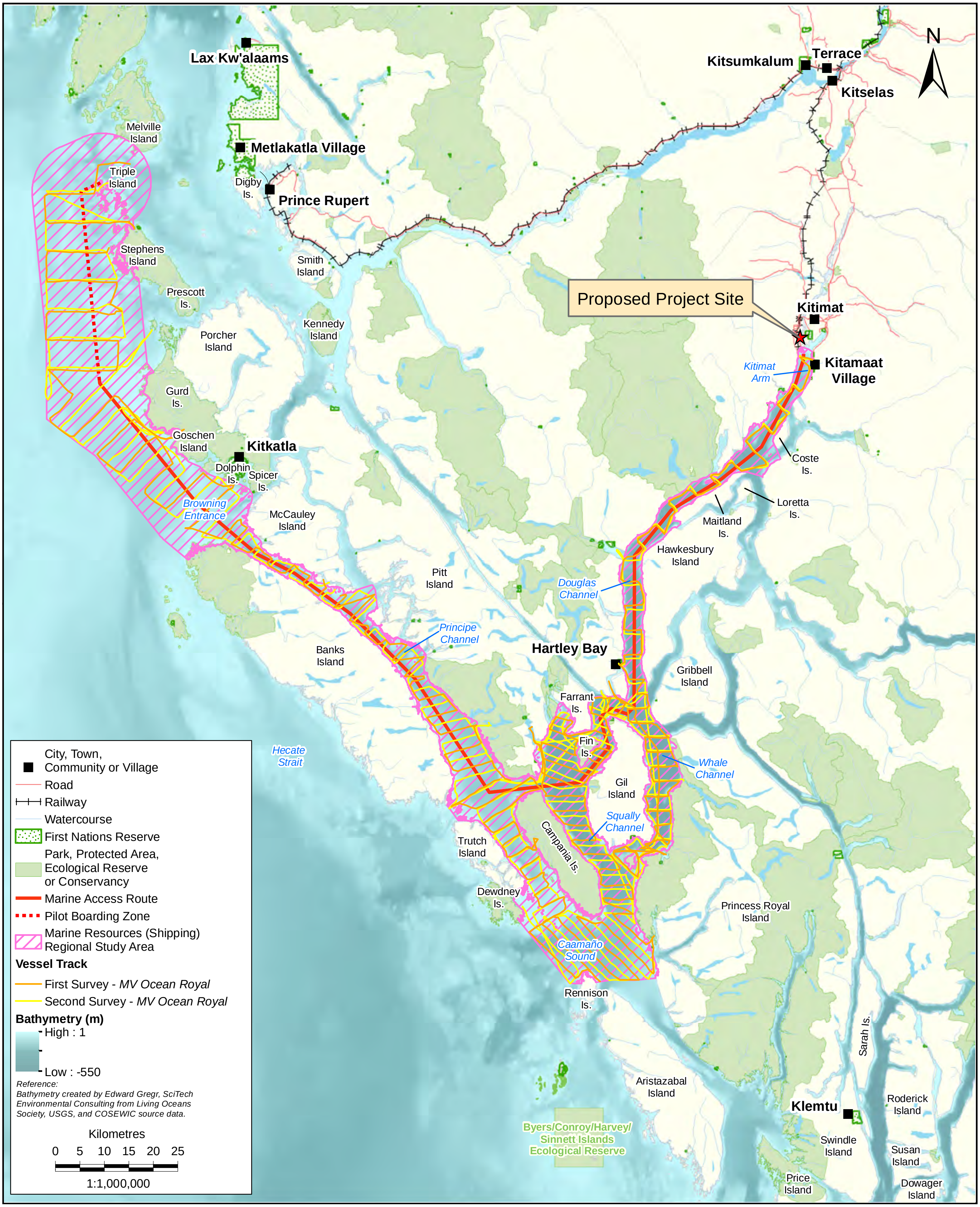

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MARINE RESOURCES TECHNICAL DATA REPORT

FALL SURVEY VESSEL TRACKS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
04-JUL-14	4.4-7

Table 4.4-5: Realized Survey Effort by Stratum

Stratum	Area (km^2)	Survey	Length (km)	Number of Transects
Kitimat Arm/ Douglas Channel	327,446	Winter 1	57.1	16
		Winter 2	58.7	17
		Spring 1	46.7	17
		Spring 2	49.6	18
		Early summer 1	51.2	16
		Early summer 2	56.4	17
		Mid-summer 1	50.4	17
		Mid-summer 2	50.2	16
		Late summer 1	54.3	17
		Late summer 2	47.6	17
		Fall 1	48.8	17
		Fall 2	54.5	17
Total Kitimat Arm/Douglas Channel			**625.5**	**202**
Squally Channel	377,129	Winter 1	115.4	19
		Winter 2	108.2	17
		Spring 1	113.5	19
		Spring 2	109.3	18
		Early summer 1	104.7	19
		Early summer 2	101.8	19
		Mid-summer 1	104.7	19
		Mid-summer 2	102.0	17
		Late summer 1	109.1	17
		Late summer 2	109.7	19
		Fall 1	105.8	19
		Fall 2	106.7	19
Total Squally Channel			**1,290.9**	**221**
Whale Channel	217,672	Winter 1	58.3	14
		Winter 2	60.6	15
		Spring 1	55.8	15
		Spring 2	62.5	15
		Early summer 1	54.1	14
		Early summer 2	59.5	14
		Mid-summer 1	52.2	14
		Mid-summer 2	59.4	15
		Late summer 1	65.3	15
		Late summer 2	72.7	16

Stratum	Area (km^2)	Survey	Length (km)	Number of Transects
		Fall 1	60.4	15
		Fall 2	63.1	15
Total Whale Channel			**723.9**	**177**
Estevan Sound/ Caamaño Sound	571,312	Winter 1	156 .4	17
		Winter 2	132.8	15
		Spring 1	161.9	18
		Spring 2	148.8	17
		Early summer 1	159.3	18
		Early summer 2	159.1	18
		Mid-summer 1	143.6	19
		Mid-summer 2	165.0	17
		Late summer 1	68.4	12
		Late summer 2	170.4	19
		Fall 1	157.2	17
		Fall 2	154.3	18
Total Estevan Sound/Caamaño Sound			**1,620.8**	**205**
Principe Channel	398,551	Winter 1	–	–
		Winter 2	–	–
		Spring 1	80.7	16
		Spring 2	78.4	19
		Early summer 1	67.7	17
		Early summer 2	77.2	19
		Mid-summer 1	69.7	17
		Mid-summer 2	68.2	18
		Late summer 1	74.9	18
		Late summer 2	68.3	19
		Fall 1	73.2	18
		Fall 2	78.4	18
Total Principe Channel			**736.7**	**179**
Triple Island	1,211,363	Winter 1	–	–
		Winter 2	–	–
		Spring 1	118.1	13
		Spring 2	178.2	15
		Early summer 1	184.6	15
		Early summer 2	177.3	16
		Mid-summer 1	171.2	16
		Mid-summer 2	181.7	16

Stratum	Area (km^2)	Survey	Length (km)	Number of Transects
		Late summer 1	19.9	2
		Late summer 2	175.1	16
		Fall 1	164.0	16
		Fall 2	172.0	15
Total Triple Island			**1,542.1**	**140**
Total	**3,103,473**		**6,539.9**	**1,124**

NOTE:
– not conducted

4.4.2.1 Winter Survey Period

Small toothed whales and pinnipeds were the primary marine mammals sighted during the winter survey period (Table 4.4-6, Figure 4.4-8). Most of these sightings were located in Kitimat Arm and Douglas Channel, Whale Channel, and Squally Channel. Several larger groups of Dall's porpoise, from 20 to 50 animals, were sighted in Douglas Channel and the northern section of Whale Channel. The remaining sightings were of approximately 10 animals or less. Of those sightings, 23% of the Dall's porpoises exhibited porpoising behaviour, and 17% were travelling towards the vessel. Pacific white-sided dolphins were by far the most abundant species sighted, with several groups of approximately 100 to 250 individuals in Whale and Squally channels, and a group of 100 animals in Kitimat Arm (Photo 4.4-1). Of those sightings, 6% of the Pacific white-sided dolphins were travelling towards the vessel, and 12% exhibited porpoising behaviour. Steller sea lions were recorded in the water and at various haulouts. Approximately 25 to 30 individuals were sighted on a haulout just north of Loretta Island, and up to 120 animals were hauled out on rocks adjacent to Ashdown Island (Ashdown Island haulout). Numerous harbour seals were sighted primarily as single individuals. One haulout with approximately 20 seals was recorded near Logan Rock in Estevan Sound.

