From: Kevin Obermeyer [mailto:oberkev@ppa.gc.ca]
Sent: September 27, 2017 5:56 PM
To: Myles,Debra [CEAA]
Cc: Isabelle Forget
Subject: RE: Letter from the Review Panel for the Roberts Bank Terminal 2 Project Environmental Assessment

Good afternoon Debra:

Please find attached the Tetra Tech environmental study conducted for the potential anchorage off Gabriola Island.

If there are any questions please feel free to contact me.
Best regards
Kevin

Kevin Obermeyer
CEO

Pacific Pilotage Authority
1000 - 1130 West Pender Street
Vancouver, BC V6E 4A4

Ph: <contact information removed>
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Our mission is to provide a safe and efficient pilotage service by working in partnership with pilots and the shipping industry to protect and advance the interests of Canada.

-----Original Message-----
From: Myles,Debra [CEAA] [mailto:Debra.Myles@ceaa-acee.gc.ca]
Sent: September-27-17 2:02 PM
To: Kevin Obermeyer
Cc: Panel RBT2 / Commission RBT2 (CEAA/ACEE)
Subject: Letter from the Review Panel for the Roberts Bank Terminal 2 Project Environmental Assessment

Captain Obermeyer

Please find a letter and information request from the Review Panel, attached.

Thank you,

Debra Myles
Review Panel Manager, Roberts Bank Terminal 2 Project
Tel.: 613-957-0626 or 1-613-808-0165 /
Panel.RBT2@ceaa.gc.ca<mailto:Panel.RBT2@ceaa.gc.ca>

Debra Myles
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Environmental Overview Assessment of Proposed Anchorages off Gabriola Island, BC.



PRESENTED TO

Pacific Pilotage Authority

APRIL 26, 2016
ISSUED FOR REVIEW
FILE: VENV03029-01

This document has been "Issued for Review" to allow the client/design team to review and provide comments back to Tetra Tech EBA. This document is subject to revision based on input received and therefore any decisions based on this unsigned document should be reviewed in relation to the subsequent "Issued for Use" document.

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EXECUTIVE SUMMARY

Tetra Tech EBA Inc. (Tetra Tech EBA) has been retained by Pacific Pilotage Authority (PPA) to conduct an Environmental Overview Assessment (EOA) on five proposed anchorages east of Gabriola Island, BC (“Anchorage[s])”). This EOA is being conducted for due diligence purposes to evaluate potential Anchorage interactions with the physical environment and is intended to provide a framework for regulatory approvals that may be required in the future.

Shipping at Port Metro Vancouver (PMV) has been steadily increasing and the size of vessels entering the port have also been increasing. With the increase in shipping, there has been an increase in vessels anchoring outside of PMV and many of those anchorages are not easily accessible or appropriately sized. It has become increasingly clear that additional deep sea anchorages for larger vessels (~300 m) is required to adapt to the changing realities of the shipping industry and that there is a need to designate new anchorage locations to accommodate the increased traffic and vessel size in Vancouver.

In 2011 the Chamber of Shipping, BC Coast Pilots Ltd, PMV, Nanaimo Port Authority (NPA) and PPA jointly reviewed coastal anchorages to determine how to address the increased demand and assess potential locations for new anchorages. Various changes to existing anchorages at Port of Prince Rupert, PMV, Port of Nanaimo and Southern Gulf Islands included anchorage additions, removals and realignments. Multiple locations were assessed for suitability of use for large vessels. Based on the conditions required for a suitable anchorage site, the area east of Gabriola Island was considered a prime candidate.

The objective of this EOA is to describe the activities occurring in the Anchorage area, summarize existing environmental conditions and conduct an assessment of potential Anchorage-valued component (VC) interactions. It was limited to assessment of the natural environment, except where specifically requested by PPA; it does not include components such as health, heritage, economic, aesthetics or other social factors. Quantitative assessment of the Anchorage area was largely absent within this high-level EOA. Publicly available resources, such as government and non-government organization databases and published scientific reports, were relied on heavily to provide baseline conditions and inform effect interaction evaluations.

The results of this EOA indicate that, with application of appropriate mitigation measures, most Anchorage-VC interactions result in residual effects that are ***not significant***. Negative environmental effects are generally localized and/or short term.

Tetra Tech EBA notes that although anchor drag/scour causing localized destruction of fish habitat and individual fish mortality was found to be *Not Significant* based on the established methodology “serious harm to fish” is prohibited under Section 35 of the *Fisheries Act.* Serious harm to fish includes permanent alteration or destruction of fish habitat. Activities causing serious harm to fish require an Authorization under subsection 35(2) of the *Fisheries Act*.

Several ***significant*** adverse residual effects were identified, though with a low likelihood of occurrence:

- Marine mammals may be killed or injured by ship strike. Because several sensitive marine mammal species are potentially present in the Anchorage area, and because marine mammals generally have low reproductive rates, loss of an individual could have implications for local populations (e.g., loss of a mature female Killer Whale from the endangered Southern Resident population limits potential growth/recovery of that population).

- Several VCs (i.e., water quality, terrestrial mammals and marine birds, marine mammals, fish and aquatic habitat and Aboriginal, recreational and commercial fisheries) may be significantly impacted if a deleterious substance is released to the aquatic environment. Intentional and operational releases of deleterious substances are prohibited by federal and provincial regulations as well as international conventions and accidental releases are anticipated to be both infrequent and unlikely.

Although these residual effects would be *significant*, they are deemed unlikely to occur. Accordingly, the PPA may consider these *significant* residual effects to be acceptable.

Tetra Tech EBA recognizes that there is a lack of specific, quantitative information. There is potential that expert advice or quantitative information, should it become available, would change the effects characterization and significance determination(s).

Further, the lack of Public/First Nations consultation leaves potential for significant effects to occur within social components, including those assessed within the EOA (i.e., noise, light and fisheries). Consultation may identify concerns and further investigation may determine that Anchorage activities have significant adverse residual impacts on social components.

TABLE OF CONTENTS

EXECUTIVE SUMMARY I

1.0 INTRODUCTION 1
1.1 Location 1
1.2 Justification 1
1.3 Components and Scheduling...1

2.0 ALTERNATIVES CONSIDERED 2

3.0 METHODOLOGY 3

4.0 EXISTING NATURAL ENVIRONMENT 4
4.1 Climate 4
4.2 Air Quality 5
4.3 Foreshore & Adjacent Terrestrial Habitat 6
4.4 Subtidal & Foreshore Substrates..6
4.5 Aquatic Habitat..7
4.5.1 Aquatic Macrovegetation 7
4.5.2 Sponges, Shellfish and Invertebrates..7
4.5.3 Fish 9
4.5.4 Marine Birds & Marine Mammals...10
4.5.5 Surface Water Quality...11
4.6 Species at Risk 12
4.7 Noise..13
4.8 Ambient Light...15

5.0 EXISTING HUMAN ELEMENTS 16
5.1 Municipalities and Communities 16
5.2 First Nations...16
5.3 Public & Commercial Use 17

6.0 EFFECT ASSESSMENT SCOPE & METHODOLOGY 19
6.1 Valued Components 19
6.2 Boundaries...21
6.2.1 Spatial Boundaries..21
6.2.2 Temporal Boundaries 22
6.3 Effects Characterization and Significance Assessment Criteria......................................22

7.0 POTENTIAL EFFECTS TO VALUED COMPONENTS 24
7.1 Air Quality 24
7.2 Water Quality 26
7.2.1 Increased Turbidity 27
7.2.2 Release of Deleterious Substances 27
7.3 Acoustic Environment 29
7.3.1 In-Air Noise 29

7.3.2 Underwater Noise 30
7.4 Ambient Light 31
7.5 Terrestrial Wildlife and Marine Birds 33
7.5.1 Physical Presence of Vessels 34
7.5.2 Artificial Light 34
7.5.3 In-Air Noise 35
7.5.4 Release of Deleterious Substances 35
7.6 Marine Mammals 35
7.6.1 Physical Presence of Vessels 36
7.6.2 Artificial Light 37
7.6.3 Noise Disturbances 37
7.6.4 Increased Turbidity 39
7.6.5 Release of Deleterious Substances 39
7.7 Fish and Aquatic Habitat 40
7.7.1 Physical Presence of Vessels 40
7.7.2 Artificial Light 41
7.7.3 Noise Disturbance 41
7.7.4 Anchor Scour 42
7.7.5 Increased Turbidity 42
7.7.6 Release of Deleterious Substances 43
7.8 Aboriginal, Recreational and Commercial Fisheries 44
7.8.1 Physical Presence 44
7.8.2 Release of Deleterious Substances 45

8.0 SIGNIFICANCE OF RESIDUAL EFFECTS 45

9.0 ACCIDENTS AND MALFUNCTIONS 61
9.1 Accidental Release of a Deleterious Substance 61
9.2 Physical Disturbance to Aquatic Habitat 63
9.3 Collision with Marine Mammals 63

10.0 CUMULATIVE EFFECTS ASSESSMENT 63
10.1 Boundaries 64
10.2 Included Projects 64
10.3 Summary of Cumulative Effects 65

11.0 FOLLOW-UP 72

12.0 SUMMARY AND CONCLUSIONS 72

13.0 CLOSURE 74

REFERENCES 75

APPENDIX SECTIONS

FIGURES

Figure 1 Anchorage Area
Figure 2 Local Study Area
Figure 3 Regional Study Area
Figure 4 Light Spill

APPENDICES

Appendix A Tetra Tech's General Conditions
Appendix B Diesel Exhaust Air Dispersion Study for the Proposed Gabriola Anchorages (Tetra Tech EBA 2016b)
Appendix C Underwater and In-Air Noise Modeling Study (Kalapinski, Varnik and Pellerin 2016)
Appendix D Effects Of Anchoring On Biological Resources At Proposed Gabriola Anchorages (Mire 2016a)
Appendix E Effects of Ballast Water Discharge on The Environment At Proposed Gabriola Anchorages (Mire 2016b)
Appendix F Marine Mammal And Sea Turtle Tech Memo (Zoidis 2016)
Appendix G Species At Risk
Appendix H Aboriginal Overview Assessment (Tetra Tech EBA 2016)
Appendix I Marine Atlas of Pacific Canada Maps

ACRONYMS & ABBREVIATIONS

AAQO	Ambient Air Quality Objective
AIS	Automatic Identification System
AQHI	Air Quality Health Index
ATV	All-Terrain Vehicle
AWQG	Ambient Water Quality Guideline
BCMCA	BC Marine Conservation Analysis
CAAQS	Canadian Ambient Air Quality Standards
CAC	Criteria Air Contaminant
CAD	Consultative Area Database
CCME	Canadian Council of Ministers of the Environment
CDC	Conservation Data Centre
CDF	Coastal Douglas-fir
CEA	Cumulative Effects Assessment
CEAA	Canadian Environmental Assessment Act, 2012
CIE	Commission Internationale de L'Eclariage (International Commission on Illumination)
CO	Carbon Monoxide
COSEWIC	Committee on the Status of Endangered Species in Canada
CRC	Canadian Collision Regulations
CSSP	Canadian Shellfish Sanitation Program
dB A	A-weighted decibels (in-air sound)
dB RMS	Decibel Root Mean Square (underwater sound)
dB	Decibel
DFO	Fisheries and Oceans Canada
EOA	Environmental Overview Assessment
EPA	Environmental Protection Agency
IBA	Important Bird Area
IMO	International Marine Organization
Ldn	Sound Level
LSA	Local Study Area
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973
MBCA	Migratory Birds Convention Act
MMPA	Marine Mammal Protection Act
MOE	Ministry of Environment
NATO	North Atlantic Treaty Organization
NIS	Nonindigenous Species
NO_2	Nitrogen Dioxide
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrous Oxides
NPA	Nanaimo Port Authority
NSA	Noise Sensitive Area
NURC	NATO Underwater Research Centre
OGC	Oil and Gas Commission

PM	Particulate Matter
PMV	Port Metro Vancouver
PPA	Pacific Pilotage Authority
PTS	Permanent Threshold Shift
RDN	Regional District of Nanaimo
ROV	Remote Operated Vehicle
RSA	Regional Study Area
SAR	Species at Risk
SARA	Species at Risk Act
SO_2	Sulphur Dioxide
SOx	Sulphur Oxides
TSS	Total Suspended Solid
TTS	Temporary Threshold Shift
VC	Valued Component
VTS	Vessel Traffic Services

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Pacific Pilotage Authority and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Pacific Pilotage Authority, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) has been retained by Pacific Pilotage Authority (PPA) to conduct an Environmental Overview Assessment (EOA) on five proposed anchorages east of Gabriola Island, BC ("Anchorage(s)"). This EOA is being conducted for due diligence purposes to evaluate potential Anchorage interactions with the biophysical environment and is intended to provide a framework for regulatory approvals that may be required in the future.

Although this EOA generally conforms to the format of assessments conducted under Section 67 of the *Canadian Environmental Assessment Act, 2012* (CEAA) for non-designated projects it does not include components such as health, heritage, economic, aesthetics or other social factor unless specifically requested by PPA. This EOA has been limited to components of the natural environment[1].

1.1 Location

The Anchorages and the area assessed area located in the nearshore waters off the east coast of Gabriola Island, BC (Table 1-1; Figure 1).

Table 1-1: Proposed Anchorage Locations

Name	Latitude	Longitude	Max. Vessel Length (m)	Depth of Anchorage (m)	Diameter of Swing Circle (nautical mile)
G1	49° 10.10' North	123° 43.55' West	300	50	0.7
G2	49° 10.35' North	123° 44.63' West	300	50	0.7
G3	49° 10.75' North	123° 45.57' West	300	50	0.7
G4	49° 11.05' North	123° 46.55' West	300	50	0.7
G5	49° 11.43' North	123° 48.06' West	260	50	0.6

1.2 Justification

Port Metro Vancouver (PMV), Canada's largest port, operates 27 major marine cargo and passenger terminals that service the international and domestic shipping community (PMV, 2016). While cargo tonnage has been increasing annually, total pilotage assignments have been decreasing, mostly due to the increase in the overall size of the vessels (Obermeyer 2015). With the increase in shipping, there has been an increase in vessels anchoring outside of PMV; in 2014, 170 vessels anchored in the southern Gulf Islands while waiting to berth at a PMV terminal (Obermeyer 2015). Many anchorages outside of PMV are not currently easily accessible or appropriately sized. Therefore, there is a need to designate new anchorage locations to accommodate the increased traffic and vessel size in Vancouver.

1.3 Components and Scheduling

The Anchorages include designation of five new anchorages east of Gabriola Island, BC. No infrastructure will be constructed. The Anchorages are anticipated to be used to accommodate vessels, predominantly coal ships, bound for PMV terminals.

[1] Section 2(1) of CEAA defines "environment" as the components of the Earth and includes (a) land, water and air, including all layers of the atmosphere; (b) all organic and inorganic matter and living organisms; and(c) the interacting natural systems that include components referred to in paragraphs (a) and (b).

Ships drop anchor in the centre of the assigned anchorage and are monitored by the Nanaimo Port Authority (NPA). If the Anchorages are considered suitable locations, use would begin almost immediately and continued usage would be jointly reviewed every 12 months by PPA, the pilots and the industry (Brian Young, Pers. Comm. March 15, 2016).

Vessel traffic is influenced by the size of the grain crop, demand for coal, labour fluctuations in neighboring countries, availability of trains and trucks, winter weather, and other factors. Therefore, occupancy, frequency of use and length of stay are difficult to predict. However, use will likely increase in winter when weather can cause a backlog for inland shipping (Kevin Obermeyer, Pers.Comm. March 3, 2016).

2.0 ALTERNATIVES CONSIDERED

In 2011, the Chamber of Shipping, BC Coast Pilots Ltd, PMV, NPA and PPA jointly reviewed coastal anchorages to determine how to address the increased demand and assess potential locations for new anchorages (Obermeyer, 2015). Various changes to existing anchorages at Port of Prince Rupert, PMV, Port of Nanaimo and Southern Gulf Islands included anchorage additions, removals and realignments. It has become increasingly clear that additional deep sea anchorages for larger vessels (~300 m) is required to adapt to the changing realities of the shipping industry.

Adequate deep sea anchorages for large vessels require:

- Water depth between 25 and 50 m;
- Protection from wind and current;
- Stable holding ground (mud and sand hold better than rock and silt);
- Sufficient swing room (approximately 555 m for a 300 m vessel in 50 m of water);
- Proximity to heavily populated/residential areas;
- Proximity to marine reserves;
- Ease of speed and access; and
- Multiple anchorages available in one location.

With these parameters, several potential areas were considered for new anchorage locations (Table 2-1).

Table 2-1: Alternatives Considered (Obermeyer 2015)

Location	Rationale for Exclusion
Boundary Bay	▪ Most locations inside US waters
Howe Sound	▪ Deep water with steep shoreline ▪ Only one anchorage that can be used (and can only be used in an emergency)
Vancouver Mainland (Sea Island to Tsawwassen)	▪ Loose silt substrate unsuitable for holding ▪ Bottom is fouled by log booming material ▪ Deep water in close proximity to the traffic separation lanes
Sheltered water between Georgia Strait and Vancouver Island	▪ Sheltered waters already have designated anchorages

Table 2-1: Alternatives Considered (Obermeyer 2015)

Location	Rationale for Exclusion
Valdez Island, Georgia Strait side	▪ Deep water with steep shoreline ▪ Pinnacles present that pose a navigational hazard ▪ Strong currents ▪ Only one anchorage position available for large (300m) vessel
Nanoose Bay	▪ Sufficient depth ▪ Department of National Defense restricted area ▪ Oyster and eel-grass beds present in non-restricted areas

The proposed anchorage locations east of Gabriola Island were found to meet the criteria to anchor large vessels and were determined to be the most suitable locations based on:

- Appropriate depth for large vessels;
- Sufficient swing room;
- Adequately sheltered from predominant currents and winds;
- Accessible to Nanaimo and PMV;
- Open water (supports noise dissipation and allows for maneuverability in the event of dragging); and
- Bottom trawling in area has disturbed sea bed and limits fishing (Obermeyer 2015).

3.0 METHODOLOGY

The EOA has been based on:

- Potential applicability of regulatory requirements associated with the Anchorages (e.g., *Fisheries Act*, *Species at Risk Act* [SARA] and *Migratory Bird Convention Act* [MBCA]);
- Application of professional judgement by qualified professionals;
- A desktop review of publicly available resources and reports for projects conducted near the Anchorage area. Information provided by the PPA was also reviewed;
- Specialized assessments conducted on several elements to address specific concerns:
  - Air Quality (Appendix B);
  - Noise (Appendix C);
  - Anchor Drag and Scour (Appendix D);
  - Ballast Water (Appendix E); and
  - Marine Mammals (Appendix F).