Few large whales were seen during the winter surveys, with three humpback whale sightings, one fin whale sighting, and one killer whale sighting (Table 4.4-6, Figure 4.4-8). The humpback whale sightings were all of individual whales located in Hecate Strait, Otter Passage, and Estevan Sound. The fin whale sighting was located very close to the shore of the eastern side of Campania Island in Squally Channel. The killer whale sighting consisted of two killer whales travelling together.

Table 4.4-6: Winter Marine Mammal Sighting Summary

Stratum	Fin Whale		Humpback Whale		Killer Whale		Dall's Porpoise		Harbour Porpoise		Pacific White-sided Dolphin		Harbour Seal		Steller Sea Lion	
	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I
Kitimat Arm/Douglas Channel	ND	ND	ND	ND	ND	ND	40	288	3	7	9	136	14	26	14	25
Whale Channel	ND	ND	ND	ND	ND	ND	5	65	ND	ND	28	537	4	6	8	129
Squally Channel	1	1	ND	ND	1	2	1	2	ND	ND	13	430	13	22	2	3
Estevan Sound/Caamaño Sound	ND	ND	3	3	ND	ND	1	2	ND	ND	1	3	7	37	4	12
Total	**1**	**1**	**3**	**3**	**1**	**2**	**47**	**357**	**3**	**7**	**51**	**1,106**	**38**	**91**	**28**	**169**

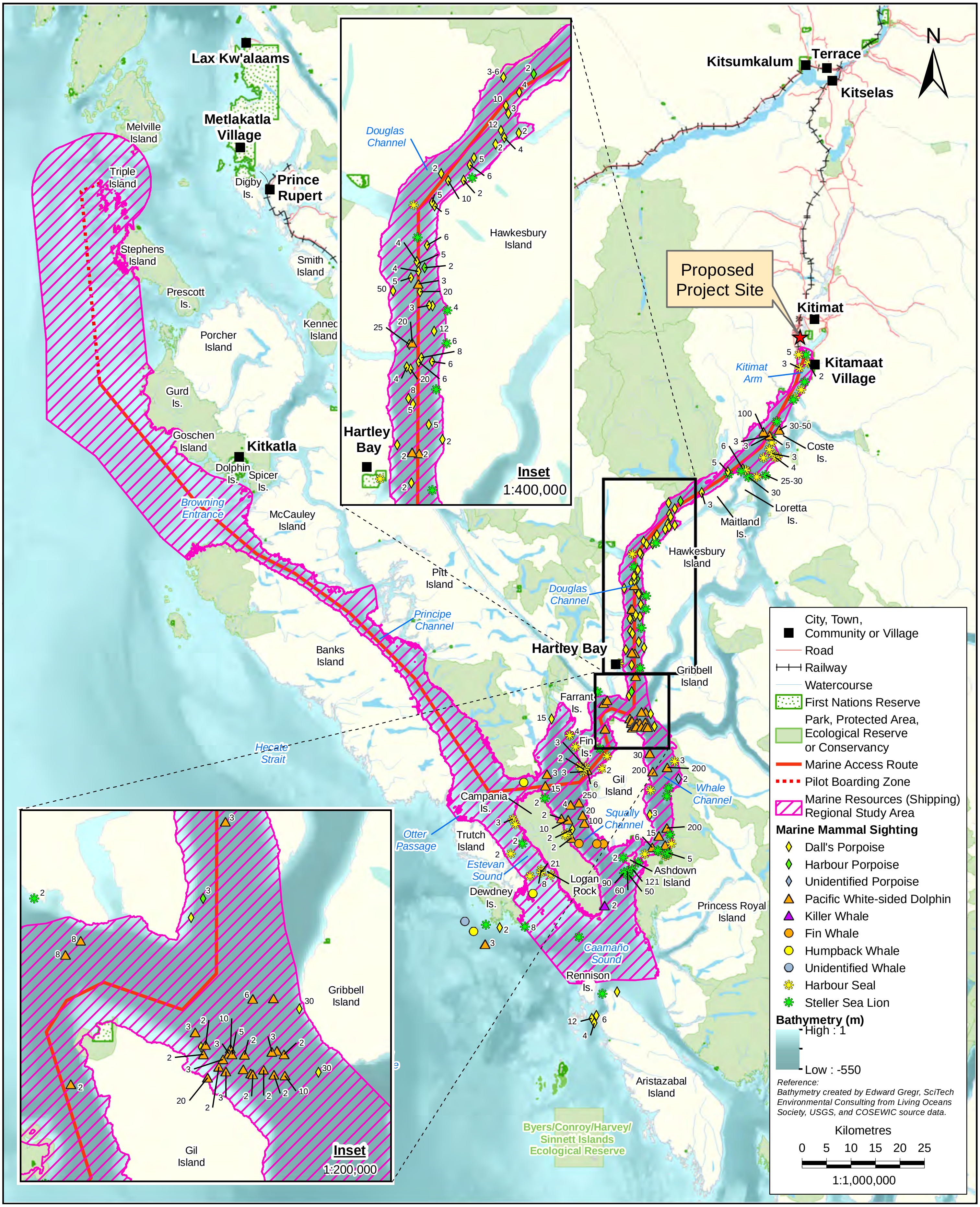
NOTES:

S – sighting

I – individuals

ND – not detected

Multiple sightings of pinnipeds at the same haulout were considered one sighting. The number of individuals (I) was the highest number of animals recorded during one of the sightings.



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MARINE RESOURCES TECHNICAL DATA REPORT

WINTER SURVEY
MARINE MAMMAL SIGHTINGS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
04-JUL-14	**4.4-8**

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Photo 4.4-1: Pacific White-sided Dolphins Sighting

Photo 4.4-2: Killer Whale Winter Sighting

4.4.2.2 Spring Survey Period

During the spring surveys, baleen whales, toothed whales, pinnipeds, and sea otters were sighted (Table 4.4-7, Figure 4.4-9). Humpback whales, harbour seals, and Steller sea lions were the most commonly sighted marine mammals.

Notable baleen whale sightings included grey whales in Hecate Strait, west of the Caamaño Sound strata. Most sightings were of one or two whales (Photo 4.4-3), with three sightings of four to five whales. One of the fin whale sightings was of an adult and calf in the nearshore waters of Wright Sound (Photo 4.4-4). Most humpback whale sightings were in the Triple Island strata, between Browning Entrance and Stephens Island. One sighting occurred just off Coste Island in Kitimat Arm. Many individuals exhibited breaching (10% of sightings), lobtailing (1% of sightings), and fin-slapping behaviours. There was some evidence of feeding behaviour by humpback whales outside of Browning Entrance. Feeding behaviour was observed in 1% of humpback sightings. Krill were observed at the surface of the water right after a humpback whale dove (Photo 4.4-5). Two minke whales were observed northwest of Porcher Island, one during each survey (Photo 4.4-6).

Five killer whales were sighted in Whale Channel. Photo identification was inconclusive; however, they were possibly a northern resident killer whale family group. Correspondence with Cetacealab confirmed they heard two killer whales that day: an adult female, A43, and a single male, A61. A group of six killer whales were observed west of Fin Island, including one, and possibly two, juveniles. Three other individual killer whales were sighted in the Triple Island strata, northwest of Porcher Island.

Numerous Dall's porpoises and Pacific white-sided dolphins were observed. Fewer Pacific white-sided dolphins were sighted than in the winter; and, no large groups were observed. Dall's porpoises were still present in high numbers, with most sightings consisting of groups of six or fewer individuals. Of the Dall's porpoise sightings, 3% were travelling towards the vessel, and 22% exhibited porpoising behaviour. For Pacific white-sided dolphin sightings, 33% were travelling towards the vessel, and 11.5% exhibited porpoising behaviour.

Steller sea lions and harbour seals were sighted throughout the survey area; there were two sea otter sightings. Steller sea lions were sighted frequently, with large numbers present at various haulouts: greater than 150 individuals at Warrior Rock; approximately 150 animals just north of Loretta Island; up to approximately 200 individuals on Roland Rock northwest of Stephens Island; and up to 150 individuals on the haulout by Ashdown Island. Sea lions were observed at these haulouts during both surveys. Harbour seals were hauled out in larger numbers at several locations: approximately 20 on and near Glide Island in Estevan Sound; approximately 30 near the southern tip of Pitt Island; approximately 20 on Cartwright Rocks in Estevan Sound; just over 10 on rocks at the southern tip of McCauley Island in Principe Channel; and up to 30 seals on Seal Rock northwest of Porcher Island. Only four sea otters were sighted, with one sighting during both spring surveys. Three sea otters were sighted together very close to shore at the southern end of Douglas Channel, and one was sighted in Browning Entrance.

Table 4.4-7: Spring Marine Mammal Sighting Summary

Stratum	Fin Whale		Grey Whale		Humpback Whale		Minke Whale		Killer Whale		Dall's Porpoise		Harbour Porpoise		Pacific White-sided Dolphin		Harbour Seal		Steller Sea Lion		Sea Otter	
	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I
Kitimat Arm/ Douglas Channel	ND	ND	ND	ND	1	1	ND	ND	ND	ND	12	63	ND	ND	ND	ND	4	5	14	167	1	3
Whale Channel	ND	ND	ND	ND	3	3	ND	ND	3	9	7	43	4	8	ND	ND	3	9	5	154	ND	ND
Squally Channel	1	2	ND	ND	2	2	ND	ND	1	6	2	26	ND	ND	2	40	17	61	4	19	ND	ND
Estevan Sound/ Caamaño Sound	4	5	18	37	5	9	ND	ND	ND	ND	6	19	ND	ND	1	5	8	52	4	5	ND	ND
Principe Channel	ND	ND	ND	ND	1	1	ND	ND	ND	ND	2	10	ND	ND	ND	ND	11	30	5	7	ND	ND
Triple Island	ND	ND	ND	ND	96	166	2	2	6	12	2	9	1	2	3	26	5	34	9	225	1	1
Total	**5**	**7**	**18**	**37**	**108**	**182**	**2**	**2**	**10**	**27**	**31**	**170**	**5**	**10**	**6**	**71**	**48**	**191**	**41**	**577**	**2**	**4**

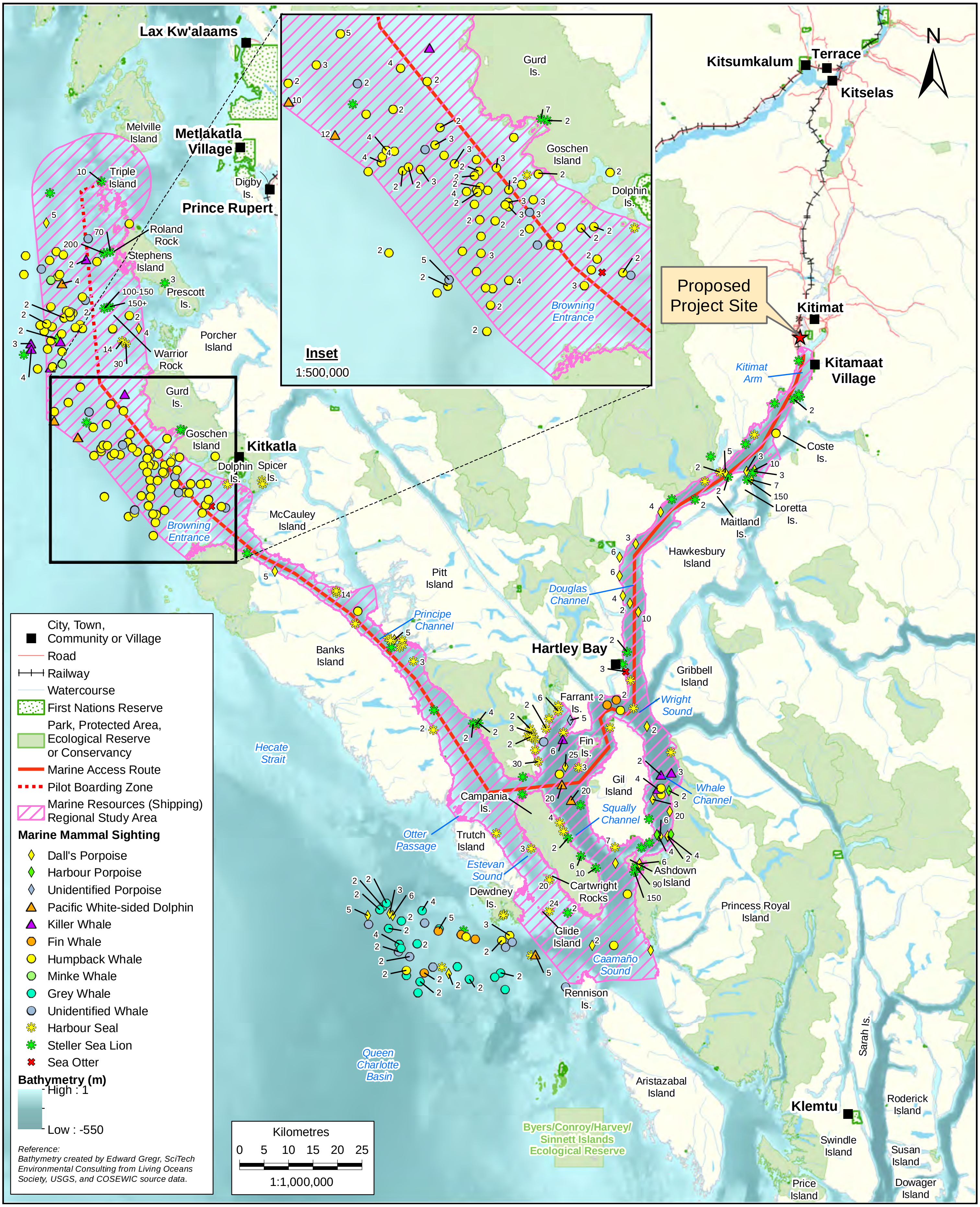
NOTES:

S – sighting

I – individuals

ND – not detected

Multiple sightings of pinnipeds at the same haulout were considered one sighting. The number of individuals (I) indicated was the highest number of animals recorded during one of the sightings.