- Consultation with the public and/or First Nations was beyond the scope of this EOA as it was predominantly focussed on the biophysical VCs. Tetra Tech EBA recognizes the importance of conferring with these groups and understands that PPA intends to conduct consultation at a later date.
- Results of a Remote Operated Vehicle (ROV) survey of subtidal portions of the Anchorage area:
  - Tetra Tech EBA observed the ROV survey on December 15, 2015 (Table 3-1). An unsuccessful attempt at the ROV survey was made on November 3, 2015. The ROV equipment, boat and personnel were supplied and operated by the NPA.A 300T twisted pair 2/2 thruster ROV system from Seamor Marine was used to record subtidal conditions along transects run through each of the proposed anchorage areas. A total of six transects were completed; five 0.7 nautical mile (1.3 km) transects were run roughly perpendicular to shore, through each of the anchorage locations and one 0.25 nautical mile (0.5 km) transect was run parallel to shore along the 20 m isobath (Figure 1). The ROV field of view was limited to approximately 1 m^2 immediately in front of the camera and only along the transect course. The ROV survey commenced at 10:00. At the time of the survey, the weather was overcast with 10 km/hr winds that increased to 15 km/hr by 15:00.

Table 3-1: Tidal Conditions at Nanaimo Station #7917 During ROV Survey on December 15, 2015 (Fisheries and Oceans Canada [DFO] 2016a)

Time	(m)	(ft)
1:32	0.8	2.6
8:57	4.8	15.7
14:50	3.1	10.2
19:19	3.8	12.5
Tide differential during the ROV survey was approximately 1.7m.		

4.0 EXISTING NATURAL ENVIRONMENT

4.1 Climate

Climate is a measure of key atmospheric variables over time. Climatic parameters, such as temperature, precipitation and length of growing season, are often the factors differentiating ecological communities. Climatic conditions in the region are largely influenced by the Pacific Ocean but are also moderated by the Central Vancouver Island Mountains. The moderating effect of the ocean and the additional rainshadow of Mount Benson is more pronounced in the local climate on Gabriola Island which has slightly warmer temperatures and less precipitation than neighbouring Nanaimo (Malaspina University College 2009).

The Government of Canada maintains a National Climate Data and Information Archive that summarizes average climatic conditions. The nearest historical climate station to the Anchorage area is located on Gabriola Island (climate ID: 1023042) at 49° 09' 14.000" north and 123°44'01.000" west. Data for this station was compiled between 1981 and 2010 (Table 4-1). Although this data is now 6 years old, it provides a nearly 30-year picture of climate trends in the area. In Georgia Strait, prevailing winds are from the northwest in summer and the southeast in winter; by spring, the winds are predominantly south easterly to easterly (WeatherSpark 2016).

Table 4-1: Climate Normals for Gabriola Island Climate Stations 1981-2010 (Environment Canada 2015)

Temperature	
Average Daily Temperature	9.6°C
Extreme Maximum Temperature	32.0°C July 22, 1994
Average Maximum Temperature	13.9°C
Extreme Minimum Temperature	-16.0°C January 30,1996
Average Minimum Temperature	5.3°C
Precipitation	
Average Total Annual Rainfall	922.9 mm
Extreme Daily Rainfall	66.0 mm March 17, 1997
Average Total Annual Snowfall	34.7 cm
Extreme Daily Snowfall	63.5 cm December 27, 1968
Average Total Precipitation	957.5 mm
Extreme Daily Precipitation	66.0 mm March 17, 1997
Average Annual Snow Depth	0 cm
Extreme Daily Snow Depth	58 cm January 19, 1972

4.2 Air Quality

Air quality is typically determined by the concentrations of pollutants in the atmosphere, which are, in turn, affected by the dispersion of pollutants from emission sources. The Air Quality Health Index (AQHI) is an initiative of Environment Canada, Health Canada, the BC Ministry of Environment, the BC Ministry of Healthy Living and Sport, the BC Ministry of Health Services and the BC Lung Association that indicates the level of health risk associated with local air quality. The nearest AQHI monitoring station is located in Nanaimo/Parksville and is usually rated towards the "low risk" end of the spectrum with sporadic, short-lived increases. Historical data show that over the last 5 years the average AQHI in Nanaimo was less than 2.5 (low) (Environment Canada, 2016).

The Anchorage area is open to the outdoors and is bound by the marine waters of Georgia Strait. It is part of the Georgia Basin-Puget Sound Airshed (Environment Canada & US Environmental Protection Agency [EPA], 2014). The Anchorage area is located immediately east of Gabriola Island and approximately 12 km east of downtown Nanaimo.

Potential emission sources at or near the Anchorage area include:

- Community sources, including road traffic, off-road traffic (e.g., ATVs), vehicle refuelling and residential heating (e.g., fuel oil, natural gas, wood combustion);
- Aviation (i.e., fixed wing and rotary-wing aircraft);

- Commercial and Industrial sources, (e.g., Harmac, industry on Duke Point and near Assembly Wharf); and
- Marinas and marine vessels.

Intermittent sources such as forest fires, fugitive dust from soil disturbances, paving or other construction activities may also contribute emissions.

Recreational and commercial marine vessel operation is the primary contribution to air emissions in the Anchorage area. Commercial vessels include mostly fishing boats, ferries and tug boats but larger cargo vessels and cruise ships are also present in the area. Multiple marinas are present in the area, including two marinas on the southern end of Gabriola Island: Page's Resort and Marina and Silva Bay Resort and Marina Ltd. Emissions from the shipping industry have traditionally been known as a primary contributor to air pollution because the fuel most used, known as bunker fuel, has a high sulphur content.

4.3 Foreshore & Adjacent Terrestrial Habitat

The Biogeoclimatic Ecosystem Classification is a land classification system that groups similar ecosystems based on climate, soils and vegetation. This classification system was developed in British Columbia and is widely used as a framework for resource management as well as for scientific research.

The eastern shore of Gabriola Island, adjacent to the Anchorages, is within the Coastal Douglas-fir zone moist maritime subzone (CDF mm) zone. The Coastal Douglas-fir zone is limited to a small part of southeastern Vancouver Island, several islands in the Gulf of Georgia, and a narrow strip of the adjacent mainland; it is characterized by warm, dry summers and mild, wet winters (Meidinger and Pojar 1991). The coastal variety of Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) is the most common tree species in upland forests. Western red cedar (*Thuja plicata*), grand fir (*Abies grandis*), arbutus (*Arbutus menziesi*), Garry oak (*Quercus garryana*), and red alder (*Alnus rubra*) frequently accompany Douglas-fir, depending on site moisture and nutrient regime.

The backshore and uplands area of Gabriola Island is primarily occupied by residential development. Available satellite imagery indicates a stretch of approximately 2 km, adjacent to Anchorage Location G3 that is undeveloped and covered in mature conifer-dominated forest. A narrow buffer of mature conifers is generally present along the entire shoreline. The shoreline substrates adjacent to the Anchorages is primarily low rock/boulder (rocky shore with slopes <20 degrees) with a section of boulder/cobble beach (boulder/cobble covers over soft sediment beach, potential for pebble sand on upper beach, associated with erosional areas) adjacent to G3 and a section of sea cliff (rocky shore with steep slopes >20 degrees) at the southeastern end adjacent to locations G2 and G1 (Islands Trust Fund 2016).

4.4 Subtidal & Foreshore Substrates

Canadian Hydrographic Services Harbour Map #3458 indicates sandy substrate at the G5 location and muddy substrate in the other anchorages (DFO 1995). DataBC's iMapBC (Government of BC 2016) also indicates muddy marine substrates with low roughness and relief in the Anchorage area.

During the ROV survey sandy substrates were most commonly observed. Coarse substrates, mostly small gravels, increased from west to east within the Anchorage area. Large rocks were present along the G1 transect. Substrates were also coarser closer to shore with greatest concentration of gravels and large rocks present in the 45m depth. At approximately 50 m the substrates generally appeared sandy and became muddier with increasing depth.

4.5 Aquatic Habitat

4.5.1 Aquatic Macrovegetation

Most marine aquatic macrovegetation occurs within the intertidal zone which typically extends up to 10 m below the low tide level and is characterized by abundant dissolved oxygen, sunlight, nutrients, generally high wave energies and water motion, and, in the intertidal subzone, alternating submergence and exposure. The Anchorage area occurs within subtidal waters greater than 10 m below the low tide level.

The herbarium at the University of British Columbia contains over 5700 specimens in 402 different taxa, collected by Robert Scagel and his associates in the central coast region over the past 50 years, but no comprehensive flora of the benthic marine plants of BC has been published (Lucas and Lindstrom, 2007). Common "seaweeds" (benthically attached algae) near the Anchorage area include sea lettuce (*Ulva* spp.), rockweed (*Fucus gardneri*) and Turkish towel *(Chondrachanthus exasperates*). Bull kelp (*Nereocystis luetkeana*), giant kelp (*Macrocystis integrifolia*) and native eelgrass (*Zostera marina*) also commonly occur and provide essential habitat for other organisms including birds, invertebrates, and both juvenile and adult fish, as well as providing much of the substrate for herring spawn (Lucas and Lindstrom 2007).

Kelp beds are typically located along exposed and semi-exposed coastlines with a relatively even distribution of sandy, mud-covered and rocky or hard substrate types. Giant kelp attaches to rocks in the lower intertidal zone (to 10 m) while bull kelp may be found to 20 m (Harbo 1999). Kelp beds are important spawning and nursery areas for fish and invertebrates such as herring, salmon, surf smelt, sand lance, abalone, and sea urchins (Lucas and Lindstrom 2007).

Eelgrass beds are found in soft sediments within the lower intertidal and shallow subtidal (to 1 m) zones, most often in protected waters (Harbo 1999; Lucas and Lindstrom 2007), Eelgrass provides habitat for a variety of organisms such as waterfowl, crab, herring and juvenile salmon; eelgrass roots also help stabilize substrates (Lucas and Lindstrom 2007; BC Ministry of Sustainable Resource Management 2002).

Publicly available mapping shows that there are no kelp forests or eelgrass beds within the Anchorage area (DFO 2013; Islands Trust Fund 2016). Fragments of eelgrass and kelp were observed during the ROV survey but no kelp forests or eelgrass beds were detected. However, Burd et al (2008) and iMapBC maps (Government of British Columbia 2016) identify a kelp forest in the nearshore area along Gabriola Island, adjacent to the Anchorage area (Figure 2 in Appendix D). ROV transects were largely devoid of any vegetation. Turkish towel was the only rooted vegetation observed.

4.5.2 Sponges, Shellfish and Invertebrates

Three types of sponges are found in BC: glass sponges, calcareous sponges and demosponges. Sponges can provide valuable habitat for fish and invertebrates and act as water filters. Glass Sponges are of particular interest as they were thought to be extinct until they were identified in coastal BC waters in the late 1980s (Living Oceans 2016). Two species of glass sponge (*Aphrocallistes vastus* and *Heterochone calyx*) are known to build reefs in the Strait of Georgia. Glass sponges cover 700 km^2 in BC waters, mostly in Hecate Strait but there are five known clusters in the Strait of Georgia (Institute for Coastal and Ocean Research 2016). One reef is located off the northeastern tip of Gabriola Island, but is outside the Anchorage area. As with most reefs, the Gabriola Island Glass Sponge reef has been heavily damaged by bottom trawling. As of 2015, DFO prohibits all commercial and recreational bottom contact fishing activities within identified Glass Sponge Reef areas (DFO 2015b)[2].

[2] Current sponge reef closures are available at: http://www.pac.dfo-mpo.gc.ca/oceans/protection/sponge_reef-recif_eponge-eng.html

A variety of shellfish and invertebrates occur in the intertidal and subtidal waters of the Strait of Georgia. The Strait of Georgia Data Centre (2016) and the Pacific Northwest Shell Club (2015) contain extensive lists of invertebrates observed within the Strait of Georgia.

Intertidal clams are commonly harvested, including Pacific Littleneck (*Protothaca staminea*), Manila (*Venerupis philippinarum*) and Butter Clams (*Saxidomus gigantea*). Clams generally occupy mixed substrates of gravel, sand, mud and shell in the intertidal zone. Geoduck Clams (*Panopea abrupta)* occupy the lower intertidal zone to deep subtidal (over 100 m) in sand, silt, gravel and other soft substrates.

The DFO Clam Atlas, part of the now archived Mapster online mapping tool, documents clam beaches on the south coast of BC, specifically those that support populations of Manila, Littleneck, and Butter Clams important to Aboriginal, commercial and recreational harvesters (DFO 2013a). A clam beach is identified on the eastern end of Locke Bay; no clam beds are identified within the Anchorage area.

Several species of shrimp and crab are found in the waters off of Gabriola. The Marine Atlas of Pacific Canada (British Columbia Marine Conservation Analysis [BCMCA], 2011) documents Dungeness Crab (*Cancer magister*), Humpback Shrimp (*Pandalus hypsinotus*), Pink Shrimp (*Pandalus borealis*), Sidestripe Shrimp (*Pandalopsis dispar)* and Prawn (*Pandalus platyceros*) in the Anchorage area. Dungeness crab are found to depths of 100 m in sandy substrates and moderate to strong currents. Shrimp are generally benthic and, depending on the species, occur on both soft and rocky substrates. Prawns occupy intertidal to deep subtidal waters with coarse substrates.

Bernard (1978) conducted sampling at over 300 stations in the Strait of Georgia, including several stations within or near the Anchorage area, to identify macroinvertebrates. This inventory described six invertebrate communities that were comprised according to dependent on depth and substrate type. Table 4-2 summarizes the dominant invertebrates that could be encountered with the environmental parameters of the Anchorage area.

Table 4-2: Summary of Dominant Organisms at 20-100 m Depth (Bernard, 1978)

Mud and Silt Substrate		Sand Substrate	
English Name	**Scientific Name**	**English Name**	**Scientific Name**
Divaricate Nutclam (Bivalve)	*Acila castrensis*	(Echinoderm)	*Amphiura polyacantha*
(Polychaetous Annelid)	*Aphrodita japonica*	Alaska Astarte (Bivalve)	*Astarte alaskensis*
(Sea urchin)	*Brisaster latifrons*	Pacific Blood Star (Echinoderm)	*Henricia leviuscula*
Milky Venus (Bivalve)	*Compsomyax subdiaphana*	(Bivalve)	*Miodontiscus prolongata*
(Polychaetous Annelid)	*Glycera capitata*	Hundred-Line Cockle (Bivalve)	*Nemocardium centifilosum*
(Echinoderm)	*Luidia foliata*	(Polychaetous Annelid)	*Pectinaria californiensis*
(Polychaetous Annelid)	*Maldane glebifex*	Lord Dwarf-Venus (Bivalve)	*Psephidia lordi*
Tube-dwelling Anemone (Cnidarian)	*Pachycerianthus fimbriatus*	Slender Sea Pen (Cnidarian)	*Stylatula elongata*
Threaded Pandora (Bivalve)	*Pandora filosa*		
(Polychaetous Annelid)	*Sternaspis fossor*		
Milky Turretsnail (Gastropod)	*Tachyrhynchus lacteolus*		

During the ROV survey, several shellfish and invertebrates were observed (Table 4-3).

Table 4-3: Shellfish and Invertebrate Specimens Identified During ROV Survey

English Name	Scientific Name	English Name	Scientific Name
Echinoderms			
Sea Cucumber	*Chiridota* spp.	West Coast Sand Dollar	*Dendraster excentricus*
Feather Star	*Flometra serratissima*	Gunpowder Star	*Gephyreaster swifti*
Blood Stars	*Henricia spp.*	Vermillion Star	*Mediaster aequalis*
Ochre Star	*Piaster ochraceus*	Wrinkled Star	*Pteraster militaris*
Morning Sun Star	*Solaster dawsoni*		
Sponges			
Bristly Vase Sponge	*Leucandra neathi*	Finger Sponge	*Neoesperiopsis* spp.
Tube Sponge	*Niphatidae* family		
Bivalves			
Pink Scallop	*Chlamys rubida*	Pacific Oyster	*Crassosterea gigas*
Pacific Blue Mussel	*Mytilus edulis*	Unidentifiable shell fragments were abundant	
Other			
Sea Whip	*Balticina septentrionalis*	Crab	*Cancer* sp.
Short Plumose Anemone	*Metridium senile*	Calcareous Tube Worm	*Serpula vermicularis*
White Sea Pen	*Virgularia* spp.		

4.5.3 Fish

The Strait of Georgia Data Centre (2016) lists 417 fish species occurring in the Strait of Georgia. Salmon and a few other finfish species are of particular importance because of their commercial, recreational and/or Aboriginal fisheries values. DFO Creel Data[3] (Wilf Luedke, Pers. Comm, March 8, 2016) for the recreational fishery in Pacific Fisheries Management Area 17-10 (waters east of Gabriola Island) between 1981 and 2013 specifies 25 fish species or categories (Table 4-4).

Table 4-4: Fish Species Likely Present Off Gabriola Island (DFO angling Creel data)

Common Name	Scientific Name	Common Name	Scientific Name
Pacific Cod	*Gadus macrocephalus*	English Sole	*Parophrys vetulus*
Greenling	*Hexagrammidae* family	Starry flounder	*Platichthys stellatus*
Halibut (Pacific)*	*Hippoglossus stenolepis*	Flatfishes	*Pleuronectiforme* order
Rock Sole	*Lepidopsetta bilineata*	Skates	*Rajidae* family
Hake (Pacific)*	*Merluccius productus*	Mackerel (Chub)*	*Scomber japonicus*
Pacific Tomcod	*Microgadus proximus*	Rockfish	*Sebastes* spp.
Pink Salmon	*Oncorhynchus gorbuscha*	Dogfish (Spiny)	*Squalus* spp.
Chum Salmon	*Oncorhynchus keta*	Pollock (Alaskan)*	*Theragra chalcogramma*

[3] The Creel Data provided includes boat based angling only. It does not include trap, dive, beach, or other kinds of fisheries.

Table 4-4: Fish Species Likely Present Off Gabriola Island (DFO angling Creel data)

Coho Salmon	*Oncorhynchus kisutch*	Groundfish (includes Cod, Flounder, Halibut and Sole)	-
Sockeye Salmon	*Oncorhynchus nerka*	Not Identified Salmonids	-
Chinook Salmon	*Oncorhynchus tshawytscha*	Other	-
Lingcod	*Ophiodon elongatus*	Other Sole	-
* only a general category was identified by DFO (e.g. “Pollock”). Tetra Tech EBA provided the likely species based on known ranges and distribution.			

DFO has also indicated that herring (Pacific Herring, *Clupea pallasii*) gill and seine fisheries are present on the northeast shore of Gabriola Island (Brenda Spence, Pers.Comm, January 22, 2016).

During the ROV survey, very few fish were observed. Only Ling Cod and English Sole were identified and in low numbers.

4.5.4 Marine Birds & Marine Mammals

Marine birds (i.e., shorebirds, seabirds and seaducks) commonly utilize nearshore waters and adjacent foreshore for foraging, refuge and nesting. A variety of piscivorous waterfowl frequent Gulf Island waters largely because of the abundance of herring, and diving ducks are also common because of the availability of molluscs, crustaceans and herring eggs in the nearshore waters. Glaucous-winged Gull (*Larus glaucescens*), Pigeon Guillemot (*Cepphus columbia*), Pelagic Cormorant (*Phalacrocorax pelagicus*) and Double-crested Cormorant (*Phalacrocorax auritus*) are common breeding marine birds within the Strait of Georgia; Western Grebes (*Aechmophorus occidentalis*), Surf Scoter (*Melanitta perspicillata*), Greater Scaup (*Aythya marila*) and Common Murres (*Uria aalge*) also occur (Vermeer, 1983).

Marine mammals occurring in BC include 25 different cetaceans, 5 pinnipeds and 1 mustelid (Ford and Nichol 2011). Many of these species spend most of their time in BC waters while others migrate through in the summer, sometimes staying well into winter (BC Cetacean Sighting Network 2015). Twelve cetaceans, 5 pinnipeds and 1 mustelid have potential to occur in the Anchorage area (Table 4-5; Zoidis 2016).

Table 4-5: Marine Mammals with Potential to Occur in Anchorage Area

Common Name	Scientific Name	Common Name	Scientific Name
Cetaceans			
Minke Whale	*Balaenoptera acutorostrata*	Killer Whale[4] ▪ Northeast Pacific Offshore pop. ▪ Northeast Pacific Southern Resident pop. ▪ Northeast Pacific Northern Resident pop. ▪ Northeast Pacific Transient pop.	*Orcinus orca*
Sei Whale	*Balaenoptera borealis*		
Blue Whale	*Balaenoptera musculus*		
Fin Whale	*Balaenoptera physalus*		
Grey Whale	*Eschrichtius robustus*		
North Pacific Right Whale	*Eubalaena japonica*		
Pacific White-sided Dolphin	*Lagenorhynchus obliquidens*		
Humpback Whale	*Megaptera novaeangliae*		
Dall Porpoise	*Phocoenoides dalli*		
Harbour Porpoise	*Phocoena phocoena*		

[4] While all these populations have potential to occur in the Anchorage area, the Southern Resident population and the Transient population are the most common (DFO 2011b).

Table 4-5: Marine Mammals with Potential to Occur in Anchorage Area

Sperm Whale	*Physeter macrocephalus*		
Pinnipeds			
Northern Fur Seal	*Callorhinus ursinus*	Stellar Sea Lion	*Eumetopias jubatus*
Northern Elephant Seal	*Mirounga angustirostris*	Harbour Seal	*Phoca vitulina*
California Sea Lion	*Zalophus californianus*		
Mustelids			
Sea Otter	*Enhydra lutris*		

The BC Cetacean Sightings Network at Vancouver Aquarium maintains a database of observations. Cetaceans observed in the Anchorage area include Killer Whales, Pacific White-Sided Dolphins, Gray Whales, Humpback Whales and unidentified Porpoise/Dolphin (Figure 1 in Appendix F).

4.5.5 Surface Water Quality

Water quality sampling of parameters such as temperature, salinity and chemical characteristics (oxygen, nutrients, carbon and pH) was not conducted as part of this assessment. Tides, currents and wave action contribute to the dynamic water quality conditions in a localized marine setting. Long-term sampling programs over a large area can provide an indication of regional trends. Within the Strait of Georgia water temperatures are generally increasing and oxygen concentrations are generally decreasing (Johannnessen and McCarter, 2010). Irvine and Crawford (2012) suggest that temperatures in the eastern Pacific Ocean have actually been decreasing since 2008 because of La Niña conditions.

Transport Canada operates the National Aerial Surveillance Program which patrols for spills and acts as deterrent to illegal discharges of pollution at sea. One study estimating the risk of pollution from marine oil spills in Canadian waters (WSP Canada Inc., 2014) identified the Strait of Georgia as having a significant potential for spill frequency and a high or very high Environmental Risk Index[5].

Small spills in nearshore waters account for most of the oil discharge. Data from the National Aerial Surveillance Program suggests that marina densities and intensity of local vessel activity (as opposed to international shipping) generally determine oil discharge patterns in the Pacific Region (Irvine and Crawford, 2012). Large oil spills are relatively uncommon on the West Coast – in 2006, the BC ferry Queen of the North sank with 240 tonnes of oil on board and in 1988, Vancouver Island was affected by a spill from the Nestucca, an oil barge that lost approximately 87 tonnes of oil, most of which drifted onto the west coast of the island (Transport Canada, 2015). Most recently the M/V Marathassa spilled approximately 2800 L of fuel into English Bay on April 8, 2015 (Canadian Coast Guard, 2015).

The BCMCA Marine Atlas of Pacific Canada (2011) includes a layer that maps land or ship-based spills reported between 2006 and 2012. This layer shows fewer than 5 reported spills within or adjacent to the approximate Anchorage area. Most reported spills were concentrated between Gabriola and Newcastle Islands, or near the southeast end of Gabriola Island. Spills can include any pollutant but are most commonly fuel and/or oil.

[5] Environmental Risk Index is a relative index combining probability and environmental sensitivity.

4.6 Species at Risk

Although species provincially ranked as Red, Yellow, or Blue are considered to be a conservation priority, there is no legislation providing formal protection, with the exception of those wildlife species specifically listed under the British Columbia's *Wildlife Act* or listed under Schedule 1 of the federal *Species at Risk Act* (SARA_. SARA protects listed mammals, reptiles, amphibians, molluscs, lepidopterans, and plants on federally managed areas, migratory songbirds (as listed under the *Migratory Birds Convention Act,* MBCA) and fish in all areas in Canada. Species that are legally protected under SARA are those listed as Endangered or Threatened and are listed in Schedule 1 of the *Act*. Those species listed as Special Concern and all species listed in Schedule 3, regardless of their status, are not legally protected by SARA.

For the purposes of this EA, Species at Risk (SAR) were considered any wildlife or vegetation element that met one or more of the following criteria:

- Listed on the Red or Blue List in the provincial Species Ranking system (BC Conservation Data Centre [CDC] 2015a);
- Assessed as Special Concern, Threatened, or Endangered by the Committee on the Status of Endangered Species in Canada (COSEWIC; Government of Canada 2015a); or
- Listed as Special Concern, Threatened, or Endangered in SARA.

A list of SAR with potential to occur in the Anchorage area (Appendix G) was developed based on a review of published information and database searches including:

- BC CDC Internet Mapping tool (BC CDC 2015b):
  - Area search for known occurrences within a 5 km radius of the centre of the Anchorage area. Both non-sensitive and masked-sensitive were queried. Non-sensitive occurrences are observations whose exact locations are provided in the mapping service. Masked-sensitive occurrences are observations whose exact location is not provided in the mapping service, rather, a general area is provided. To obtain the exact location of an occurrence, a regional biologist at the Ministry of Environment (MOE) must be contacted.
  - A total of 8 non-sensitive species and 2 community occurrences are found within 5 km of the Anchorage area. These occurrences are all terrestrial plants or animals that will not likely be directly impacted by the Anchorages. Five masked sensitive occurrences are within 5 km of the Anchorage area. The release of specific location and details of secured occurrences susceptible to persecution or harm is subject to a signed Confidentiality and Non-Reproduction Agreement, which must be signed by any individual viewing the information. Tetra Tech EBA is aware of the masked-sensitive species identification and location and has considered them in this EOA.
- BC CDC Species and Ecosystems Explorer (BC CDC 2015a):
  - Forest Districts: South Island Forest District (Restricted to Red, Blue, and Legally designated species); MOE Regions:1- Vancouver Island (Restricted to Red, Blue, and Legally designated species); Regional Districts: Nanaimo (RDN) (Restricted to Red, Blue, and Legally designated species); Habitat Types: Anthropogenic, Forest, Ocean, Riparian, Rock/Sparsely Vegetated Rock, Stream/River, Wetland; (Restricted to Red, Blue, and Legally designated species) and Biogeoclimatic Zone: Coastal Douglas Fir (CDF).

  - Based on the above search criteria, a total of 32 plant species and 53 wildlife species were identified in this database of which 11 plants and 26 wildlife also met the SAR definition. All of the vegetation species are terrestrial species that will not be directly impacted by the Anchorages. Only two wildlife species occur within marine waters and have potential to be impacted by the Anchorages – Steller Sea Lion (*Eumetopias jubatus*) and Northern Abalone (*Haliotis kamtschatkana*). Three marine birds were also identified – Marbeled Murrelet (*Brachyramphus marmoratus*), Double-crested Cormorant and Common Murre.

- Stewardship Centre for BC's *Species at Risk BC* (Stewardship Centre for BC 2016):
  - SAR search by habitat: inshore marine and intertidal habitats within the Nanaimo Regional District.
  - A total of 23 species were identified in inshore marine habitats and 6 intertidal species were identified, all of which could occur within the Anchorage area or the immediately adjacent foreshore.

- Marine Mammal and Sea Turtle Tech Memo (Zoidis 2016; Appendix F):
  - Potential presence of marine mammals and sea turtles in the Anchorage area was based on known ranges and observations and compared to COSEWIC and SARA statuses.
  - A total of 12 marine mammals were identified as a SAR with potential to occur in the Anchorage area.

While a variety of species have the potential to occur within the region the Anchorage area itself would not likely support most SAR given their habitat requirements and/or ranges. All of the vegetation and many of the wildlife SAR are terrestrial and do not occur within the Anchorage area. Species that directly inhabit or utilize marine waters or the immediate foreshore are most likely to be encountered in the Anchorage area.

4.7 Noise

"Sound is what we hear. Noise is unwanted sound. The difference between sound and noise depends upon the listener and the circumstances." (Government of Canada 2016). Sound levels in both air and water are reported in decibels (dB), a logarithmic scale formed by taking 20 times the logarithm of the ratio between a measured value and a reference value (Table 4-6). Measuring sound levels in air and under water requires application of different reference values. In-air sound levels are presented in terms of dBA and often referenced to 20 μPa, to better reflect human hearing response. Underwater noise is presented in terms of linear decibels, referred to as dBL or dB RMS and referenced to 1 μPa.

Table 4-6: Sound Pressure Level of Common Sounds (Cowan 1994; Government of Canada 2016)

Sound	Approximate Sound Level (dBA)
Threshold of hearing	0
Just audible	10
Leaves rustling	20
Library, isolated broadcast studio	30-40
Typical suburban area	50
Busy office; conversation at 1 m	60
On sidewalk with passing car	70
Passing bus or diesel truck 50 km per hour at 20 m	80
Lawn mower at 1 m	90

Table 4-6: Sound Pressure Level of Common Sounds (Cowan 1994; Government of Canada 2016)

On platform of passing train	100
Maximum levels at a rock concert	110
Hand held circular saw at 1 m	115
Air raid siren at 15 m/ Threshold of discomfort	120
Threshold of pain	140

Relative "loudness" varies in air and water, partly because of differences in the acoustic impedance, density and compressibility of the media (Table 4-7). For example, 160 dB in-air can cause tissue damage to human ears but 160 dB under water is the equivalent to 100 dB in air, which is akin to standing next to a tractor.

Table 4-7: Sound Pressure Levels and Comparison to Relative Human Loudness Thresholds (Kinsler and Frey 1962 in Kalapinski, Varnik & Pellerin 2016)

Pressure in Air re 20 µPa/Hz	Pressure in Water re 1µPa/Hz	Relative Loudness (human perception of different reference sound pressure levels in air)
0	62	Threshold of Hearing
58	120	Generally Low Level but Potentially Audible Depending on the Existing Acoustic Environment
120	182	Uncomfortably Loud
140	202	Threshold of Pain
160	222	Threshold of Direct Damage

Site-specific sound measurements were beyond the scope of this EA; therefore, the acoustic environment is not quantitatively known. However, qualitative estimates of the both in-air and underwater sound levels are available based on certain conditions.

In-Air - Health Canada (2011) provides a qualitative estimate of baseline sound level (Ldn) based on community characteristics and population density. With a population of approximately 4,500 on just over 52.5 km^2, Gabriola Island fits between Health Canada's "quiet rural" and "quiet suburban residential" categories which have Ldn values of less than or equal to 45 dBA and 48-52 dBA, respectively.

Under Water - The Fisheries Hydroacoustic Working Group, a collaboration between the California Department of Transportation and Federal Highways Administration, provides the *Technical Guidance for Assessment and Mitigation of Hydroacoustic Effects of Pile Driving on Fish* (Caltrans 2015) which describes typical underwater sound levels:

- Background with boat traffic (ranging from quiet estuary to water body with boat traffic) – 60 to 120 dB RMS
- Fish trawler passby (low speed) at 20 meters – 140 dB RMS
- Large ship at 100 meters - 160 dB RMS

Existing noise in the Anchorage area is primarily the result of marine traffic (both recreational and commercial vessels). Other noise contributions originating from outside the Anchorage area may include:

- Float plane traffic;
- Residential traffic on Gabriola Island;
- Industrial activity (e.g., Harmac, NPA Assembly Wharf, Duke Point Industrial Park); and
- Other intermittent sources (e.g., construction activities).

4.8 Ambient Light

Determining site-specific measurements of existing ambient light conditions were beyond the scope of this EA. However, the limited sources (i.e., absence of significant light sources such as industrial yards) and the vegetated buffer along the eastern shore of Gabriola Island contribute to a relatively "natural" light environment in the Anchorage area.

Current light contributions in the Anchorage area are primarily from:

- Natural ambient lighting (e.g., sun and moon) – varies with cloud cover, precipitation, air quality (e.g., dust) and moon phase;
- Lighting from adjacent communities' (e.g., traffic, outdoor/street lights); and
- Marine vessels.

Ambient light conditions can be quantified by illumination levels, or the amount of light incidence per unit area. It is typically measured in "lux" which is weighted for the spectral sensitivity of the human eye. How bright light contributions (i.e., artificial light) appear depends on the ambient light level (Table 4-8).

Table 4-8: Illumination Levels Associated with Common Ambient Sources (Rich and Longcore, eds. 2006)

Source	Illuminance Level (lux)
Full sunlight	103,000
Partly sunny	50,000
Cloudy day	1,000 – 10,000
Most homes	100 – 300
Lighted parking lot	10
Full moon in clear sky	0.1 – 0.3
Overcast night sky	0.00003 – 0.0001

The International Commission on Illumination, or Commission Internationale de L'Éclairage (CIE), has outlined four environmental zones to establish a basis for outdoor lighting regulations and demonstrate relative levels of light (Table 4-9).

Table 4-9: CIE Environmental Lighting Zones (CIE 1997)

Zone	Description
E1 – Natural	Areas with intrinsically dark landscapes National parks or residential areas with strict limits on light trespass Roads usually unlit
E2 –Rural	Areas of low ambient brightness Outer urban or rural residential areas
E3 – Suburban	Areas of medium ambient brightness Urban residential areas
E4 - Urban	Areas of high ambient brightness Urban areas, residential and commercial with high levels of night time activity

Because of its proximity to Nanaimo and limited light contributions the Anchorage area would likely fit somewhere between the (E1) Natural and (E2) Rural environmental zones while Gabriola Island would likely be somewhere between the (E2) Rural and (E3) Suburban environmental zones.

5.0 EXISTING HUMAN ELEMENTS

This section is presented as a general overview to offer additional context of the Anchorage area. It is not intended to be comprehensive and is based solely on publicly available resources.

5.1 Municipalities and Communities

The Regional District of Nanaimo (RDN) is located west of the Anchorage Area. It is comprised of four municipalities and seven electoral areas, which include unincorporated communities. The City of Nanaimo, Electoral Area A and Electoral Area B are most proximate to the Anchorage area (Table 5-1). Electoral Area A includes Cassidy, Cedar, Yellowpoint and South Wellington while Electoral Area B includes Gabriola, DeCourcy and Mudge Islands.

Table 5-1: Communities Proximate to the Anchorage Area (RDN 2012)

Community	Population (2011 Census)*	Approximate Distance/Direction from Anchorage Area
City of Nanaimo	83,810	8 km west
Electoral Area A	6,908	8.5 km southwest
Electoral Area B	4,045	<1 km west

5.2 First Nations

The Anchorages are within the traditional area of the Coast Salish. BC's Consultative Area Database (CAD) system provides information on First Nations to be consulted with in respect to a proposed development project, based on the project location; CAD identified eight First Nation organizations (Appendix H):

- Cowichan Tribes;
- Halalt First Nation;
- Hul'qumi'num Treaty Group;

- Lake Cowichan First Nation;
- Lyackson First Nation;
- Penelakut Tribe;
- Snuneymuxw First Nation; and
- Stz'uminus First Nation.

With the exception of the Snuneymuxw, all of the First Nations/Tribes listed are members of the Hul'qumi'num Treaty Group. In addition, the Stz'uminus, Snuneymuxw, and Halalt are members of the Naut'sa Mawt Tribal Council, based in Tsawwassen.

The Anchorage area is within the traditional territory of several First Nations. Both the Cowichan Tribes and Lyackson are in proximity to Gabriola Island and have asserted territorial claims through the Hul'qumi'num Treaty Group. However, the Snuneymuxw First Nation is most proximate and has substantial traditional and current presence in the area. Snuneymuxw First Nation is comprised of approximately 650 people and includes six small reserves, one of which occurs on Gabriola Island on the west point at mouth of Degnen Bay (Aboriginal Affairs and Northern Development Canada 2015). The Snuneymuxw are included in the Douglas Treaties of the 1850s wherein an area of land was surrendered "entirely and forever" in exchange for cash, clothing, or blankets. The signatories and their descendants retained existing village sites and fields for their continued use, the "liberty to hunt over unoccupied lands" and the right to "carry on their fisheries as formerly" (Indigenous and Northern Affairs Canada 2013).

Aquatic plants and grasses, crabs, oysters and clams, among other marine organisms, were traditionally harvested from the intertidal zone of the area (Snuneymuxw First Nation 2013). Marine resources were used not only for subsistence but also for trade, ceremony and recreation. Snuneymuxw fishing rights within the coastal waters, as per the Douglas Treaties, encompass the Anchorage area. According to a 2003 Agreement in Principle, which has not been ratified, the Anchorage area is included within Snuneymuxw tidal fishing areas. Therefore, it is understood that the Snuneymuxw peoples may conduct fishing or other activities at or near the Anchorages.