MARINE RESOURCES TECHNICAL DATA REPORT

SPRING SURVEY
MARINE MAMMAL SIGHTINGS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
04-JUL-14	4.4-9

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Photo 4.4-3: Grey Whale Sighting

Photo 4.4-4: Adult Fin Whale Sighting

Photo 4.4-5: Humpback Whale Feeding Behaviour Evidence

Photo 4.4-6: Minke Whale Sighting

4.4.2.3 Early Summer Survey Period

Baleen whales, toothed whales, seals, sea lions, and one sea otter were sighted during the early summer surveys (Table 4.4-8, Figure 4.4-10). Humpback whale was the most frequently sighted species.

Large numbers of humpback whales were recorded in Squally Channel, Estevan Sound, Caamaño Sound, and in the Triple Island strata. The whales tended to be active and exhibited breaching (8% of sightings), lobtailing (3% of sightings), and fin-slapping behaviours (Photo 4.4-7). Humpback whales were also observed feeding in 1% of sightings. One minke whale was observed in Caamaño Sound. Most fin whale sightings were individual whales.

Porpoises were the most sighted toothed whales. Dall's porpoises were primarily seen in groups of less than four, with more sightings occurring in the outer strata (Estevan Sound, Caamaño Sound, Principe Channel, and Triple Island) than the inner coast strata (Figure 4.4-10). Dall's porpoises were observed travelling towards the vessel in 15% of early summer sightings; 17% of the time, they exhibited porpoising behaviour. Numerous harbour porpoise sightings were made, including one sighting of a group of 10 animals in Wright Sound. Pacific white-sided dolphin sightings occurred primarily west of Prescott Island in the Triple Island strata. Of these sightings, the Pacific white-sided dolphins travelled towards the vessel 9% of the time and exhibited porpoising behaviour 9% of the time.

Table 4.4-8: Early Summer Marine Mammal Sighting Summary

Stratum	Fin Whale		Humpback Whale		Minke Whale		Killer Whale		Dall's Porpoise		Harbour Porpoise		Pacific White-sided Dolphin		Harbour Seal		Steller Sea Lion		Sea Otter	
	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I
Kitimat Arm/ Douglas Channel	ND	ND	ND	ND	ND	ND	1	4	2	3	5	7	1	2	14	41	ND	ND	ND	ND
Whale Channel	ND	ND	5	5	ND	ND	1	3	4	13	18	40	1	2	2	4	8	177	ND	ND
Squally Channel	7	8	47	54	ND	ND	ND	ND	3	10	10	15	ND	ND	3	55	4	6	ND	ND
Estevan Sound/ Caamaño Sound	1	2	12	33	1	1	5	13	15	35	9	21	ND	ND	22	131	4	14	1	1
Principe Channel	ND	ND	1	1	ND	ND	ND	ND	8	19	2	2	ND	ND	4	50	ND	ND	ND	ND
Triple Island	ND	ND	41	64	ND	ND	8	38	12	21	7	13	7	10	7	30	5	255	ND	ND
Total	**8**	**10**	**106**	**157**	**1**	**1**	**15**	**58**	**44**	**101**	**51**	**98**	**9**	**14**	**52**	**311**	**21**	**452**	**1**	**1**

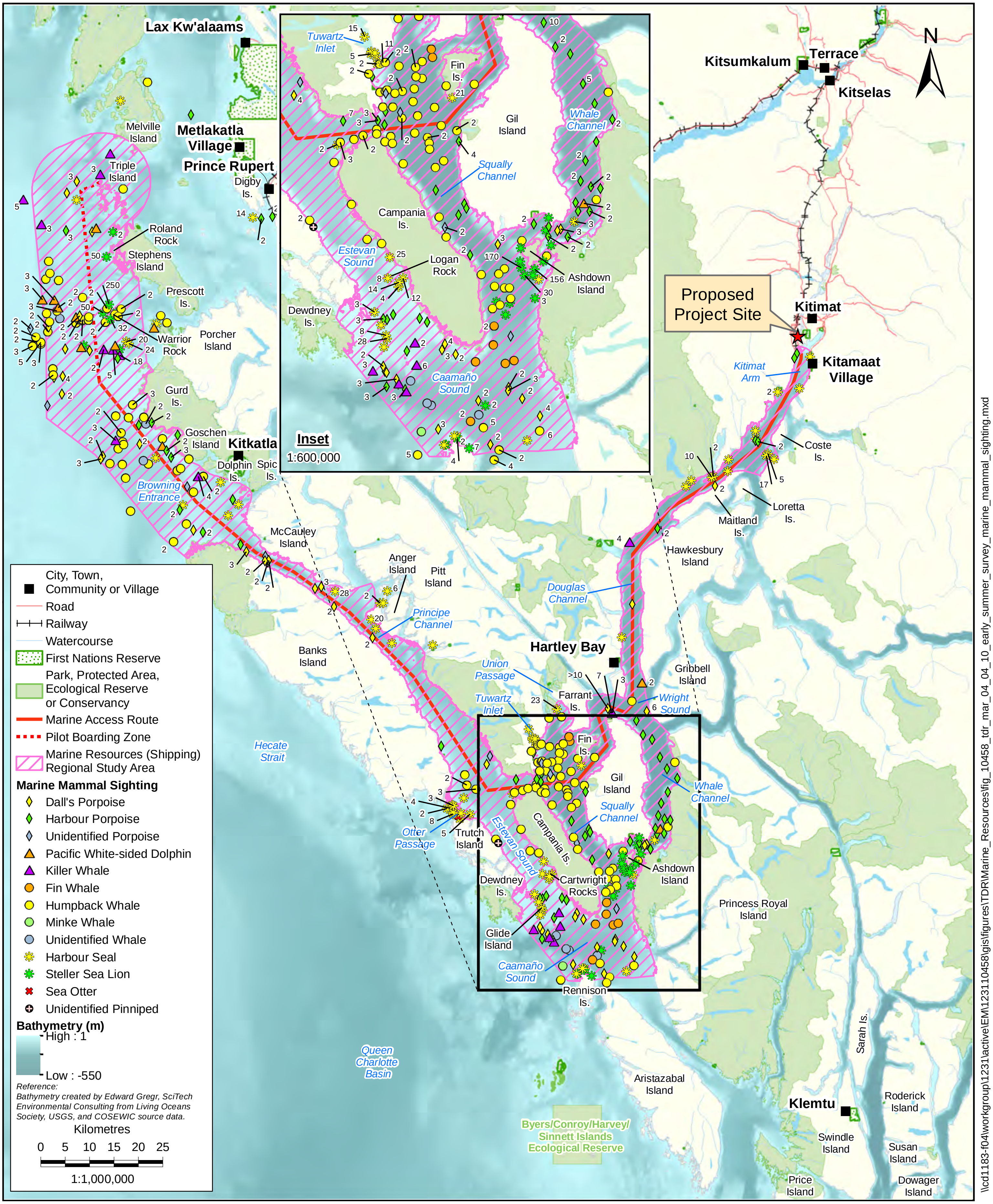
NOTES:

S – sighting

I – individuals

ND – not detected

Multiple sightings of pinnipeds at the same haulout were considered one sighting. The number of individuals (I) indicated was the highest number of animals recorded during one of the sightings.