According to an Aboriginal Overview Assessment (Appendix H), traditional land use and occupancy along the north side of the island is affirmed by the presence of several archaeological sites, "*Notably, there are 6 registered archaeology sites along the shoreline adjacent the proposed development zone, with an additional 26 registered sites in the Flat Top Islands archipelago to the east/southeast, and another 9 to the west/northwest. The presence of these sites indicates significant antiquity and use in proximity to the development*" (Tetra Tech EBA 2016a).

5.3 Public & Commercial Use

Public and commercial use of the Anchorage area is predominantly related to various fisheries, but also includes recreational boating, scuba diving, sea kayaking and wildlife viewing. Sandwell Provincial Park is located approximately 500 m from the northwestern limit of the Anchorage area. This park was established in 1988 to protect archaeological sites, including a petroglyph and shell middens, and the sandy beach ecosystem (BC MOE, 2009). It is a popular destination on Gabriola Island and the Anchorage area is visible from its beach.

The Marine Atlas of Pacific Canada identifies several sport fishing areas within or immediately adjacent to the Anchorage area including anadromous fish, crab, ground fish and prawn/shrimp (BCMCA 2011; Appendix I). Creel surveys conducted by DFO indicate that between 1981 and 2013 a total of 216,063 (an average of approximately 6,750 per year) finfish were kept by boat angling in Pacific Management Area 17-10 (Wilf Leudke, Pers.Comm, March 9, 2016). Local residents also confirm presence of "large" recreational fisheries (Al MacDonald, Pers.Comm. October 19, 2015; Robert Meyer Pers. Comm, November 4, 2015).

The Marine Atlas also shows recreational boating routes proximate to the Anchorage area and scuba diving sites to the north and south (Appendix I). No sea kayak routes are mapped on the eastern side of Gabriola Island, although this activity likely occurs in the area, at least periodically.

Commercial fisheries are present within and adjacent to the Anchorage area (Table 5-2). Although this information is somewhat dated it provides an indication of the scale of the fisheries, which are diverse but limited in magnitude. The Marine Atlas divides the estimated catch into scaled categories and all of the fisheries present in the Anchorage area were recorded in the lowest range. The Marine Atlas also includes a layer describing the hours of different vessel traffic. Vessel traffic hours generally fell within the highest range, with the exception of research vessels (lowest range) and tankers. Within the Anchorage area, tanker vessel hours were ranked in the lowest range but the surrounding areas were higher; areas north and east were ranked in the second and third highest ranges, respectively.

Table 5-2: Commercial Fisheries Catch and Vessel Hours in Anchorage Area (BCMCA, 2011)

Commercial Fisheries		
Fishery	**Estimated Catch**	**Date**
Chinook (gill net)	1-12,0000 lbs	2001-2007
Chum (gill net)	88-250,000 lbs	2001-2007
Coho (gill net)	1-2,500 lbs	2001-2007
Pink (gill net)	1-100,000 lbs	2001-2007
Sockeye (gill net)	1-500,000 lbs	2001-2007
Geoduck	52-250,000 lb	2000-2005
Herring, roe (gill net)	10-7,000 t	1997-2004
Humpback Shrimp	1-14,000 lb	1997-2004
Prawn	25-25,000 lb (most of area) 50,000-75,000 lb (immediately north)	2001-2004
Pink Shrimp	10-1.5M lb	1997-2004
Rockfish (hook and line)	0 (most of area) 75-80,000 kg (N & S end of area)	1993-2004
Sidestripe Shrimp	1-48,000 lb	1994-2004
Shrimp (trawl)	2-400,000 lb	1996-2004
Schedule II Fish*	139-65,000 kg	1996-2004
Shipping and Transportation		
Vessel Type	**Hours**	**Data Year**
Fishing Vessel	+3.38	2010
Government Vessel	+6.08	2010
Cargo/Bulk Vessel	+8.82	2010
Passenger/Cruise Vessel	+3.71	2010

Table 5-2: Commercial Fisheries Catch and Vessel Hours in Anchorage Area (BCMCA, 2011)

Commercial Fisheries		
Fishery	**Estimated Catch**	**Date**
Pleasure Craft/Yacht	1.28-5.85	2010
Research Vessel	<0.11	2010
Tanker Vessel	<0.15	2010
Tug & Service Vessel	+37.06	2010
* "Schedule II" is a fishing licence category. In the directed Schedule II fishery, only certain species may be caught, including lingcod (*Ophiodon elongatus*), spiny dogfish (*Squalus acanthias*), skates, sole, flounder and Pacific cod (*Gadus macrocephalus*). Some rockfish are also caught as part of Schedule II.		

6.0 EFFECT ASSESSMENT SCOPE & METHODOLOGY

The methods used in this EOA are generally analogous to those used in environmental assessments conducted under of Section 67 of the CEAA 2012. The CEAA framework includes scoping, analysis, mitigation, significance and follow up. However, because this is a high-level EOA being conducted for due diligence rather than to meet a regulatory requirement, elements may vary from CEAA.

The following steps were applied in conducting the effect assessment:

- Identify the valued components (VC) that may be affected by the Anchorages;
- Identify spatial and temporal boundaries in which effects are likely to occur; and
- Assess potential *adverse* effects of the Anchorages:
  - Identify and characterize potential interactions between each VC and the Anchorage based on current scientific knowledge, precedents set by similar projects and professional judgement.
  - Identify general mitigation measures for each potential interaction.
  - Identify potential residual effects that remain following application of appropriate mitigation measures.
  - Determine if the likely residual effects are significant or not significant.
  - Determine if significant adverse residual effects are likely to occur.

6.1 Valued Components

VCs are "environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Aboriginal peoples or the public. The value of a component not only relates to its role in the ecosystem, but also to the value people place on it" (Canadian Environmental Assessment Agency 2015b). E*nvironmental components* are further defined as a "Fundamental element of the physical, biological or socio-economic environment, including the air, water, soil, terrain, vegetation, wildlife, fish, birds and land use that may be affected by a designated project, and may be assessed in an environmental assessment" (Canadian Environmental Assessment Agency 2015b). VCs must be a receptor and susceptible to potential adverse effects of interactions with a project.

This EOA was limited to assessing features of the natural environment and does not include social components, except where specifically requested by PPA (e.g., effects of noise and light on people or effects on fisheries).

The VCs selected for this EOA (Table 6-1) were based on ecological importance or value to the existing environment and the relative sensitivity of these components to potential direct interactions with Anchorage activities (Table 6-2). These factors were determined in consultation with PPA, using professional judgement and review of similar activities. Public and First Nations consultation was beyond the scope of this EOA.

Table 6-1: Selected Valued Components

VC	Rationale
Air Quality	▪ Anchorage activities will contribute air emissions to the environment that have potential to exceed applicable guidelines or international conventions. ▪ Identified as a concern by PPA.
Water Quality	▪ Anchorage activities have potential to release deleterious substances, thorough intentional or operational action, to the aquatic environment or cause disturbances that reduce water quality. *Accidental releases are discussed in Section 9.0, Accidents and Malfunctions* ▪ Water quality is managed by federal and provincial guidelines as well as international convention. ▪ Identified as a concern by PPA.
Acoustic Environment	▪ Anchorage activities will produce sounds that have the potential to disturb people. ▪ Identified as a concern by PPA.
Ambient Light	▪ Anchorage activities will contribute light emissions to the environment that may increase ambient light levels beyond acceptable guidelines or may disturb people. ▪ Identified as a concern by PPA.
Terrestrial Wildlife and Marine Birds	▪ Anchorage activities have the potential to harm (i.e., disturb, displace or kill) terrestrial wildlife and marine birds. ▪ Protected by federal regulation (e.g., MCBA, SARA).
Marine Mammals	▪ Increased presence and activity of vessels may disturb, displace or harm marine mammals (e.g., noise and ship strike). ▪ Protected by federal regulation (e.g., SARA).
Fish and Fish Habitat	▪ Anchorage activities have the potential to disturb or destroy fish and fish habitat. ▪ Protected by federal regulation (e.g., *Fisheries Act*, MCBA, SARA). ▪ Identified as a concern by PPA.
Aboriginal, Recreational and Commercial Fisheries	▪ Anchorage activities have the potential to affect aboriginal, recreational or commercial fisheries quantity and quality. ▪ Protected by federal regulation (e.g., *Fisheries Act*, MCBA, SARA). ▪ Identified as a concern by PPA.

Table 6-2: Potential Anchorage Activity-VC Direct Interactions

Activity	Air Quality	Water Quality	Acoustic Environment	Ambient Light	Terrestrial Wildlife & Marine Birds	Marine Mammals	Fish and Fish Habitat	Aboriginal, Recr.,& Com. Fisheries
Physical presence of vessels may cause harm or displacement					x	x		x
Vessels contribute air emissions (e.g., exhaust)	x							
Vessels contribute artificial light				x	x	x	x	
Vessels generate in-air noise			x		x	x		
Vessels generate underwater noise			x			x	x	
Anchoring may cause seafloor scour							x	
Anchoring may increase turbidity		x				x	x	
Physical presence of anchor chain in water column may cause harm or displacement						x	x	
Operational/intentional release of deleterious substance to aquatic environment		x			x	x	x	x

6.2 Boundaries

6.2.1 Spatial Boundaries

Under CEAA 2012 the spatial boundaries for each VC should be defined separately, as the geographic extent within which the potential effects may occur likely vary with each element. For example, the geographic extent of effects to air quality is much larger than the extent of effects to sessile invertebrates. Because of the limited scope of this EOA, all VCs were consolidated into generalized spatial boundaries based on the Anchorage area described by PPA (Section 1.1; Figure 1; Table 6-3) and the zone of influence where Anchorage activities were expected to be non-detectable.

Table 6-3: Spatial Boundaries

Spatial Boundary Area	Definition	Description
Anchorage Area	The area subject to direct disturbance from Anchorage activities.	Located approximately 1 km off the eastern shore of Gabriola Island, occupying approximately 970 hectares (1.3 x 7.5 km or 0.75 x 4 nautical miles). Georeferenced boundaries are described in Section 1.1. (Figure 1)
Local Study Area (LSA)	Area surrounding and including the Anchorage area where there is reasonable potential for immediate environmental impacts due to ongoing activities.	Generally a 10 km radius from centre of Anchorage area, including all of Gabriola Island. (Figure 2)

Table 6-3: Spatial Boundaries

Spatial Boundary Area	Definition	Description
Regional Study Area (RSA)	Area where there is the potential for cumulative and socio-economic effects and that will be relevant to the assessment of any wider-spread effects of the project.	Generally a 60 km radius from the centre of the Anchorage area, which includes PMV terminals (Figure 3).

6.2.2 Temporal Boundaries

Temporal boundaries encompass the periods during which a project is expected to have potential effects on the VCs and considers both the phases of an activity and the characteristics of the VCs (BC Environmental Assessment Office 2013). As with spatial boundaries, temporal boundaries should be defined according to the characteristics of each VC. However, because of the limited scope, the temporal boundaries of this EOA are defined by the project schedule and include the "operation" phase. Since the Anchorages do not include any physical infrastructure there is no construction or decommissioning phases for the Anchorages, only an operation phase.

Inaugural use of the anchorages is dependent on need. The Anchorage area may be assigned for use but not be needed for several months depending on the capacity and backlog at PMV. Use of the Anchorages will be reviewed after 12 months, at which time use may be continued or eliminated. Therefore, any temporal boundary applied is somewhat arbitrary. For the purposes of this EOA a temporal boundary of January 1, 2017 to December 31, 2026 (20 years) has been applied.

6.3 Effects Characterization and Significance Assessment Criteria

Determining significance is fundamental to assessing potential effects and requires consistent evaluation criteria. Under Section 5 of CEAA, only *adverse* residual effects are assessed for significance. The evaluation of effects for each VC is addressed in terms of the nature of residual effects that remain after the application of mitigation measures. Residual effects are characterized based on qualitative descriptions of five key criteria (Table 6-4; Canadian Environmental Assessment Agency 2015a).

Table 6-4: Residual Effects Criteria

Criteria	Rating Term	Definition
Magnitude	Negligible	Effect will produce no detectable change from baseline conditions.
	Low	Effect is within the range of baseline conditions or natural variation.
	Moderate	Effect is at or slightly exceeds baseline conditions or the limits of natural variation.
	High	Effect will produce a notable change beyond baseline conditions or the upper or lower limit of natural variation
Geographic Extent	Localized	Effect is limited to the footprint of the Anchorage area.
	LSA	Effect includes Anchorage area and extends to an area immediately surrounding the project footprint (LSA).
	RSA	Effect has implications to RSA radius.
	Broader than RSA	Effect extends beyond RSA radius.
Duration	Short Term	Effect present during activity or for a short period after (i.e., <3 months).
	Medium Term	Effect remains for a period after activities are complete (i.e., effect remains for multiple seasons – 3 months to 2 years).
	Long Term	Effect lasts well beyond end of activities (i.e., >2 years)

Table 6-4: Residual Effects Criteria

Criteria	Rating Term	Definition
Frequency	Once	Effect occurs once.
	Intermittent	Effect occurs periodically.
	Continuous	Effect occurs continuously.
Reversibility	Reversible	Effect is reversed after the activity ceases.
	Partially-reversible	Effect is partially reversed after the activity ceases.
	Non-reversible	Effect will not be reversed when activity ceases.
	Medium	Effect is likely but may not occur.
	High	Effect will occur.

Residual effects are next characterized as “significant” or “not significant”.

The Canadian Environmental Assessment Agency *Reference Guide: Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects* (2012b) describes the five key criteria’s relationship to significance. While CEAA requires that significance of effects be assessed and the Canadian Environmental Assessment Agency provides some broad guidelines, there is no prescribed methodology.

Tetra Tech EBA has developed a three-part matrix to standardize assessment of significance (Table 6-5). Step one includes rating magnitude, geographic extent and duration. These three criteria were selected as the foundation for significance because if these occur at the low end of their ratings, other criteria are also likely to be low. As magnitude of impact increases, extent of an effect widens or persists for longer, the potential for significance increases.

Effects that are *Potentially Significant* based on magnitude, geographic extent and duration continue in Step 2 where frequency and reversibility are considered. Effects that occur repeatedly and cannot be reversed are more likely to be significant than those that occur sporadically and are reversible. In this step, only effects that are reversible are considered Not Significant; all other effects are considered *<u>Significant</u>* and continue to Step 3.

Finally, the likelihood of occurrence for *<u>Significant</u>* residual effects is evaluated based on professional judgement and experience with similar past environmental effects. A proponent may consider *Significant* residual effects to be acceptable when the likelihood of it occurring is low.

Table 6-5: Significance Rating Criteria

Step 1: All potential effects included			
Impact Magnitude	**Geographic Extent**	**Duration**	**Significance**
Negligible	Any	Any Duration	Not Significant
Low	Any	Any Duration	Not Significant
Moderate	Localized	Any Duration	Not Significant
	LSA	Short-term	Not Significant
		Medium-term	Not Significant
		Long-term	*Potentially Significant*
	RSA	Short-term	Not Significant
		Medium-term	*Potentially Significant*
		Long-term	*Potentially Significant*

Table 6-5: Significance Rating Criteria

Step 1: All potential effects included			
Impact Magnitude	**Geographic Extent**	**Duration**	**Significance**
	Beyond RSA	Short-term	Not Significant
		Medium-term	*Potentially Significant*
		Long-term	*Potentially Significant*
High	Localized	Short-term	Not Significant
		Medium-term	Not Significant
		Long-term	*Potentially Significant*
	LSA	Short-term	Not Significant
		Medium-term	*Potentially Significant*
		Long-term	*Potentially Significant*
	RSA	Any Duration	*Potentially Significant*
	Beyond RSA	Any Duration	*Potentially Significant*
Step 2: *Potentially Significant* effects continue below			
Frequency	**Reversibility**	**Significance**	
Once	Reversible	Not Significant	
	Partially Reversible	*Significant*	
	Non-Reversible	*Significant*	
Intermittent	Reversible	Not Significant	
	Partially Reversible	*Significant*	
	Non-Reversible	*Significant*	
Continuous	Reversible	Not Significant	
	Partially Reversible	*Significant*	
	Non-Reversible	*Significant*	
Step 3: *Significant* effects continue below			
Likelihood	**Description**		
Low	Effect unlikely but could occur		
Medium	Effect likely but may not occur		
High	Effect will occur		

7.0 POTENTIAL EFFECTS TO VALUED COMPONENTS

7.1 Air Quality

Anchorage activities have the potential to affect air quality by:

- Contributing air emissions to the environment that have potential to exceed applicable Ambient Air Quality Objectives (AAQOs) or international conventions.

The International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL), and its 1978 and 1997 Protocols, is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. MARPOL Annex VI limits the main air pollutants contained in ships exhaust gas, including sulphur oxides (SOx) and nitrous oxides (NOx), and prohibits deliberate emissions of ozone depleting substances.

Federal and provincial AAQOs are national goals for outdoor air quality that protect public health, the environment, or aesthetic properties of the environment (Canadian Council of Ministers of the Environment [CCME] 1999) for various contaminants, including PM_{10}, $PM_{2.5}$, ozone, sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and carbon monoxide (CO). The BC AAQO is applied based on various pollution control levels defined by industry. "Miscellaneous Industries" has two levels: A (Intended to provide adequate long-term protection) and C (Intended to provide adequate short-term protection) (BC MOE 2016a).

Canadian Ambient Air Quality Standards (CAAQS) are voluntary, health-based air quality objectives for pollutant concentrations in outdoor air that establish standards for fine particulate matter ($PM_{2.5}$) and ground-level ozone. They were established under the Canadian Environmental Protection Act, 1999, in 2013. Standards for NO_2 and SO_2 are being developed.

Tetra Tech EBA modelled scenarios considered emissions of main criteria air contaminants (CAC) for typical vessel types that call at shipping ports through the region (Appendix B). Air dispersion modelling was conducted with CALPUFF, a multi-layered, multi-species, non-steady state Gaussian dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport. The CALPUFF outputs presented in this report describe the maximum predicted concentrations of CACs at ground level over the duration of the simulations.

Several vessel types were assessed, including Bulk Vessel, Container Ship, General Cargo and Motor Vehicle Carrier. Models for each vessel type were run for two different scenarios: one assuming vessels were at anchor, using only auxiliary power and boilers and the other assumed a vessel was maneuvering in the designated moorage location, using 3% of main engine capacity, in addition to auxiliary engines and boilers. To capture any seasonal differences in atmospheric dispersion characteristics, the scenarios were modelled in both January (winter) and June (summer).

Baseline ambient air quality was obtained from monitoring stations nearest the study area - Nanaimo Labieux and Duncan Cairnsmore - and compared to the BC AAQOs for CO, NOx, PM and SO_2. CALPUFF's post processor provided maximum predicted concentrations for each pollutant over averaging times consistent with the BC AAQOs for each modelled scenario (Table 7-1).

Table 7-1: Predicted Concentrations and Applicable Objectives (in µg/m^3)

Maximum Predicted Concentration at Any Receptor – at Anchor Scenario (Table 5.1 in Appendix B)						
Modelled Scenario	**NO_2**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**CO**	**VOC**
Bulk Carrier Moored at G-1	98	32	0.64	0.58	8.3	3.0
Vehicle Carrier Moored at G-2	85	18	0.78	0.71	4.7	1.7
Cargo Vessel Moored at G-3	98	32	0.64	0.57	8.3	3.0
Container Vessel Moored at G-4	176	79	1.0	0.92	21	7.6
Bulk Carrier Moored at G-5	47	19	0.36	0.32	4.9	1.1
Cumulative Full Moorage at Anchor	*194*	79	1.1	1.0	21	7.6
Full Moorage with Container Vessel Maneuvering	*620*	*308*	4.8	4.3	186	186

Table 7-1: Predicted Concentrations and Applicable Objectives (in µg/m^3)

Maximum Predicted Concentration at Any Receptor – at Anchor Scenario (Table 5.1 in Appendix B)							
Modelled Scenario		**NO_2**	**SO_2**	**PM_{10}**	**$PM_{2.5}$**	**CO**	**VOC**
Regional/Observed Background Levels (Table 5.1 in Appendix B)							
Most Stringent Observed Background Levels		9.7 ^{A,B}	2.3 ^{D}	11.9 ^{D}	4 ^{A,C}	259 ^{D}	1.6 ^{D}
Average of all Regional Observation Locations		-	14.5	17.1	-	741.3	5.2
BC AAQOs (BC MOE 2016a)							
Concentration		188	200	50	25	14,300	-
Averaging Period		1 hour	1 hour	24 hour	24 hour	1 hour	-
CAAQs (CCME 2014)							
2015 Standard	**Annual**	-	-	-	10	-	-
	24 hour	-	-	-	28	-	-
2020 Standard	**Annual**	-	-	-	8.8	-	-
	24 hour	-	-	-	27	-	-

Notes:

Italicized & Underline predicted concentrations exceed BC AAQOs.

^{A} The more stringent of January/June observations has been provided in this table.

^{B} Observed at Nanaimo Labieux Station (2010 – 2013).

^{C} Observed at Duncan Cairnsmore Station (2010 – 2013).

^{D} Observed at Cheeka Peak, WA (Coastal, rural location similar to Anchorage area).

See Appendix B, Table 5.1 for full data.

The air dispersion modelling study indicated that when vessels are anchored, emissions from an individual ship comply with both BC AAQO and CAAQ. If all anchorages are occupied NO_2 concentrations may slightly exceed the BC AAQO, though modelling indicates the exceedance occurs only over the vessels and not over land. The BC AAQOs for NO_2 and SO_2 are potentially exceeded when a container-type vessel is maneuvering. The container category of vessels have the highest emission rates of the four vessel types considered in the modelling study because of a large main engine capacity and a higher auxiliary engine load than the other vessels (COS 2007 in Tetra Tech EBA 2016b, pg. 13). Observed background levels of the CACs are much lower than either the BC AAQO or CAAQ. The potential NO_2, SO_2 and VOC emissions generated by the Anchorages are above ambient levels. Both CO and PM are predicted to be below background levels.

The highest concentration of the CECs are predicted to occur over the vessels (Figures 5.1 to 5.11 in Appendix B).

7.2 Water Quality

Anchorage activities have the potential to affect water quality by:

- Increasing turbidity levels; and
- Releasing deleterious substances through intent or operation, including
  - Introducing nonindigenous species (NIS) and/or chemical residues to local water through ballast water exchange; or
  - Discharging pollutants such as sewage, garbage or oily water.

7.2.1 Increased Turbidity

Physical disturbance of the seafloor occurs with contact when the anchor is laid and retrieved, or when the anchor is dragged. Propeller movement can also disturb sediments already in the water column but is unlikely to disturb the seafloor as the vessels will be in deep water (50 m). Disturbed sediments can increase turbidity and exceed applicable water quality guidelines.

The BC MOE has developed water quality guidelines that are "science-based levels of physical, biological and chemical parameters for the protection of water uses such as aquatic life, wildlife, agriculture, drinking water and recreation" (BC MOE 2016b). The Approved Water Quality Guidelines (AWQG) include criteria for turbidity in aquatic ecosystems (Table 7-2). Criteria for both turbidity and total suspended solids (TSS) are provided, as other regulatory agencies and research studies typically measure effects of sediments in water by TSS.

Table 7-2: BC Approved Water Quality Guidelines (BC MOE 2016b)

Water Use	Turbidity	Total Suspended Solids
Aquatic Life (freshwater, marine and estuarine)	Change from background of 8 NTU at any one time in a 24 hour period during low/clear flows (dry weather)[1]	Change from background of 25 mg/L at any one time in a 24 hour period during low/clear flows (dry weather)[1]
	Change from background of 2 NTU at any one time for a period of 30 days during low/clear flows (dry weather)[2]	Change from background of 5 mg/L at any one time for a period of 30 days during low/clear flows (dry weather)[2]
	Change from background of 5 NTU at any one time when background is 8 to 50 NTU during high/turbid flows (wet weather)[1]	Change from background of 10 mg/L at any one time when background is 25 to 100 mg/L during high/turbid flows (wet weather)[1]
	Change from background of >10% at any one time when background is > 50 NTU during high/turbid flows (wet weather)[2]	Change from background of >10% at any one time when background is >100 mg/L during high/turbid flows (wet weather)[2]

1. Turbidity should not exceed the level expressed in any single measurement.

2. Average turbidity (minimum 5 measurements over 30 days) should not exceed the level expressed.

Background turbidity levels in the Anchorage area are currently unknown. Because of the highly variable nature of the marine environment establishing background turbidity would require a long-term sampling program (i.e., at least one year to establish seasonal patterns). Relative changes in turbidity may be monitored by collecting measurements immediately before, during and after vessel occupation.

Increases in turbidity are expected to be localized and temporary. Turbidity caused by vessel anchoring has been studied relatively little compared to that caused by dredging, which arguably has a larger impact both spatially and temporally. Research has shown that dredging induced turbidity increases are short lived, lasting 4 to 5 tidal cycles, and are confined to within a few hundred meters from the point of discharge (IADC 2015 ; Hitchcock and Bell 2004 and Newel, Seiderer and Hitchcock 1998 in Todd et al. 2014, page 5).

7.2.2 Release of Deleterious Substances

Water quality may be negatively affected if deleterious substances are released to the aquatic environment. Release may occur because of operational practices, intention or accident.

Accidental release of deleterious substances may occur while vessels are anchored, as the result of vessel collision (with another vessel or wildlife) or because of a vessel running aground. Accidents are considered unlikely and are discussed further in Section 9.0.

Ballast Water Exchange

Information presented in this subsection is largely based on a technical memo prepared by Tetra Tech OGA, unless otherwise stated (Mire 2016b; Appendix E).

Ballast water may contain a variety of chemical residues and biological organisms, including animals, plants and pathogens that can negatively affect the local environment. Historically, ballast water was considered to be the largest single source of introduced NIS in Canada's waterways (DFO 2011a).

The Anchorages are designed to accommodate Capesize vessels, so named because they must travel around Cape Horn to move between the Atlantic and Pacific Oceans as they are too large to navigate the Panama Canal. Capesize vessels rely on ballast for safety and stability during their trans-Pacific voyage and usually arrive with empty cargo holds and full ballast tanks. Ballast water is typically released at the arrival port when cargo is loaded, potentially releasing chemical residues and/or NIS picked up during the previous ballast water exchange. Although it is not possible to predict the last port of call of the vessels using the Anchorage area, some research suggests 70 percent of ballast discharge in Canadian Pacific ports originates in Asia.

Ballast water discharge is managed by the Canada Shipping Act Ballast Water Control and Management Regulations. The International Maritime Organization's (IMO) voluntary guidelines, *International Guidelines for Preventing the Introduction of Unwanted Aquatic Organisms* and *Pathogens from Ships' Ballast Water and Sediment Discharges* as well as the 2004 International *Convention for the Control and Management of Ships' Ballast Water and Sediments*, commonly referred to as the "BWM Convention", provide recommendations and procedures to manage ballast water discharges and prevent spread of NIS.

Canada Shipping Act Ballast Water Control and Management Regulations are complementary to international guidelines, including the BWM Convention. Transport Canada provides four options for ballast water management but only ballast water exchange is likely to be used by large bulker-type vessels. Additionally, PMV has required vessels to conduct mid-ocean ballast water exchange since 1997. This involves replacing ballast water taken into tanks in one location (usually freshwater or brackish water) with water from an open ocean environment.

Numerous studies show that mid-ocean ballast water exchange is not always feasible or completely effective in reducing NIS in ballast water. Discharged ballast water is likely to contain NIS and/or chemical residuals despite IMO and Transport Canada's efforts. The IMO, Canada, the United States, and Australia have called for an end of ballast water exchange as a means of controlling NIS, largely because it is not effective in meeting the IMO D-2[6] standards and poses safety risks to some vessels. Alternative or additional treatments for Capesize vessels may include chemical treatment, deoxygenation, ozone generation, chlorine generation and UV irradiation but these do not guarantee that the ballast water if free of NIS or chemical residues to the extent it is safe for humans or the environment.

Although there is potential for NIS to be introduced via ballast water, the Capesize vessels anticipated at the Anchorages are not the principal vectors of NIS in the Strait of Georgia. The long transit time from Asian ports and the required open ocean exchange reduces the likelihood of viable propagules surviving. Other vessel classes, especially intracoastal ships that travel along the Pacific Coast of North America, are more likely to contribute NIS

[6] Regulation D-2 "Ballast Water Performance Standard" concerns water quality for discharge, related to specified maximum concentrations of micro-organisms.

to the Strait of Georgia since, under Transport Canada regulations, vessels that do not venture outside the 200 nautical mile continental limit are exempt from ballast water exchange requirements. (DiBacco et al. 2012 in Mire 2016b, page 9).

Other Pollutants

Vessels have the potential to release other pollutants such as sewage, garbage or oily water to the aquatic environment.

Operational or intentional release of deleterious substances is prohibited by international convention and federal regulations. MARPOL Annex I covers prevention of pollution by oil, Annex IV covers prevention of pollution by sewage and Annex V covers prevention of pollution by garbage. MARPOL Annex IV regulates sewage discharges and requires vessels be at least 12 nautical miles from land if they are releasing untreated sewage. MARPOL also contains provisions covering materials being transported.

The Canada Shipping Act, Vessel Pollution and Dangerous Chemicals Regulations prohibit vessels in Canadian waters from discharging pollutants, which are defined as oil and oily water, garbage or organotin compounds and requires that equipment be maintained in good working order. These regulations are complementary to the standards set out in MARPOL.

Additionally, Section 7 of the *Practices and Procedures to be Followed by Ships in the Port Of Nanaimo*[7] (NPA 2009) prohibits discharge of sewage or other pollutant into the harbour.

Should a deleterious substance be released to the aquatic environment, federal and provincial guidelines provide criteria for concentrations of pollutant constituents that are likely to cause harm. The BC AWQG and the CCME Water Quality Guidelines for the Protection of Aquatic Life protect freshwater and marine organisms from anthropogenic stressors and provide numerical limits for a variety of physical and chemical parameters. For example, bunker fuel contains volatile organic compounds such a benzene and toluene for which the CCME has developed acceptable limits. Pollutants, or components of a pollutant, may exceed these guidelines in the event of a release.

Intentional or operational releases of deleterious substances are not expected to occur since they are prohibited activities.

7.3 Acoustic Environment

Anchorage activities have the potential to negatively affect the acoustic environment by producing unwanted sounds (noise) that may disturb people. Vessels will generate both in-air and underwater noise. The effects of noise on other organisms is discussed in subsequent sections. Information presented in this subsection is largely based on an in-air and underwater noise propagation technical memo prepared by Tetra Tech CES, unless otherwise stated (Kalapinski, Varnik and Pellerin 2016; Appendix C).

7.3.1 In-Air Noise

Noise exposure can be linked to hearing loss, sleep disturbance, interference with speech intelligibility, noise complaints and a high level of annoyance (Berglund and Schwela (eds.) 1999 in Health Canada 2011). What constitutes noise is often highly subjective and may change with time. What one person considers loud and annoying may not be noticed by another and a noise that was once distinct may become familiar.

[7] The Anchorage area currently outside the NPA jurisdiction but is proposed to be managed by the NPA.

In-air noise is managed by legislation and standards at all government levels and tends to be very industry specific. For example, under the Canadian Aviation Regulations, Transport Canada regulates aircraft noise. Transport Canada provides several “noise standards” which relate to occupational noise exposure and construction of small vessels but nothing specific to limiting noise produced by large vessels. Health Canada provides guidance concerning human health effects related to noise exposure is based on internationally recognized standards (such as the United States EPA, the International Standards Organization and World Health Organization), but does not have enforceable noise thresholds or standards. The BC Oil and Gas Commission (OGC) *British Columbia Noise Control Best Practices Guideline* provides receptor-based guidelines for acceptable sound levels that were designed for oil and gas operations and facilities but can provide a framework for other noise emitters (BC OGC 2009).

In-air noise generated by the vessels at the Anchorages will be produced by the generator exhaust including the mechanical ventilation fans for the engine room and the main boiler and generator mechanical noise. Tetra Tech CES modelled two scenarios, a vessel located at the closest anchorage position and vessels located simultaneously at all five anchorage positions. Conservative assumptions and parameters were applied to model noise propagation to key existing noise sensitive areas (NSAs) within a 2 km radius of the anchorages (i.e., residential structures and other areas where noise may be of principle concern).

Modelling indicates that the Anchorages would generate sound levels between 31 and 39 dBA at the NSAs in either modelled scenario (Table 6 and Figure 7 in Appendix C). These modelled levels are below the sound level for “quiet rural” areas which Health Canada (2011) estimated at 45 dBA (see Section 4.7).

There is no known risk of hearing loss associated with sound levels below 70 dBA1 regardless of the exposure duration (Health Canada 2011). The BC OGC guidelines limits for rural residential areas during the nighttime (10 p.m. to 7 a.m.) period, the most stringent category, is 40 dBA (BC OGC 2009 in Kalapinski, Varnik and Pellerin 2016, page 15). The results were also shown to be below Health Canada’s baseline level for quiet rural areas (45 dBA) and compliant with their sleep disturbance criteria of 30 dBA (indoor) which is defined at the exterior of a residential structure at 45 dBA (Health Canada 2011 in Kalapinski, Varnik and Pellerin 2016, page 15).

Because the modelled in-air sound levels are below the best known guidelines for noise, as well as the likely ambient sound level, Anchorage activities are not anticipated to have a significantly adverse effect on people.

7.3.2 Underwater Noise

There are currently no federal or international laws to regulate underwater noise though the IMO, the UN agency that governs the world’s maritime shipping, has adopted guidelines for minimizing underwater noise from commercial ships (World Wildlife Fund 2013; IMO 2014). The National Oceanic and Atmospheric Administration (NOAA) has produced guidance on acoustic threshold levels in marine mammals (NOAA 2013; NOAA 2016). The North Atlantic Treaty Organization (NATO) Centre for Maritime Research and Experimentation, formerly the NATO Underwater Research Centre (NURC), has threshold guidance for divers (NURC 2006).

The underwater acoustic propagation model considered two scenarios - vessels at all five anchorage positions (G1-G5) concurrently and one vessel transiting within the Anchorage area. The hydroacoustic modeling conducted accounted for the variation of the bathymetry, geoacoustic properties of the sea bottom, and seasonal variations of the sound speed profile in the water column. In general, stationary vessels produce less noise than vessels in transit and are generally considered low level sound sources. During transit, every vessel has a unique frequency signature which changes with speed and noise is generally magnitudes greater than stationary vessels.

Specific sound levels for three functional hearing groups (low, mid and high range frequency-hearing cetaceans) and an unweighted group was found to be greatest at the vessel and decreased with both vertical and horizontal distance (Kalapinski, Varnik and Pellerin 2016). Because the sound level can change significantly over relatively small distances (2 to 5 dBL or more over a few meters [Figure 4 in Appendix C]) the precise location of the receptor is important. Receptors only a few meters apart may receive very different sound levels (Figures 5 and 6 in Appendix C). Unweighted sound levels, the most stringent values, were 160 dB RMS at the vessel but decreased to 130 dB RMS within 35 and 250 m and to 110 dB RMS within 275 and 1400 to 2000 m for stationary and transiting vessels, respectively.

Underwater noise exposure to humans is limited, occurring only during swimming or diving. NURC (2006) thresholds for human divers is 160 to 177 dB RMS, depending on frequency, for coherent sources. These thresholds are greater than the modelled maximum sound levels generated by the Anchorages (160 dB RMS), which occur in the immediate vicinity of the vessel. Additionally, divers are unlikely to be close to an anchored vessel as it is anticipated they would enact reasonable precaution to ensure safe dives. Therefore the effects of underwater noise generated by the Anchorages on humans is considered minimal.

Underwater noise disturbances to marine mammals are discussed in Section 7.6.3 and to fish in Section 7.7.3.

7.4 Ambient Light

Anchorage activities have the potential to contribute artificial light that may increase ambient light levels beyond applicable guidelines and disturb people. The effects of artificial light contributed by the Anchorages on terrestrial and aquatic organisms is discussed in subsequent sections. Artificial light emissions in low ambient light appears “brighter” so this assessment is focused on changes to ambient light at night.

A quantitative light assessment was beyond the scope of this EOA. Assessment of this VC is based solely on a desktop review of other lighting assessments conducted in marine settings with large vessels (e.g., GHD 2012 and Stantec 2014), an estimation of baseline conditions and a qualitative prediction of effects.

There are no provincial or federal regulations regarding the amount of light allowed to be emitted from marine vessels. The Convention on the International Regulation For Preventing Collisions At Sea (IMO 1972) and Canadian Collision Regulations (CRC 2016) requires all vessels, including those in transit, at anchor and at berth, to maintain certain standards of lighting during certain periods of visibility and at certain hours. Annex 1 of the CRC provides positioning and technical details of lights but boats that are navigating generally require more lights than boats at anchor.