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MARINE RESOURCES TECHNICAL DATA REPORT

EARLY SUMMER SURVEY
MARINE MAMMAL SIGHTINGS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
04-JUL-14	**4.4-10**

Photo 4.4-7: Humpback Whale Sighting

Notable killer whale sightings included a pod of 18 killer whales observed in Hecate Strait, just northwest of Porcher Island (Photo 4.4-8). Several sightings of groups of up to six whales were also made in Caamaño Sound and in the Triple Island strata. Photo identification of these individuals was inconclusive.

Pinnipeds were also numerous, with multiple sightings recorded for both harbour seals and Stellar sea lions in water and at haulouts. Harbour seals were observed hauled out in Kitimat Arm on rocks west of Maitland Island (south of Point Ashton); on rocks in Tuwartz Inlet and Union Passage off Squally Channel (Photo 4.4-9); off the southern tip of Fin Island; on Glide Islands at the southern end of Estevan Sound; on and near Cartwright Rocks at the southern end of Estevan Sound; just off Anger Island and McCauley Island in Principe Channel; and on Seal Rocks in Triple Island. Steller sea lion haulouts included a group of over 150 animals on the rocks by Ashdown Island, up to 200 animals northwest of Porcher Island on Grenville Rocks (Photo 4.4-10), and approximately 50 animals near Stephens Island. A single sea otter was sighted at Otter Passage in the Estevan Sound/Caamaño Sound strata.

Photo 4.4-8: Killer Whale Sighting

Photo 4.4-9: Harbour Seals in Union Passage

Photo 4.4-10: Steller Sea Lions on Grenville Rocks

4.4.2.4 Mid-Summer Survey Period

During the mid-summer survey period, baleen whales, toothed whales, seals, and sea lions were sighted (Table 4.4-9, Figure 4.4-11). Humpback whales were the most frequently sighted marine mammals.

Large numbers of individual humpback whales were observed in the Squally Channel and Estevan/Caamaño Sound strata. Most sightings recorded were individuals, although a group of five humpback whales was sighted bubble net feeding in Squally Channel. Humpback whales exhibited a variety of behaviours, including breaching (5% of sightings), lobtailing (1% of sightings), and feeding (0.5% of sightings). Fin whale sightings were primarily of individuals; two individual minke whales were sighted in the Squally Channel and Triple Island strata.

Notable killer whale sightings included a pod of 14 killer whales just off the northern tip of Aristazabal Island and a pod of Bigg's killer whales preying on a Dall's porpoise at Browning Entrance. Killer whales were sighted in all strata except Whale Channel, including several sightings in Estevan Sound, Caamaño Sound, and the Triple Island strata. Photo identification confirmed the sighting of Bigg's individual T162 in the Triple Island strata at Browning Entrance (Photo 4.4-11).

Table 4.4-9: Mid-Summer Marine Mammal Sighting Summary

Stratum	Fin Whale		Humpback Whale		Minke Whale		Killer Whale		Unid Whale		Dall's Porpoise		Harbour Porpoise		Unid Porpoise		Pacific White-sided Dolphin		Harbour Seal		Steller Sea Lion	
	S	**I**	**S**	**I**	**S**	**I**	**S**	**I**	**S**	**I**	**S**	**I**	**S**	**I**	**S**	**I**	**S**	**I**	**S**	**I**	**S**	**I**
Kitimat Arm/ Douglas Channel	ND	ND	2	2	ND	ND	1	2	ND	ND	6	26	2	1	ND	ND	1	1	15	97	ND	ND
Whale Channel	1	3	22	27	ND	ND	ND	ND	3	3	9	33	5	17	ND	ND	ND	ND	3	32	3	203
Squally Channel	20	28	77	104	1	1	4	13	9	11	15	47	5	10	ND	ND	ND	ND	12	101	1	200
Estevan Sound/ Caamaño Sound	21	35	53	100	ND	ND	5	30	3	3	22	46	5	14	1	2	ND	ND	18	163	4	14
Principe Channel	ND	ND	6	7	ND	ND	1	1	ND	ND	7	17	1	1	ND	ND	1	1	12	53	1	1
Triple Island	ND	ND	31	36	1	1	5	13	2	1	34	81	2	2	ND	ND	1	6	9	64	3	332
Total	**42**	**66**	**191**	**276**	**2**	**2**	**16**	**59**	**17**	**18**	**93**	**250**	**20**	**45**	**1**	**2**	**3**	**8**	**69**	**510**	**12**	**750**

NOTES:

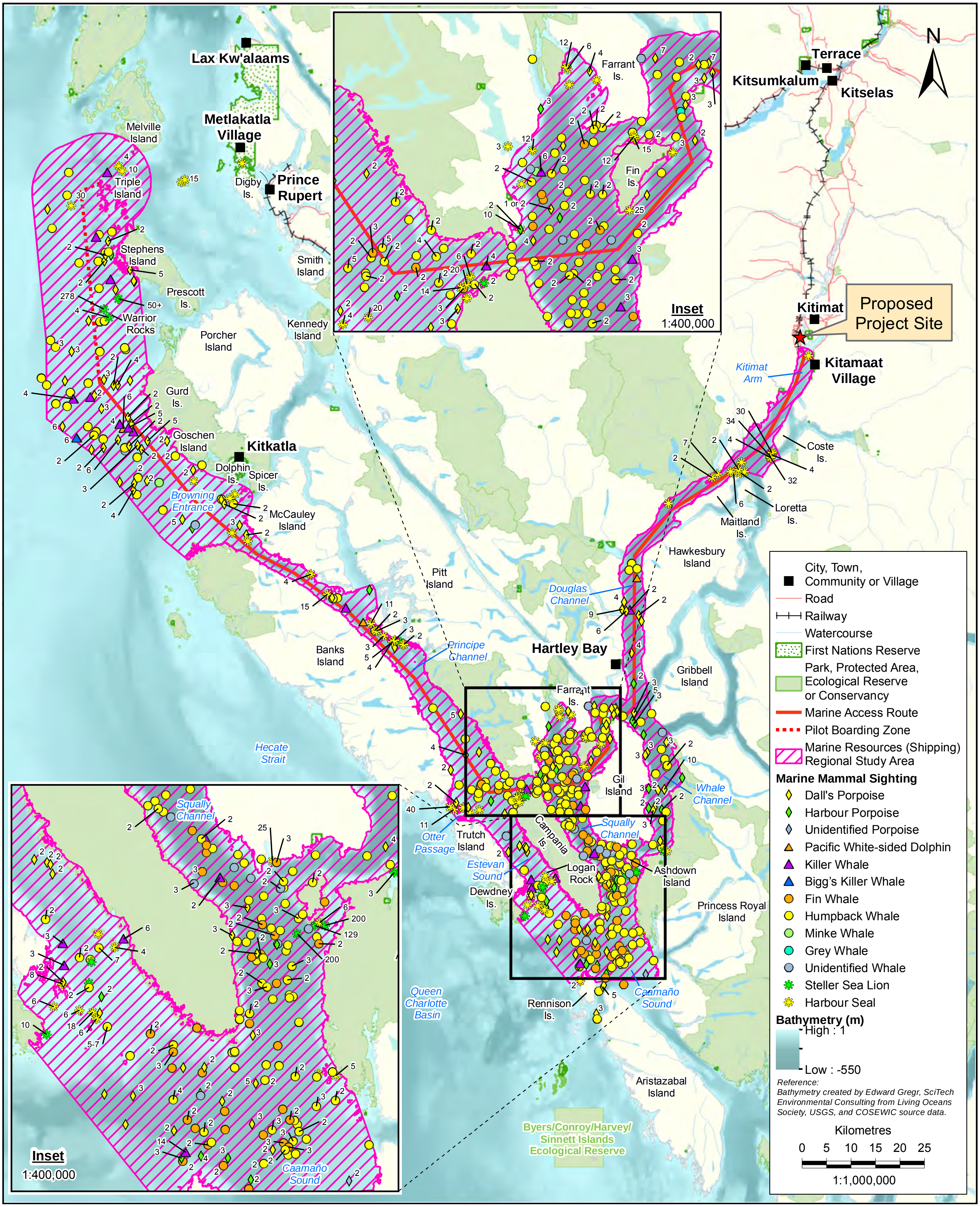
S – sighting

I – individuals

ND – not detected

Unid – unidentified

Multiple sightings of pinnipeds at the same haulout were considered one sighting. The number of individuals (I) indicated was the highest number of animals recorded during one of the sightings.