Rule 30 says, “*A vessel at anchor shall exhibit where it can best be seen: (i) in the fore part, an all-round white light or one ball, (ii) at or near the stern and at a lower level than the light prescribed in subparagraph (i), an all-round white light.”* It also requires vessels greater than 100 m in length at anchor to have working lights to illuminate the deck. The lights of vessels (≥ 50 m length) in transit must have navigation lights bright enough to be visible at a minimum range of 3 to 6 nautical miles (CRC 2016). Annex 1, Section 8 of the CRC provides a calculation for *minimum* luminous intensity of vessel lights and notes “The maximum luminous intensity of navigation lights should be limited to avoid undue glare.”

Maximum values for light spill and glare have been developed by the CIE. The CIE *Guide on the Limitations of the Effect of Obtrusive Light from Outdoor Lighting* (2003) provides guidelines for assessing the impacts of outdoor lighting and recommends parameters to limit the effects based on environmental zones and time of day. These guidelines have been adopted by other projects in Canada, mainly industrial facilities (Stantec 2014), but could be applied to large marine vessels.

Specific baseline light levels in the Anchorage area are unknown but are conservatively estimated to be (E1) Natural and (E2) Rural on Gabriola Island (Table 4-9, Section 4.8). Light spill, the light that illuminates surfaces beyond the area intended to be illuminated, was the parameter assessed as it was considered likely to have the greatest adverse effect[8]. CIE (2003) recommends maximum levels for light spill in each of its described environmental zones (Table 7-2).

Table 7-2: Recommended Maximum Levels for Light Spill (CIE 2003)

Time of Day	Environmental Zone			
	E1 (Natural)	E2 (Rural)	E3 (Suburban)	E4 (Urban)
19:00-23:00	2 lux	5 lux	10 lux	25 lux
23:00-06:00	0 lux	1 lux	2 lux	5 lux

The actual number and intensity of onboard lights varies among vessels but GHD (2012) modelled the lux of a typical bulk carrier at berth and found a maximum light spill of 2 lux, most of which occurred directly on the vessel. The purple line in Image 1 shows light spill of 0.2 lux, equivalent to a new moon on a clear night (GHD 2012) to the surrounding marine environment. GHD's model found that a vessel at berth would have a maximum light spill of 4.6 ha to the marine environment. Applied to the Anchorages, light spill is not likely to reach beyond the Anchorage area (Figure 4).

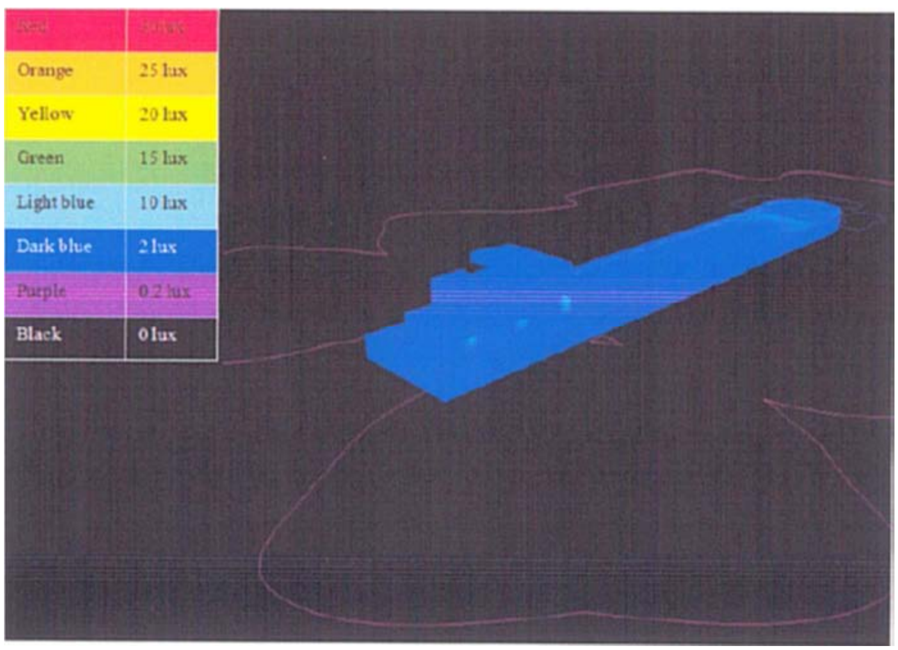

Image 1: Modelled lux of a typical bulk carrier at berth (GHD 2012).

[8] Glare and sky glow are other light effects that may be considered. *Glare* is the contrasting lighting that reduces an organism's ability to see. *Sky Glow* is the illumination of the night sky or parts of it, by natural and artificial sources.

Although vessel lighting will be visible to the onshore residents of Gabriola Island, light spill is not expected to increase ambient lighting beyond the CIE (2003) guidelines.

7.5 Terrestrial Wildlife and Marine Birds

Anchorage activities have the potential to affect terrestrial wildlife and marine birds by:

- Causing disturbance or harm because of physical presence of vessels;
- Contributing artificial light that causes disturbance;
- Generating in-air noise that causes disturbance; and
- Releasing deleterious substances, through intent or operation, which cause harm.

Although the Anchorages occur in marine waters there is potential effects to terrestrial wildlife. Terrestrial wildlife includes a variety of mammals, amphibians, reptiles, birds and invertebrates, all of which have potential to use the foreshore and immediate backshore. Birds are likely the prime users of this habitat, including songbirds, raptors, seabirds (birds that spend most of their life at sea), shorebirds (migratory birds that forage along the shore looking for food), and wading birds (taller birds that wade in shallow water for food). Because birds are probably the principal terrestrial wildlife receptors of Anchorage activities they are the focus of this assessment.

Residential development is present over most of the shoreline and may limit wildlife presence. According to Google Earth imagery (accessed March 15, 2016) approximately 2 km of shoreline adjacent to G2 and G3 are not developed. Some wildlife activity, such as bird nesting, is likely more concentrated in this area though some activity, such as feeding, may occur along the entire foreshore. Marine bird colonies are known on Gabriola Island, particularly on the western side, and on other small islands in the area. Snake Island, approximately 3 km off the northwest tip of Gabriola Island, is recognized as an Important Bird Area (IBA) for Glaucous-winged Gulls and Pelagic Cormorants (Booth 2001). The IBA Program is an international conservation initiative coordinated by BirdLife International whose Canadian co-partners are Bird Studies Canada and Nature Canada.

Management of terrestrial wildlife, including marine birds, occurs primarily through British Columbia's *Wildlife Act*, MBCA and SARA. The MCBA, which is managed by Environment Canada, prohibits the disturbance, destruction, or possession of migratory birds, their nests, or eggs (Section 6) or the deposition of a substance harmful to migratory birds in any areas that they frequent (Section 5). If a species is listed under Schedule 1 of SARA as Extirpated, Endangered or Threatened, it is an offence to kill, harm, harass, capture or take an individual, and that species has legal protection related to the species' residence and critical habitat as specified in SARA. These prohibitions apply to Threatened or Endangered wildlife in areas of federal jurisdiction and to migratory birds and aquatic species wherever these species are located.

Section 34 of the BC *Wildlife Act* prohibits disturbance or destruction of any bird or its eggs, or its nest (while occupied by a bird or its eggs). Nests of eagles, peregrine falcon, gyrfalcon, osprey, heron, or burrowing owl are protected year-round (Section 34[c]) in areas where the legislation applies.

The Islands Trust Act was enacted in 1974 to protect the islands and waters between the BC mainland and southern Vancouver Island, including Howe Sound and as far north as Comox. The Islands Trust area includes 13 major islands and more than 450 smaller islands. Gabriola Island is one of twelve local trust areas, each of which is responsible for its own land use planning and regulation. The Official Community Plan for the Gabriola Island Trust Area includes goals and policies to protect the natural environment, including the marine foreshore. This jurisdiction does not extend into the Anchorage area but is relevant to protecting terrestrial habitat for marine birds and terrestrial wildlife.

7.5.1 Physical Presence of Vessels

The physical presence of vessels may disturb or harm terrestrial wildlife, specifically birds, by causing temporary displacement or changes in behaviour. While in the Anchorage area vessels will physically occupy space that some bird species may otherwise use, impeding activities such as foraging or staging. Given the temporary duration of vessel occupancy, the mobility of birds and the availability of marine habitat available in the local area, this effect is anticipated to be minimal.

Vessels in transit may collide with birds or elicit a response such as flight or diving. Sensitivity and response to disturbances varies with species. Chatwin et al (2013) suggests that disturbance impacts decrease with time as seabirds habituate; seabirds in areas with high vessel traffic (>6 boats per day) were found to have no response to boats more than 50 m away. Schwemmer et al (2011) also found habituation in some seabirds, especially in areas of channeled traffic where transit routes were predictable. Recreational vessels and commercial fishing boat likely have a greater impact on birds than large vessels. These smaller boats tend to move faster and have more erratic, undefined movements that increase the risk of collision (BirdLife 2012a). In Alaska, Marbled Murrelets were found to be sufficiently habituated to marine vessels so that they paddled away rather than flew away, which is more energy-expensive (Speckman, Piatt and Springer 2004 in BirdLife 2012a). Collision is considered unlikely as the vessels will transit at low speeds in the Anchorage area and birds are capable of avoiding them. Most bird collisions occur with tall structures with reflective surfaces and reported collisions with vessels are predominantly associated with fishing vessels (Rich and Longcore 2006; Merkel 2010).

7.5.2 Artificial Light

Vessels in the Anchorage area will have navigational, anchor and deck lights that contribute artificial light to the environment. Terrestrial wildlife may be disturbed by changes in ambient light conditions.

"*The impact of artificial lighting on wildlife is a relatively new and poorly understood topic. Studies are few, and they have been primarily conducted in laboratory settings or limited to species of bats, insects, birds and sea turtles*" (The Nature Conservancy 2015). Adding artificial light to the natural environment can cause changes to wildlife behaviour, including altered foraging and reproductive behaviors, predator-prey interactions, habitat use, community structure and physiology. Similar to noise disturbances, the potential effects of light on terrestrial wildlife varies highly among species. Sensitivity to artificial lighting varies not only between different species but also among age classes and according to the influence of season, lunar phase and weather conditions (BirdLife 2012a).

Artificial light is known to cause disorientation in birds and interfere with their navigation systems. Artificial light can disrupt foraging, social and reproductive behaviours. Nocturnal birds are especially sensitive to artificial light. Mortality may occur if a bird strikes a structure, though research into this impact mostly investigates collision with buildings. Rich and Longcore (2006) suggests that although vessel lighting is a source of artificial light that affects birds, lighthouses, marine gas and oil platforms and light-induced fisheries have a greater impact. Negative impacts of vessel lighting on birds has been reported mostly in night-time fishing boats, which use high intensity lighting, rather than tanker-type vessels (Thompson 2013).

Section 7.4 estimated illuminance as 2 lux in the immediate vicinity of the vessel, decreasing to 0.2 lux and with a maximum light spill of 4.6 ha (Figure 4). This level is similar to a clear night with a full moon therefore light emitted by vessels in the Anchorage is not expected to increase ambient lighting at the foreshore significantly. Subsequently, light-related impacts to terrestrial wildlife are anticipated to be minimal.

7.5.3 In-Air Noise

Vessels will produce sounds that have the potential to disturb terrestrial wildlife. In-air noise may cause adverse behavioural responses or altered behaviour.

Research shows excessive noise can affect wildlife physiology and behaviour but determining the effects is complex as response varies between species and among individuals of a population (Radle 2007). These variable responses are due to the characteristics of the noise and its duration, the life history characteristics of the species, habitat type, season, activity at the time of exposure, sex and age of the individual, level of previous exposure, and whether other physical stresses such as drought are occurring around the time of exposure (Busnel and Fletcher (eds.) 1978 in Radle 2007, page 3).

In the absence of sound level standards or guidelines to protect wildlife, only general assumptions can be made. It is recognized that species have varying levels of tolerance and what may negatively affect one animal may have no effect on another. Health Canada (2011) describes a background sound level for "quiet rural" areas such as Gabriola Island as 45 dBA and in-air noise propagation by the Anchorages was modelled to be less than 40 dBA at the Gabriola shore (Section 7.3.1; Appendix C). Therefore, it is unlikely that the Anchorages will produce in-air noise above background levels that terrestrial wildlife in the area are acclimated to.

7.5.4 Release of Deleterious Substances

Wildlife that use the foreshore or marine waters, especially marine birds, have potential to be directly affected by deleterious substances released to the aquatic environment. Hydrocarbon-based materials (e.g., oil spills) in particular can have an adverse impact. Physical coating occurs with contact and causes fur or feathers to lose its insulation, potentially leading to hypothermia. Wildlife may also become sick from ingesting oils after attempting to clean themselves or feeding in contaminated areas. However, most impacts are indirect, by way of habitat degradation or reduced ecosystem function.

Operational or intentional release of deleterious substances is prohibited by international convention and federal regulations (see Section 7.2.2, *Other Pollutants*). Vessels are expected to comply with these requirements and the release of deleterious substances is anticipated to be unlikely. Accidental releases of deleterious materials is discussed in Section 9.0.

7.6 Marine Mammals

Anchorage activities have the potential to affect marine mammals by:

- Causing disturbance or harm because of physical presence of vessels;
  - Ship strikes;
  - Anchor chain in water column;
- Contributing artificial light that causes disturbance;
- Generating in-air and underwater noise that causes disturbance;
- Increasing turbidity; and
- Releasing deleterious substances through intent or operation.

Information presented in this subsection is largely based on a technical memo prepared by Tetra Tech EMI, unless otherwise stated (Zoidis 2016; Appendix F). Tetra Tech EBA contacted DFO for expert advice regarding marine mammals in the Anchorage area, but had not received a response at the time of report submission.

Zoidis (2016) identified 12 cetacean species, five pinniped species and 1 mustelid species with potential to occur in the Anchorage area. Many of the species identified with potential to occur in the Anchorage area will likely not occur with regularity but rather observed periodically, given their large ranges, seasonal movements and/or highly mobile nature. Species likely to be encountered in the Anchorage area include: Humpback Whale, Gray Whale, Killer Whale, Harbour Porpoise, Dall Porpoise, Pacific White-sided Dolphin, California Sea Lion, Harbour Seal and Steller Sea Lion.

Human interactions are known to interrupt marine mammal life processes but there is limited legislation or regulations that speak to potentially harmful activities, especially those related to shipping. Marine mammals are protected under the Marine Mammal Regulations of the *Fisheries Act*, which prohibit the disturbance and killing of marine mammals for reasons other than licenced fishing. Voluntary guidelines for wildlife watching vessels exist and proposed amendments to the Marine Mammals Regulations would require boats to stay more than 100 m from cetaceans in Canadian waters (Government of Canada 2013). If a species is listed under Schedule 1 of SARA as extirpated, endangered or threatened, it is an offence to kill, harm, harass, capture or take an individual, and that species has legal protection related to the species' residence and critical habitat as specified in SARA. Five of the species at risk identified with potential to occur in the Anchorage area are protected under SARA as Threatened or Endangered species (Appendix G).

7.6.1 Physical Presence of Vessels

Ship Strike

Vessel movements have the potential to affect marine mammals by directly striking individual animals causing injury or mortality. Virtually all of the larger whale species have been documented to have been hit by vessels. Nearly every species of dolphin and small whale in the family Delphinidae is known to have at least occasionally suffered from collisions with vessels, including killer whales and dolphins (Van Waerebeek et al, 2007 in Zoidis 2016, page 20). Jensen and Silber ([2003] on BC Cetacean Sightings Network [2016]) reported that Fin Whales are the most frequently struck large cetacean, at nearly twice that of the next most commonly struck species – Humpback Whales, which has been sighted in the Anchorage area. Ship collisions do not appear to be particularly common for porpoise and dolphins, or killer whales as they are for the larger whales. Pinnipeds are smaller and more agile and are therefore rarely struck by vessels (Laist et al. 2001).

In 2013/2014 sixty-four marine mammal vessel harassment/human interactions were reported to DFO's Marine Mammal Response Program in the entire Pacific Region (DFO 2015a). In general, the larger and faster the vessel the more likely a collision will cause mortality. Laist et al. (2001) found that "merchant ships" had fewer collisions than passenger ships, which can travel 5 to 8 knots faster.

Several species of cetacean have been observed in or adjacent to the Anchorage area (Figure 1 in Appendix F) where large vessels currently navigate daily (i.e., BC Ferries, Seaspan). The potential for ship strikes increases where high traffic areas for vessels (e.g., major shipping lanes) overlap with high use areas for marine mammals (e.g., feeding grounds). Increased vessel presence increases the potential for ship strikes to occur but occurrence is not quantifiable.

Anchor Chains

The physical presence of the anchor chain in the water column which can cause marine mammals to alter behaviour or cause temporary displacement. “The potential effects of anchor chains in the water column are acknowledged but evaluation is limited because no published research on the incidence of such effects was available” (Mire 2016a).

Cetaceans use sonar or echolocation systems to find prey and navigate, as well as avoid obstacles. Collision with the anchor chains is possible but marine mammals are mobile and should be able to avoid them. However, marine mammals may need to alter their behaviour to avoid the chains. The presence of multiple chains may have a greater effect since there are more obstacles present; a cluster of anchor chains creates a “forest” of obstructions that can adversely affect marine mammals and sharks that collide with the chains or alter their behavior to avoid the chains (DFO 2014).

7.6.2 Artificial Light

Vessels in the Anchorage area will have navigational, anchor and deck lights that contribute artificial light to the aquatic environment. Marine mammals may be disturbed by changes in underwater ambient light conditions.

The depth to which light penetrates the water column depends on the angle at which it enters and environmental factors such a turbidity. The effects of artificial light in water are generally not far-reaching, being concentrated near the light source. Most light is absorbed or scattered within a few meters of the surface and intensity of light decreases with depth (Reed 1999).

Little information is available on the effects of artificial light on marine mammals though it is possible that significant increases in underwater ambient light would have a negative impact. Many pinnipeds, such as Steller Sea Lions, Harbor Seals and Northern Fur Seals, are active at night; killer whales have also been shown to exhibit nocturnal behaviours (Newman and Springer 2008). Since some predation is adapted to low light conditions, an increase in ambient lighting could alter foraging behaviour of some seals (Yurk and Trites 2000).

The degree to which artificial light from vessels in the Anchorage would penetrate the water column is unknown and would be highly variable. However, since the luminance emitted from vessels in-air was expected to be minimal (see Section 7.4) it is reasonable to assume that luminance underwater would also be limited. The duration and intensity of artificial light emitted from anchored vessels is also expected to be limited. Effects of artificial light on marine mammals is expected to be negligible, occurring mostly near the vessel and near the surface.

7.6.3 Noise Disturbances

Vessels will produce sounds in-air and underwater that may disturb marine mammals by causing altered behaviour (e.g., avoidance). Response to noise is influenced by sound characteristics, exposure context and the animal. Sound characteristics such as level, frequency, duration and amplitude combine with species characteristics such as individual animal’s level of habituation or exposure experience, physical condition and life stage (e.g., foraging, migrating, reproducing, resting) in a complex matrix of responses. Reactions can vary by species, by sound source, by number of sound sources in the same area, sound characteristics and/or based on the activity the animals are engaged in. Because noise effects are so context dependent, and can vary not only between species but also between individuals, predicting effects is highly generalized.

Cetaceans are primarily affected by underwater noise and pinnipeds are more likely to be affected by both in-air and underwater noise. Many studies have shown that underwater noise generated by shipping can cause adverse effects to marine mammals. Most marine mammals respond to noise with short-term behavioural responses including alterations to feeding, resting and social behavioural patterns. Noise also has the potential to cause an animal to permanently leave the area of disturbance.

Canada utilizes the NOAA Fisheries standards for acoustic impacts (NOAA 2016) that rely on generic sound exposure thresholds to determine when an activity produces sound that might result in effects that constitute a “take by harassment”, which is defined by the United States Marine Mammals Protection Act (MMPA 2007) as:

- *Level A Harassment* has the potential to injure a marine mammal or marine mammal stock in the wild. This is also known as Permanent Threshold Shift (PTS). Sound exposure thresholds are defined as 180 dB re 1 µPa-1m rms[9] for cetaceans (whales, dolphins, and porpoises), and 190 dB re 1 µPa-1m rms for pinnipeds (seals and sea lions);
- *Level B Harassment* has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. This is also known as Temporary Threshold Shift (TTS). Sound exposure thresholds are defined at 120 dB RMS re 1 µPa for continuous noise and 160 dB RMS re 1 µPa for impulse noise.

The Anchorages will result in an increased number of vessels present which will increase in-air and underwater noise which has potential to negatively affect marine mammals. Section 7.3 summarizes the predicted changes to in-air and underwater acoustic environments, which is pertinent to the assessment of potential noise effects on marine mammals. It is important to note that the Anchorage area waters already contain other sources of continuous sounds including recreational and commercial vessels, aircraft, and every day common use of ship depth sonar systems.

Marine mammals immediately adjacent to a noise source may experience temporary disturbance but are typically able to quickly move beyond the harmful range to minimize further disturbance. This displacement may allow the animal to find higher quality habitat elsewhere but secondary consequences, such as reduced foraging or reproductive success, may emerge in individuals that are already stressed.

In-Air Noise

Noise modelling indicate sound levels over most of the Anchorage area will be in the 40 to 50 dBA range (Figure 7 in Appendix C). Although there are no dBA thresholds for land dwelling or in-air hearing marine mammals (e.g., pinnipeds and mustelids) these findings are below the levels NOAA considers to cause disturbance or injury.[10] “Seals, sea lions or otters that may forage, transit, pup or rest in the area are not expected to have the potential for MMPA Level B harassment, indicating the proposed activities would not result in any population level effects, injury, or death to land dwelling/ in-air hearing marine mammals.” (Zoidis 2016).

[9] dB re 1 µPa = dB RMS

[10] NOAA is developing comprehensive guidance on sound characteristics likely to cause injury and behavioral disruption in the context of the US Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA) and other statutes. Until formal guidance is available, NOAA Fisheries uses conservative thresholds of received sound pressure levels from broad band sounds that may cause behavioral disturbance and injury. The current in-air acoustic threshold for a Level B disturbance in Harbour Seals is 90 dB RMS and 100 dB RMS in non-Harbour Seal pinnipeds. Although in-air noise is typically A-weighted the RMS values are reportedly the in-air SPL at which pinniped haulout disturbance has been documented.

Underwater Noise

Underwater quantitative acoustic conditions at the Anchorage area are not currently available; therefore, only a broad qualitative assessment of effects can be made since it is not known if the Anchorage noise sources will be louder than, or masked by existing sound levels. “Likely the baseline or ambient noise levels in project area waters is already loud from other existing vessel traffic though there are no measured baseline noise levels yet that are available” (Zoidis 2016). Level A harassment is not expected as the Anchorages will not produce noise levels in the ranges applicable for this level. Level B harassment thresholds may be exceeded if marine mammals are within 5 to 10 m of a vessel when they are stationary. These impacts may be adverse, especially for low frequency hearing cetaceans. Level B harassment thresholds will likely be met for low, mid and high range frequency hearing animals, albeit at greater distances from the source.

7.6.4 Increased Turbidity

Anchor drag may increase turbidity in the Anchorage area which can cause marine mammals to alter behaviour or cause temporary displacement. Propeller movement can also disturb sediments already in the water column but is unlikely to disturb the seafloor as the vessels will be in deep water (50 m).

Marine mammals often inhabit naturally turbid environments and many utilize sophisticated sonar systems to sense the environment around them (Au et al. 2000 in Todd et al. 2014, page 5). Some mysticetes (e.g., grey whales) create plumes of sediment while feeding which suggests a tolerance to turbidity. Pinnipeds locate prey visually and may be more affected by turbid waters; however, several studies suggest they use other senses to feed when vision is limited (Todd et al. 2014).

Increased turbidity is expected to be temporary and localized (see Section 7.2.1). Marine mammals are mobile and would likely avoid a sediment plume. Given the availability of habitat in the area and the likely limited duration of increased turbidity, temporary relocation is not considered adverse. Overall, it is expected that direct impacts to marine mammals because of increased turbidity would be minimal.

7.6.5 Release of Deleterious Substances

Marine mammals have potential to be affected by deleterious substances released to the aquatic environment. Most impacts are indirect, by way of habitat degradation or reduced ecosystem function. However, physical contact with some substances can cause harm. While substances such as sewage are polluting and potentially harmful, hydrocarbon-based substances are of primary concern.

When mammals surface to breathe, oily water can cover their blowholes and enter their lungs, causing respiratory complications. Physical contact can cause skin irritation or vision damage. Ingestion is also possible. Long-term health effects, such as reduced reproductive ability, are also possible.

Operational or intentional release of deleterious substances is prohibited by international convention and federal regulations (see Section 7.2.2, *Other Pollutants*). Vessels are expected to comply with these requirements and the release of deleterious substances is anticipated to be unlikely. Accidental releases of deleterious materials is discussed in Section 9.0.

7.7 Fish and Aquatic Habitat

Anchorage activities have the potential to affect fish and fish habitat by:

- Causing disturbance or harm because of physical presence of vessels (i.e., anchor chain in water column);
- Contributing artificial light that causes disturbance;
- Generating underwater noise that causes disturbance;
- Scouring seafloor during anchoring;
- Increasing turbidity; and
- Releasing deleterious substances through intent, operation or accident.

The federal *Fisheries Act* defines fish as "parts of fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals as well as the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals". Fish habitat is defined as "spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life processes." Section 35 of the *Fisheries Act* prohibits serious harm to fish that are part of, or support, a commercial, recreational or Aboriginal fishery. Serious harm is defined as "the death of fish or any permanent alteration to, or destruction of, fish habitat."

Key fish that "support a fishery", known to occur in the Anchorage area include all five Pacific Salmon species and Pacific Herring, as well as several other species (Table 4-3, Section 4.5.3). Geoducks, Pacific Oyster, Pacific Blue Mussel and Scallops, along with Shrimp and Crab are also harvested. Though not harvested, the Pacific Sand Lance (*Ammodytes hexapterus*) is an important forage fish that is well distributed throughout coastal Pacific waters. This small forage fish feeds in open water during the day and burrows into coarse substrates at night to avoid predation. Sand Lance prefer beaches with a mixture of sand and gravel and are sheltered from wave disturbances, highly oxygenated by bottom currents and generally less than 50 m (Schweigert et al. 2007; Therriault et al. 2009). The beaches adjacent to the Anchorage area do not provide suitable Sand Lance habitat; the nearest suitable habitat occurs south of the Anchorage area among the Flat Top Islands (Mire 2016a).

7.7.1 Physical Presence of Vessels

Anchor Chain in Water Column

The chain is a physical obstruction within the water column that may cause injury through collision, avoidance behaviour or displacement in fish, especially for large fish such as sharks (DFO 2014). "The potential effects of anchor chains in the water column are acknowledged but evaluation is limited because no published research on the incidence of such effects was available" (Mire 2016a).

Collision with the chain is possible but fish are mobile and can generally avoid it. Sharks, which DFO specifically identifies as a concern, have a lateral line system that allows them to sense and avoid obstacles. Benthic feeders such as the Green Sturgeon and Bluntnose Sixgill Shark, both of which are species at risk, are more likely to encounter the chain while foraging but can still generally avoid it. As noted in Section 7.6, the presence of multiple chains may have a greater effect because there are more obstacles to avoid. Chains do not impose an entanglement risk because it is too heavy to be moved by fish.

7.7.2 Artificial Light

Vessels in the Anchorage area will have navigational, anchor and deck lights that contribute artificial light to the aquatic environment. Fish may be disturbed by changes in underwater ambient light conditions.

As described in Section 7.6.2, the degree to which artificial light affects ambient light underwater depends on the angle of entry and environmental factors, but is generally concentrated near the emission source. Artificial light emissions at night have a greater impact than those occurring during the day because the distinct contrast in light levels.

Most fish show diurnal activity patterns (Hobson 1965) and artificial light has been shown to alter fish behaviour, though response varies with species, life stage and other environmental conditions. Fish may be attracted to lights which can increase predation by other fish species, pinnipeds and cetaceans. Artificial light can alter hormones in fish and has been used in aquaculture to stimulate growth (Trippel 2010).

The degree to which artificial light from vessels in the Anchorage would penetrate the water column is unknown and would be highly variable. However, since the luminance emitted from vessels in air was expected to be minimal (see Section 7.4) it is reasonable to assume that luminance underwater would also be limited. The duration and intensity of artificial light emitted from anchored vessels is also expected to be limited. Effects of artificial light on fish is expected to be negligible, occurring only near the vessel and near the surface.

7.7.3 Noise Disturbance

Vessels will produce sounds underwater that may disturb fish by causing altered behaviour. Noise has the potential to injure fish. However, this effect is typically associated with acute noises, generated by activities such as pile driving or blasting, rather than chronic noise. “It is possible that less intense but longer lasting sounds, such as those produced by continuous boating, cause a general increase in background noise in some locations. Although it is not likely that such sounds will kill per se, there are concerns that such sounds will result in masking of biologically important sounds, cause some hearing loss, and/or have an impact on stress levels and on the immune system” (Popper and Hastings 2009). Excessive noise can create behavioural responses, primarily avoidance.

The Fisheries Hydroacoustic Working Group, a collaboration between the California Department of Transportation and Federal Highways Administration, provides the *Technical Guidance for Assessment and Mitigation of Hydroacoustic Effects of Pile Driving on Fish* (Caltrans 2015) and describes typical underwater sound levels:

- Background with boat traffic (ranging from quiet estuary to water body with boat traffic) – 60 to 120 dB RMS
- Fish trawler passby (low speed) at 20 meters – 140 dB RMS
- Large ship in transit at 100 meters - 160 dB RMS

While there have been some studies indicating behavioural changes for specific species at specific sound levels, behavioural thresholds for sound in fish are generally not available in Canada. The Washington State Department of Transportation summarizes disturbance and injury threshold levels for pile driving activities on fish from several sources (WSDOT 2016). Disturbance thresholds were described at 150 db RMS and injury was peak 206 dB RMS and 187 dB RMS cumulative.

Noise modelling calculated the Maximum-Over-Depth Sound Level (m) for vessels at anchorage and in transit in the Anchorage area (Table 4, Figures 5 and 6 in Appendix C) and are summarized in Section 7. 3. Noise was found to be generally greater for vessels in transit than those anchored. Unweighted sound levels, the most stringent value, were estimated at 160 dB RMS at the vessel but were less than 110 dB RMS over most of the Anchorage area (Kalapinski, Varnik and Pellerin 2016). These values are generally within the range of underwater noise created by background boat traffic described by Caltrans (2015) and below injury thresholds. The estimated sound level immediately around the vessels exceeds the WSDOT described behavioural threshold, but sound levels quickly diminish below the criteria as distance from the ship increases.

Boat traffic already exists in the area where fish are acclimated to vessel-generated noise. It is anticipated that fish would likely respond in a similar manner to noise produced by the Anchorages.

7.7.4 Anchor Scour

Unless otherwise stated, information presented in this subsection is based on a technical memo produced by Tetra Tech OGA (Mire 2016a; Appendix D).

Physical disturbance of the seafloor occurs with contact when the anchor and chain are dropped. Most disturbance occurs during anchor laying and retrieval but the chain may create a scour area with the “slack” required to allow the vessel to move with surface conditions. Anchor scour may result in the direct mortality of fish and/or the disturbance or destruction of fish habitat.

Marine vegetation and benthic organisms can be directly displaced, injured or killed by contact or buried by resettling sediments. The typical scour area is a function of water depth and chain length. Based on the swing diameter of each anchorage, there is potential to disturb up to 6.16 km^2 of seafloor[11] depending on the amount of anchor drag that occurs. Anchor drag appears to have a low occurrence in the area - between 2010 and 2014 only one instance of a vessel dragging anchor was reported in Nanaimo and 3 were reported in the Gulf Islands (Transportation Safety Board in Young 2015, pg. 10). NPA policy stipulates that vessels frequently check their position by “more than one recognized navigational method to confirm that the ship is not dragging its anchor” (NPA 2009). Therefore, the scour area is likely significantly less than the swing radius.

The repeated disturbance of the substrate by the anchor and chain would make it impossible for most benthic organisms to complete a normal life span. Depending on the interval between vessel visits, some regrowth of vegetation may occur but the potential for recolonization is generally considered limited. Tetra Tech EBA notes that very little vegetation was observed along the transects during the ROV survey; therefore, scour likely primarily affects benthic organisms. Motile invertebrates and fish would avoid the anchorage during active anchor dropping, and selectively relocate during periods of high-intensity chain movement. These animals are able to move in and out of the scour zone without harm, and are not expected to be adversely affected. Pelagic eggs and larvae would likely not be affected by scouring. These effects are anticipated to be limited to local populations in the Anchorage area with no effects on a species level.

7.7.5 Increased Turbidity

Sediments physically disturbed by anchors also increase turbidity, which have potential to destroy fish habitat and/or kill fish. Propeller movement can disturb sediments already in the water column but is unlikely to disturb the seafloor as the vessels will be in deep water (50 m). Sediment laden water can be considered an act that causes serious harm to fish under the *Fisheries Act*. Marine waters have natural turbidity caused by phytoplankton, tidal flows, currents, storms, and runoff/ discharge from upland sites and rivers. Natural turbidity levels can be higher during storms and periods of high runoff. Both naturally occurring and artificially increased turbidity can vary considerably depending on the environmental conditions. The duration and spatial distribution of increased turbidity caused by

[11] Calculated as total area of swing diameter of all anchorages - G1 + G2 + G3 + G4 + G5 as: ($\pi 0.6482 km^2$) + ($\pi 0.6482 km^2$) + ($\pi 0.6482 km^2$) + ($\pi 0.6482 km^2$) + ($\pi 0.5556 km^2$)

the Anchorages will vary with length of vessel stay (i.e., the effect occurs as long as a chain is present and moving) and with tides and currents.

Turbid waters can inhibit photosynthesis in marine vegetation by scattering light or from disturbed sediments settling on plant surfaces. Increased turbidity can interfere with feeding for fish (e.g., clogging feeding apparatuses for filter feeders or reducing visibility for predators) and can abrade gills. Salmon and Herring are more sensitive to high turbidity than bivalves and Dungeness crab (Stantec 2014).

Most literature and guidelines cite TSS rather than turbidity when discussing impacts to fish and other aquatic organisms. The relationship between turbidity and TSS can be correlated – generally the greater the TSS the greater the turbidity – but requires site-specific measurements to develop an accurate relationship. Lethal and sublethal concentrations of TSS to fish varies with species and environmental factors such as temperature, ranging from hundreds to hundreds of thousands of mg/L of TSS (Birtwell 1999). The BC AWQG for marine aquatic life include both turbidity and TSS and represent the levels at which chronic, non-lethal effects may occur (Table 7-2, Section 7.2.1).

Background turbidity levels in the Anchorage area are currently unknown. Because of the highly variable nature of the marine environment establishing background turbidity or TSS levels would require a long-term sampling program (i.e., at least one year to establish seasonal patterns). Relative changes in turbidity may be monitored by collecting measurements immediately before, during and after vessel occupation.

Anchorage related turbidity increases are anticipated to be temporary and localized (see Section 7.2.1). Fish and motile invertebrates are likely to leave turbid waters which limits their exposure, though causes temporary displacement. Infaunal and epibenthic organisms have a greater potential to experience harm as they could be buried if resettling sediments cannot be removed.

7.7.6 Release of Deleterious Substances

Fish have potential to be affected by deleterious substances released to the aquatic environment. Most impacts are indirect, by way of habitat degradation or reduced ecosystem function. Direct impacts may occur with physical contact or ingestion.

Motile shellfish and finish may have limited exposure to hydrocarbon releases as most oil products float at the surface. However, fish eggs in shallow water may be smothered and fish can be physically harmed (gill and skin irritation) with contact. Immobile shellfish, many of which are filter feeders occurring in shallow water, have a greater risk of exposure to oils.

Deleterious substances such as sewage, garbage or grey water can also affect shellfish. These deleterious substances are nutrient rich and can cause oxygen depletion or altered nutrient regimes in the water and can cause disease. Filter-feeding shellfish can be exposed to high concentrations of contaminants that impair health.

Fish habitat can be directly impacted by deleterious substances. Decreased water quality (see Section 7.2.2) and sediment quality may result from a release. Hydrocarbon-based releases can physically coat substrates or vegetation in shallow water and intertidal zones, making these areas inaccessible or toxic.

Operational or intentional release of deleterious substances is prohibited by international convention and federal regulations (see Section 7.2.2, *Other Pollutants*). Section 36 (3) of the *Fisheries Act* prohibits the release of a deleterious substance into waters frequented by fish. Vessels are expected to comply with these requirements and the release of deleterious substances is anticipated to be unlikely. Accidental releases of deleterious materials is discussed in Section 9.0.

7.8 Aboriginal, Recreational and Commercial Fisheries

Although social components were generally excluded from this EOA, the PPA specifically requested that potential impact to aboriginal, recreational and commercial fisheries be considered.