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MARINE RESOURCES TECHNICAL DATA REPORT

MID-SUMMER SURVEY
MARINE MAMMAL SIGHTINGS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
04-JUL-14	**4.4-11**

Photo 4.4-11: Killer Whale Sighting (Right: Transient T162)

Dall's porpoises were the most frequently sighted toothed whales and were typically observed in groups of less than four, although a group of 10 was observed together in Squally Channel approaching the vessel to bow ride. They were observed travelling towards the vessel during 10% of all sightings and exhibited porpoising behaviour for 21% of sightings. Further, a single dead Dall's porpoise was sighted in the Triple Island strata, appearing to have been attacked by a Bigg's killer whale (Photo 4.4-12). Harbour porpoises were observed individually or in groups of two to five. Only eight Pacific white-sided dolphins were sighted during the mid-summer survey period.

Pinnipeds were sighted throughout the survey area, with numerous sightings for both Steller sea lions and harbour seals. Steller sea lions, the most abundant species in the survey area, were sighted in the water and at haulout sites. Approximately 200 individuals were sighted on the rocks at Ashdown Island, and up to 278 individuals were sighted at Warrior Rock. Sea lions were observed at these haulouts during both mid-summer surveys. Harbour seals were also frequently sighted in the water and at haulouts. At haulouts, up to 40 individual harbour seals were sighted on the rocks at Otter Passage, 34 individuals were sighted south of Coste Island in Kitimat Arm, and 30 individuals were sighted on the rocks around Triple Island. Harbour seals were observed exhibiting a looking behaviour in 13% of all sightings during the mid-summer surveys.

Photo 4.4-12: Deceased Dall's Porpoise Sighting

Photo 4.4-13: Humpback Whale Sighting

4.4.2.5 Late Summer Survey Period

Baleen whales, toothed whales, seals, and sea lions were sighted during the late-summer survey period (Table 4.4-10, Figure 4.4-12). Humpback whale was the most frequently sighted species.

Humpback whales were frequently sighted throughout the survey, with the most sightings recorded in Squally Channel. They exhibited a variety of behaviours, including breaching (9% of sightings), lobtailing (0.2% of sightings; Photo 4.4-14). Humpback whales were also observed feeding during 1.5% of all sightings. West of Fin Island in Squally Channel, five humpback whales were sighted breaching several times. Several fin whales were also sighted, including one group of six whales in Squally Channel. No minke whales were observed during this survey period.

Dall's porpoises (Photo 4.4-15) were the most frequently sighted toothed whales during the late-summer survey period, and were observed in all strata. They were sighted in groups of up to seven individuals, often travelling towards the vessel (21% of sightings) to bow ride. In 32% of all sightings, they exhibited porpoising behaviour. Harbour porpoises were less frequently sighted, and were observed in all strata except Triple Island. A group of 100 Pacific white-sided dolphins were sighted immediately west of Goschen Island in the Triple Island strata.

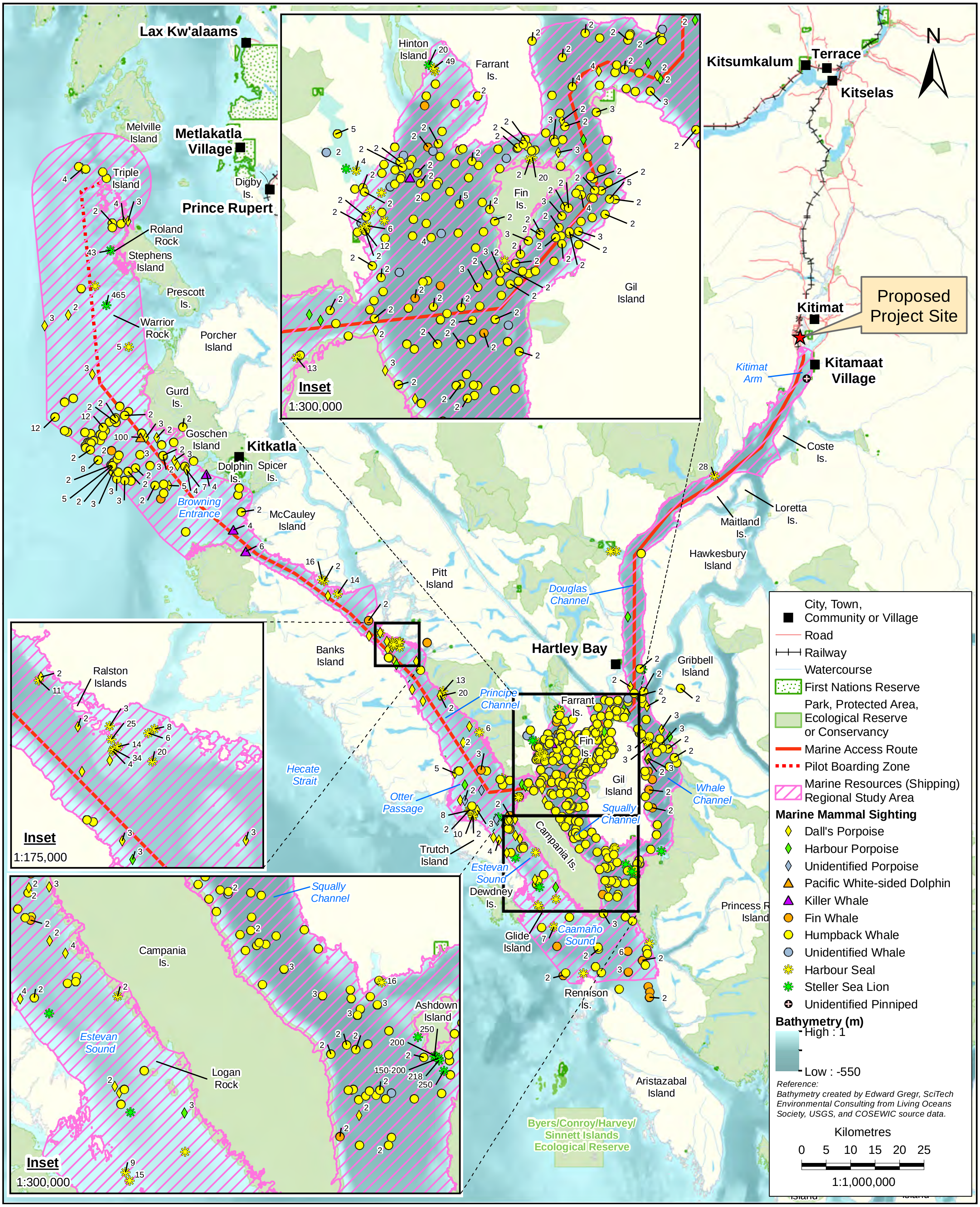
Notable killer whale sightings included a pod of six individuals, including one juvenile, and another pod of four individuals breaching and diving, at Browning Entrance in the Principe Channel Strata. Two additional killer whale sightings were also made in Squally Channel and Triple Island.

Pinnipeds were the most frequently sighted marine mammals. Both Steller sea lions and harbour seals were observed in the water and at haulout sites. At the Steller sea lion haulouts, up to 250 individuals were sighted on the rocks at Ashdown Island (Photo 4.4-16), 465 individuals on Warrior Rock, and 43 individuals on Roland Rock. Sea lions were observed at these haulout sites during both late summer surveys. Harbour seals were observed in groups of up to 49 individuals at a haulout site east of Hinton Island in the Squally Channel strata. Several harbour seals were also observed on a group of several small rocks in Principe Channel, just south of Relston Island.

Table 4.4-10: Late Summer Marine Mammal Sighting Summary

Stratum	Fin Whale		Humpback Whale		Minke Whale		Killer Whale		Unid Whale		Dall's Porpoise		Harbour Porpoise		Unid Porpoise		Pacific White-sided Dolphin		Harbour Seal		Steller Sea Lion	
	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I
Kitimat Arm /Douglas Channel	ND	ND	2	3	ND	ND	ND	ND	ND	ND	1	2	2	3	ND	ND	ND	ND	1	28	1	1
Whale Channel	2	3	42	57	ND	ND	ND	ND	1	1	6	16	4	6	ND	ND	ND	ND	2	17	4	469
Squally Channel	6	15	183	274	ND	ND	1	1	11	13	7	17	1	1	ND	ND	ND	ND	10	95	2	220
Estevan Sound/ Caamaño Sound	10	17	32	37	ND	ND	ND	ND	ND	ND	11	27	4	6	3	4	ND	ND	13	72	4	4
Principe Channel	3	6	4	4	ND	ND	2	10	ND	ND	14	26	1	3	ND	ND	ND	ND	14	194	ND	ND
Triple Island	2	3	54	95	ND	ND	ND	ND	ND	ND	10	34	ND	ND	ND	ND	1	100	2	6	2	508
Total	**23**	**44**	**317**	**470**	**ND**	**ND**	**3**	**11**	**12**	**14**	**49**	**122**	**12**	**19**	**3**	**4**	**1**	**100**	**42**	**412**	**13**	**1202**

NOTES:
S – sighting
I – individuals
ND – not detected
Unid – unidentified
Multiple sightings of pinnipeds at the same haulout were considered one sighting. The number of individuals (I) indicated was the highest number of animals recorded during one of the sightings.



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MARINE RESOURCES TECHNICAL DATA REPORT

LATE SUMMER SURVEY
MARINE MAMMAL SIGHTINGS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION	DRAWN BY
UTM9	SS
DATUM	CHECKED BY
NAD 83	SW
DATE	FIGURE NO.
04-JUL-14	**4.4-12**

Photo 4.4-14: Humpback Whale Lobtailing

Photo 4.4-15: Dall's Porpoise Sighting

Photo 4.4-16: Steller Sea Lions on Ashdown Island

4.4.2.6 Fall Survey Period

During the fall survey period, baleen whales, toothed whales, seals, sea lions, and two river otters were observed (Table 4.4-11, Figure 4.4-13). The most frequently sighted species was the humpback whale.

Humpback whales were sighted throughout the survey in groups of six or less (Photo 4.4-17). In the Triple Island strata, six humpback whales were sighted feeding at Browning Entrance. A single humpback whale was observed breaching repeatedly up to 37 times in Principe Channel (Photo 4.4-18). Humpbacks exhibited breaching behaviour in 6% of sightings and lobtailing behaviour in 3% of sightings, and were observed feeding in 0.5% of sightings. Fin whales were observed in all strata except Principe Channel, with most sightings of individuals. One group of four fin whales was sighted west of Hawkesbury Island in Douglas Channel. Few minke whales were sighted during the fall survey period: one individual in Squally Channel and two individuals in the Triple Island strata.

Table 4.4-11: Fall Marine Mammal Sighting Summary

Stratum	Fin Whale		Humpback Whale		Minke Whale		Killer Whale		Unid Whale		Dall's Porpoise		Harbour Porpoise		Unid Porpoise		Pacific White-sided Dolphin		Harbour Seal		Elephant Seal		Steller Sea Lion		River Otter	
	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I	S	I
Kitimat Arm/ Douglas Channel	1	4	15	17	ND	ND	ND	ND	ND	ND	18	69	2	4	1	1	ND	ND	12	27			2	2	ND	ND
Whale Channel	1	1	48	75	ND	ND	3	10	ND	ND	17	74	ND	ND	1	2	ND	ND	2	4	1	1	16	675	1	1
Squally Channel	3	3	59	91	1	1	ND	ND	ND	ND	14	41	ND	ND	1	1	ND	ND	15	64	ND	ND	3	6	1	1
Estevan Sound/ Caamaño Sound	5	11	24	40	ND	ND	2	5	4	7	15	50	2	4	ND	ND	ND	ND	9	86	ND	ND	3	3	ND	ND
Principe Channel	ND	ND	10	13	ND	ND	ND	ND	ND	ND	9	24	ND	ND	ND	ND	ND	ND	13	75	1	1	3	3	ND	ND
Triple Island	1	1	41	76	2	2	ND	ND	ND	ND	14	43	ND	ND	ND	ND	1	100	2	16	ND	ND	10	1,244	ND	ND
Total	**11**	**20**	**197**	**312**	**3**	**3**	**5**	**15**	**4**	**7**	**87**	**301**	**4**	**8**	**3**	**4**	**1**	**100**	**53**	**272**	**2**	**2**	**37**	**1,933**	**2**	**2**

NOTES:

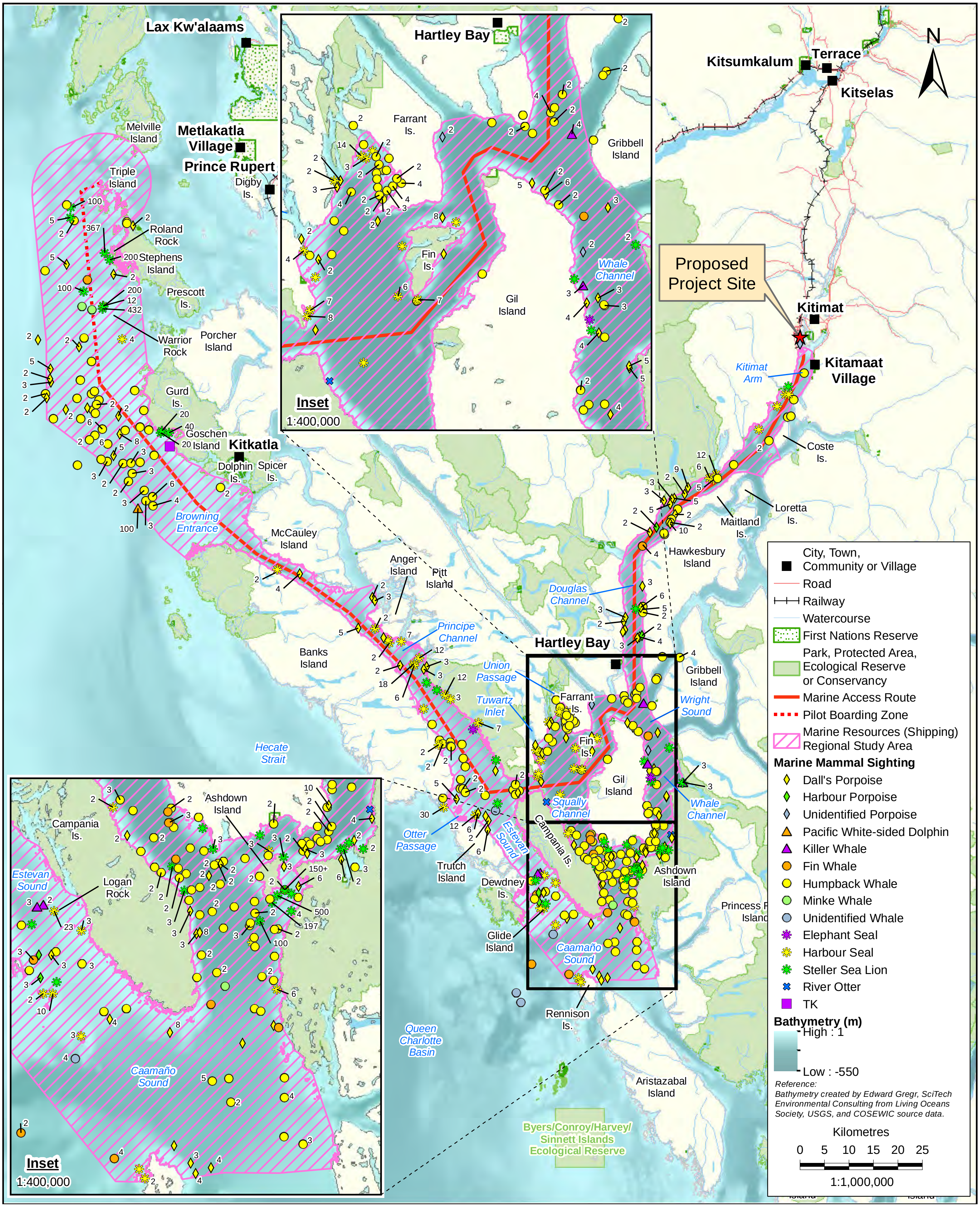
S – sighting

I – individuals

ND – not detected

Unid – unidentified

Multiple sightings of pinnipeds at the same haulout were considered one sighting. The number of individuals (I) indicated was the highest number of animals recorded during one of the sightings.



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MARINE RESOURCES TECHNICAL DATA REPORT

FALL SURVEY
MARINE MAMMAL SIGHTINGS

LNG CANADA EXPORT TERMINAL
KITIMAT, BRITISH COLUMBIA

PROJECTION UTM9	DRAWN BY SS
DATUM NAD 83	CHECKED BY SW
DATE 20-AUG-14	FIGURE NO. **4.4-13**

Photo 4.4-17: Humpback Whale Sighting

Photo 4.4-18: Humpback Whale Breaching

Dall's porpoises were frequently observed in all strata in groups of less than 10. They were active, often bow riding on the vessel for up to two minutes at a time. They travelled towards the vessel in 14% of all sightings and exhibited porpoising behaviour in 16% of all sightings. Harbour porpoises were less frequently sighted, occurring in Kitimat Arm and Estevan Sound/Caamaño Sound strata, in groups of less than three. A single Pacific white-sided dolphin sighting at Browning Entrance in the Triple Island strata included up to 100 individuals exhibiting porpoising behaviour. Killer whales were sighted in Whale Channel and Estevan Sound/Caamaño Sound in groups of two to four individuals.

Steller sea lions and harbour seals were sighted throughout the survey area in the water and at haulouts. At haulouts, Steller sea lions were observed on the rocks, with up to 500 individuals at Ashdown Island, up to 432 individuals at Warrior Rock, and up to 367 individuals at Roland Rock. Sea lions were observed at these haulout sites during both fall surveys. Harbour seals were sighted in groups of up to 30 individuals. Harbour seals were frequently sighted in large numbers hauled out at several locations, including 23 individuals on the rocks at Logan Rock and 30 individuals on the rocks at Otter Passage. Several other sightings of both Steller sea lions and harbour seals occurred in smaller groups on clusters of rocks and individually in the water. Two elephant seals were sighted in Whale Channel and Principe Channel; both individuals surfaced for several minutes before diving. Two sea otters were sighted during the second fall survey, with one individual diving off the shore in Whale Channel and another individual swimming in Squally Channel.

4.4.3 Discussion

The marine mammal surveys provided baseline information on distribution and numbers of animals throughout the shipping RSA over multiple seasons. These surveys provided a seasonal view of marine mammal distribution with consistent effort and methods throughout the year. The surveys were planned to capture biologically important times in the region.

Grey whales had recently been found to use the eastern portion of Hecate Strait during their northward migration (Ford et al. 2012). Grey whales were not observed in Hecate Strait during winter surveys; but they were observed during spring surveys. Further, during the early summer, mid-summer, late summer, and fall surveys, no grey whales were observed. These surveys did not extend as far into Hecate Strait; so, it is unclear if the lack of grey whale sightings reflects survey extent or their absence in the area at that time.

Humpback whales are known to occur in BC waters throughout the year, which was supported by the survey results. Locations of these survey sightings and their frequency varied in some areas through the year. The Triple Island strata consistently had a high number of sightings (surveyed starting in the spring period). An increase in sightings occurred in Squally Channel, Estevan Sound, and the Triple Island strata beginning in early summer. This trend continued through the summer, for all strata, with humpback whales being most frequently sighted during the late summer. The increase in sightings in these areas, beginning in the early summer (June), is consistent with the literature (Nichol et al. 2010). Humpback sightings were lowest during the winter survey period; however, during the winter survey period, Principe Channel and the Triple Island strata were excluded from the survey.

The second most frequently sighted baleen whale was the fin whale, with most sightings occurring during mid-summer. Similar to humpback whales, fin whales were sighted least during the winter survey period. Sightings of minke whales were few, with the most sightings occurring during the fall survey period.

Numerous sights of toothed whales occurred throughout the year, the most frequently sighted species being Dall's porpoise. Sightings of Dall's porpoise remained relatively constant until mid-summer, when the greatest number of sightings was recorded; sightings remained high from the mid-summer through to the fall for Dall's porpoise. Dall's porpoise sightings were lowest during the early summer.

Similar to Dall's porpoise, killer whales were most frequently sighted during the mid-summer survey period. Sightings during the winter, late summer, and fall were relatively low.

Sighting frequency also changed over time for harbour porpoises, with increased sightings beginning in the early summer surveys. These observations could support hypotheses that harbour porpoises move to offshore waters in the winter and occupy shallower nearshore waters at other times of the year (Carretta et al. 2005; Heise et al. 2007; Ford et al. 2010a).

Large groups of Pacific white-sided dolphins were present in the study area during the winter survey period; but sightings and group size dropped during the spring, summer, and fall surveys. During the spring, summer, and fall, sightings were low, between three to nine sightings of up to 71 individuals. Sightings were the lowest during the late summer and fall surveys, with only a single sighting during each survey period; but these sightings both included approximately 100 individuals. These results support hypotheses that Pacific white-sided dolphins exhibit seasonal movements, occupying inshore waters of the BC coast in the fall, winter, and spring (Stacey and Baird 1991).

Harbour seals and Steller sea lions were frequently sighted throughout the year at a number of known haulouts and rookeries. Harbour seals were most frequently sighted during the mid-summer survey (69 sightings) and least frequently sighted during the winter survey period (38 sightings). Steller sea lion sightings were most frequent during the spring survey period and least frequent during the mid-summer survey. Most individuals of both species were sighted at haulouts; however, individuals of both species were also sighted in the water. Two elephant seals were also sighted in Whale Channel and Principe Channel during the fall survey. Sightings of sea otters were few, occurring in the spring (Otter Passage), early summer (south end of Douglas Channel and Browning Entrance), and fall (Whale Channel and Squally Channel).