It is known that fisheries occur in or proximate to the Anchorage area (see Section 5.3). However, the degree to which these fisheries may be impacted cannot be adequately assessed without consultation. Tetra Tech EBA understands that PPA intends to conduct public consultation wherein the potential interactions can be better defined. Therefore, the following is a cursory assessment which is a based on a common understanding of fisheries in the Anchorage area.

Anchorage activities have the potential to affect fisheries by:

- Causing disturbance or harm because of physical presence of vessels; and
- Releasing deleterious substances through intent, operation or accident.

7.8.1 Physical Presence

Physical presence of vessels may cause harm or displacement of fisheries. Anchored vessels may be a navigational challenge to other boats and could restrict fishing activities, especially if the high use periods of the two activities overlap.

Limited data is available to accurately assess this effect. Because the proposed anchorages are expected to be used primarily to accommodate “overflow” from PMV and usage is dependent on a variety of factors such weather and economic demand, frequency of use, collective occupancy and individual length of stay cannot be accurately predicted. However, peak usage is expected during winter months (Kevin Obermeyer, Pers. Comm., March 3, 2016). The overall trend for use in the southern Strait of Georgia (2010 to 2014) showed significant increases in the number of ships anchoring year-over-year but relatively consistent average length of stay (7.6 days) (Obermeyer 2015).

A variety of fisheries occurs within the Anchorage area (Section 5.3; Appendix I). Open season for recreational fishing in marine waters for most fish species, including shellfish, is from April 1 to March 31 (year-round); Coho is a noteable exception with an open season of June 1 to December 31 (DFO 2016b). Recreational charter salmon fishing is concentrated between April and October, but winter run Chinook occurs mid-October to late March. Several fishing blogs and charter fishing websites indicate that large numbers of Chinook are present on the eastern side of Gabriola Island, especially in late May to mid-August, as well as lingcod (Predator Charters 2013; The Fishing Experience 2012; Davis 2014).

Commercial salmon fisheries typically operate May to October (DFO 2013) and geoduck is harvested year-round. Commercial shrimp licences are managed on catch ceilings rather than seasons – once the limit is reached for an area it closes. Commercial and sport prawning areas are reportedly within or adjacent to the Anchorage area (BCMCA 2011; Robert Meyer Pers. Comm., November 4, 2015).

DFO operates the Internet Recreational Effort and Catch (iRec) survey, which requires holders of a Tidal Waters Sport Fishing licence to provide information on their recreational fishing activity and catch to DFO representatives when requested. Survey data for Pacific Fisheries Management Area 17-10 indicates that most recreational fishing activity occurs during spring and summer (Rob Houtman, Pers.Comm, March 23, 2016). Commercial fisheries may operate in less favourable weather conditions and are more likely to overlap with peak vessel anchorage in winter. However, even vessels anchored in summer months are not expected to significantly affect either recreational or commercial fisheries. The vessels occupy a relatively small area for a short period of time, which could temporarily displace fisheries but is unlikely to have a long-term effect.

7.8.2 Release of Deleterious Substances

Sewage, grey water, ballast water and other deleterious substances such as oily water have the potential to indirectly affect fisheries by impacting fish and fish habitat (see Section 7.7).

Shellfish harvesting (Geoduck) occurs proximate to the Anchorage area (Sections 4.5.2 and 5.3). Harvest areas may be closed if an area is considered contaminated. EC identifies safe harvest areas through water quality monitoring under the Canadian Shellfish Sanitation Program (CSSP). DFO controls harvesting shellfish from areas that are contaminated or otherwise considered closed. As of March 22, 2016 Pacific Fisheries Management Area 17-10 was open to geoduck, horse clams, closed to all other bivalve shellfish[12]. Closures may occur because of chemical contaminants, sanitary exceedances (fecal coliforms) or high marine toxin levels (paralytic shellfish poison and domoic acid) (Canadian Food Inspection Agency 2012). Chemical contaminants include any poisonous or deleterious substance.

Operational or intentional release of deleterious substances is prohibited by international convention and federal regulations (see Section 7.2.2, Other Pollutants). Additionally, Section 7 of the *Practices and Procedures to be Followed by Ships in the Port Of Nanaimo* (NPA 2009) prohibits discharge of sewage or other pollutant into the harbour. Vessels in the Anchorage area are expected to abide by all required legislation and not contribute pollutants to the environment. Vessels are expected to comply with these requirements and the release of deleterious substances is anticipated to be unlikely. Accidental releases of deleterious materials is discussed in Section 9.0.

Ballast water has the potential to introduce NIS to an area which can influence local ecology (e.g., community composition or species assemblage) and potentially alter a fishery. For example, Zebra Mussels are native to the Black Sea region and are believed to have been introduced to the Great Lakes area in the late 1980s via ballast water and have profoundly affected eastern Canadian freshwater ecosystems (Ontario Invading Species Awareness Program 2006). The potential for ballast water to negatively impact water quality, and therefore fish and fish habitat or fisheries, is considered unlikely (Section 7.2.2).

8.0 SIGNIFICANCE OF RESIDUAL EFFECTS

The potential interactions, mitigation measures and adverse residual effects of the Anchorages and VCs are described in Table 8-1. Adverse residual effects are characterized and significance is determined in Table 8-2 and are summarized below:

Air Quality

One potential residual effect to air quality was identified:

- Vessels will contribute air emissions that may result in temporary exceedances of the BC AAQO or CAAQS.
  - Federal regulations and international conventions limit emissions and the shipping industry is moving towards more efficient equipment and lower sulphur fuels which further reduces emissions. This residual effect was found to be *Not Significant* because of its limited duration. Although air emissions may temporarily exceed

[12] Up to date closures available at: http://www.pac.dfo-mpo.gc.ca/fm-gp/contamination/biotox/index-eng.html

an established guideline, air quality is anticipated to recover shortly after the contributing vessel leaves the area.

Water Quality

Two potential residual effects to water quality were identified:

- Anchoring may disturb sediments and increase turbidity so that BC AWQG is exceeded.
  - Although an increase in turbidity may exceed an established guideline this residual impact was found to be *Not Significant* because it is localized and temporary. Turbidity levels in the marine environment typically return to pre-disturbance conditions with a few tide cycles.
- Vessels may release deleterious substances that decrease water quality and exceed BC AWQG and CCME Water Quality Guidelines.
  - Intentional and operational releases of pollutants are prohibited by federal regulations and international convention. Accidental releases are considered unlikely and/or infrequently to occur.
  - Release of a deleterious substance would have a high magnitude of impact and could persist beyond the temporal boundary of the Anchorages. Although this residual effect would occur infrequently (once) it may be only partially reversible and is therefore considered to be *Significant.* However, the likelihood of occurrence is low.

Acoustic Environment

Although vessels will contribute both in-air and underwater noise to the Anchorage area and adjacent areas, with application of mitigation measures there were no residual effects to this VC.

Ambient Light

Although vessels will contribute artificial light emissions to the Anchorage area and adjacent areas, with application of mitigation measures there were no residual effects to this VC.

Terrestrial Wildlife and Marine Birds

Three potential residual effects to terrestrial wildlife and marine birds were identified:

- Physical presence of vessels may cause temporary displacement or avoidance behaviour.
  - Vessel strikes causing injury or mortality are unlikely because of species mobility and slow vessel speeds within the Anchorage area. Because other vessel traffic already occurs in the Anchorage area, these species are anticipated to be habituated to vessel presence.
  - Because displacement and/or avoidance behaviour is expected to be localized and temporary this residual effect was considered *Not Significant.*
- Contact with deleterious substances can cause physical harm.
  - Intentional and operational releases of pollutants are prohibited by federal regulations and international convention. Accidental releases are considered unlikely and/or infrequently to occur.

  - Release of a deleterious substance would have a high magnitude of impact and could persist beyond the temporal boundary of the Anchorages. Although this residual effect would occur infrequently (once) it may be only partially reversible and is therefore considered to be *Significant*. However, the likelihood of occurrence is low.

- Reduced habitat quality caused by release of deleterious substances to the aquatic environment can indirectly impact terrestrial wildlife and marine birds.

  - Release of a deleterious substance would have a moderate impact to habitat quality and could persist beyond the temporal boundary of the Anchorages. Habitat may be degraded within the LSA but would not likely be impacted on a regional scale and would recover over time. Because the spatial and temporal impacts are limited, this residual effect was considered *Not Significant.*

Marine Mammals

Seven potential residual effects to marine mammals were identified:

- Individuals may be injured or killed by ship strike.

  - Increased vessel presence inherently increases potential for ship strike to occur. Because several sensitive marine mammal species are potentially present in the Anchorage area, and because marine mammals generally have low reproductive rates, loss of an individual could have implications for local populations (e.g., loss of a mature female Killer Whale from the endangered Southern Resident population limits potential growth/recovery of that population).

  - Although this effect is localized, the magnitude of impact is high (individual mortality) and could continue over several seasons. It is also considered non reversible, which makes it a *Significant* residual effect. However, the likelihood of occurrence is considered to be low.

- Presence of anchor chains may cause temporary displacement or avoidance behaviour.

  - Anchor chains may be an obstacle in the water column but because marine mammals are highly motile they are likely capable of avoiding contact. The temporary displacement or avoidance behaviour caused by the physical presence of anchor chains is of moderate magnitude. Although marine mammals frequently encounter and avoid other obstacles multiple chains may cause increased behavioural changes. However, because this effect is localized, occurring only around the chain, and temporary it was considered *Not Significant.*

- Vessels will contribute artificial light that may cause temporary displacement or behavioural changes.

  - Light spill to the aquatic environment is anticipated to be limited to the area immediately around the vessel and would occur only during dark hours while a vessel is present. Because the spatial and temporal impacts are limited, this residual effect was considered *Not Significant.*

- Vessels may generate underwater noise that causes temporary displacement or behavioural changes.

  - Noise modelling indicates that the sound level generated underwater by vessels would likely not exceed the NOAA (2016) exposure thresholds for marine wildlife. The Anchorages may generate underwater noise that causes temporary threshold shifts, such as avoidance behaviour, but is unlikely to cause permanent threshold shifts, such as injury. Local populations of marine mammals are likely accustomed to the existing noise levels, which are anticipated to mask (i.e., be louder than) the underwater noise contributions of the Anchorages. Nonetheless, addition of noise sources in an already noisy environment can be negative.

  - Underwater noise may have a moderate magnitude of impact, but the effect is localized and temporary. Once a vessel leaves the area the effect quickly diminishes. This residual effect was considered *Not Significant.*

- Anchor drag may disturb sediments that increase turbidity and cause temporary displacement or avoidance behaviour.
  - Marine mammals may temporarily leave the Anchorage area if turbidity increases considerably. Marine waters experience natural fluctuations in turbidity and marine mammals are adapted to these conditions. Many marine mammals utilize non-visual sensory systems, such as sonar, to ascertain their environment.
  - Although turbidity increases may have a moderate magnitude of impact, the effect is localized and temporary. If turbidity is sufficient to elicit avoidance behaviour, the displacement would be temporary as turbidity typically returns to pre-disturbance conditions quickly (e.g., within several tide cycles, depending on other contributing environmental factors). This residual effect was considered *Not Significant.*
- Contact with deleterious substances may cause physical harm.
  - Intentional and operational releases of pollutants are prohibited by federal regulations and international convention. Accidental releases are considered unlikely to occur and/or infrequent.
  - Release of a deleterious substance would have a high magnitude of impact and could persist beyond the temporal boundary of the Anchorages. Although this residual effect would occur infrequently (once) it may be only partially reversible and is therefore considered to be *Significant*. However, the likelihood of occurrence is low.
- Degraded habitat quality, including reduced food availability, caused by release of deleterious substances to the aquatic environment can indirectly impact marine mammals.
  - Release of a deleterious substance could have a high impact to habitat quality. Habitat may be degraded within the LSA but would not likely be impacted on a regional scale and would recover over time. Food sources within the Anchorage area and potentially within the LSA may be temporarily limited and cause marine mammals to seek food elsewhere.
  - Although this residual effect would occur infrequently (once) it may be only partially reversible and is therefore considered to be *Significant*. However, the likelihood of occurrence is low.

Fish and Aquatic Habitat

Ten potential residual effects to fish and aquatic habitat were identified:

- Presence of anchor chains may cause temporary displacement or avoidance behaviour.
  - Anchor chains may be an obstacle in the water column but motile fish (e.g., finfish and sharks) and invertebrates most likely to encounter them are highly mobile they are likely capable of avoiding contact. The temporary displacement or avoidance behaviour caused by the physical presence of anchor chains is of moderate magnitude. Although motile fish frequently encounter and avoid other obstacles, multiple chains may cause increased behavioural changes. However, because this effect is localized, occurring only around the chain, and temporary it was considered *Not Significant.*

- Vessels will contribute artificial light that may cause temporary displacement or behavioural changes.
  - Light spill to the aquatic environment is anticipated to be limited to the area immediately around the vessel and would occur only during dark hours while a vessel is present. Because the spatial and temporal impacts are limited, this residual effect was considered *Not Significant.*
- Vessels will contribute artificial light that may increase risk of predation.
  - Light spill to the aquatic environment is expected to be limited to the immediate vicinity of the vessel and would occur primarily during dark hours. It is anticipated that the high-intensity lighting typically associated with increased predation risk, such as that used in some commercial fisheries, would not be utilized on the vessel types most frequently using the Anchorages. This residual effect was considered *Not Significant* because it is localized and temporary.
- Vessels may generate underwater noise that causes temporary displacement or behavioural changes.
  - Underwater noise emissions were modelled below levels that typically cause injury. Sound levels generated by the Anchorages are further expected to be within the range of noise levels generated in a waterbody with boat traffic. Fish are anticipated to respond and adapt to Anchorage-generated noise similar to existing boat traffic noises. Because this effect represents little change from existing conditions, the magnitude of impact is low. As well, any avoidance or displacement would be localized and temporary, making this effect *Not Significant.*
- Anchor drag/scour will cause localized destruction of fish habitat.
  - Benthic sediments in direct contact with the anchor will be disturbed. Little vegetation is present within the Anchorage area and scour will occur at depths where most aquatic vegetation does not grow (+40 m).
  - Destruction of fish habitat will be of high magnitude but will be limited to a relatively small area. Habitat recovery is possible depending on the disturbance interval. Because this residual effect is localized and may diminish over several seasons, it was considered *Not Significant.*
  - Although this residual effect is *Not Significant,* “serious harm to fish” is prohibited under Section 35 of the *Fisheries Act.* Serious harm to fish includes permanent alteration or destruction of fish habitat. Activities causing serious harm to fish require an Authorization under subsection 35(2) of the *Fisheries Act*.
- Anchor drag/scour may cause temporary displacement or avoidance for some fish.
  - Motile fish and invertebrates are expected to leave the area of physical disturbance. Displacement or avoidance would occur only within the Anchorage area and once the anchor is pulled, fish may return to the area. Although the magnitude of impact is moderate, the disturbance is temporary and localized which makes this residual effect *Not Significant.*
- Anchor drag/scour will result in direct mortality of individual fish.
  - Motile fish and invertebrates will likely avoid the disturbance but infaunal and epifaunal invertebrates will experience mortality because of physical contact with the anchor and/or anchor drag. This has a high magnitude of impact for the individuals and potentially a local population, but is unlikely to have a species-level effect.

  - This residual effect has a high magnitude of impact for the individual but is restricted to the Anchorage area. Further, local populations may recover and recolonize if there is sufficient time between disturbances. This residual effect was considered to be *Not Significant.*
  - Although this residual effect is *Not Significant,* “serious harm to fish” is prohibited under Section 35 of the *Fisheries Act.* Serious harm to fish includes death of fish. Activities causing serious harm to fish require an Authorization under subsection 35(2) of the *Fisheries Act*.
- Anchoring may disturb sediments and increase turbidity, causing temporary displacement or avoidance behaviour.
  - Fish may temporarily leave the Anchorage area if turbidity increases considerably. Marine waters experience natural fluctuations in turbidity and fish are adapted to these conditions. Immobile benthic organisms may experience mortality if they cannot remove sediments as they resettle.
  - Although turbidity increases may have a moderate magnitude of impact, the effect is localized and temporary. If turbidity is sufficient to elicit avoidance behaviour, the displacement would be temporary as turbidity typically returns to pre-disturbance conditions quickly (e.g., within several tide cycles, depending on other contributing environmental factors). Mortality of immobile invertebrates is unlikely to occur as this would require substantial amounts of sediments resettling over a long period of time. Mortality would also be limited to individuals and not likely have a species-level impact. This residual effect was considered *Not Significant.*
- Contact with deleterious substances may cause physical harm.
  - Intentional and operational releases of pollutants are prohibited by federal regulations and international convention. Accidental releases are considered unlikely and/or infrequently to occur.
  - Release of a deleterious substance would have a high magnitude of impact and could persist beyond the temporal boundary of the Anchorages. Although this residual effect would occur infrequently (once) it may be only partially reversible and is therefore considered to be *Significant*. However, the likelihood of occurrence is low.
- Release of deleterious substances to the aquatic environment can reduce habitat quality for fish because of decreased water quality, loss of vegetation or loss of forage fish and other food sources.
  - Release of a deleterious substance could have a high impact to habitat quality. Habitat may be degraded within the LSA but would not likely be impacted on a regional scale and would recover over time. Food sources within the Anchorage area and potentially within the LSA may be temporarily limited and cause fish to seek food elsewhere.
  - Although this residual effect would occur infrequently (once) it may be only partially reversible and is therefore considered to be *Significant*. However, the likelihood of occurrence is low.

Aboriginal, Recreational and Commercial Fisheries

Two potential residual effects to fisheries were identified:

- Physical presence of vessels may cause temporary displacement of fisheries.
  - Limited information was available to assess this effect. Since the Anchorages are anticipated to hold “overflow” traffic while vessels wait to enter PMV accurate prediction of usage is not possible. However, peak backlogs at PMV have traditionally occurred in winter months. Usage of the Anchorage area for recreational

and commercial fisheries is concentrated in summer months with ancillary use in spring and fall. Because the peak usage for the two activities do not overlap, displacement is anticipated to be minimal.

- Although displacement at the time of occurrence is inconvenient, it is temporary and limited to a small area. Therefore, this residual effect is considered *Not Significant.*

- Quantity and quality of fish may be reduced, reducing fisheries availability, by release of deleterious substance to the aquatic environment.
  - Although intentional or operational releases are prohibited and accidental releases are unlikely, release of a deleterious substance could have a high impact to fish and aquatic habitat which can reduce the availability of fisheries. The quantity of fish available to be captured may be reduced if they are physically harmed (mortality) by contact with the deleterious substance or if their habitat quality is degraded sufficiently to cause displacement. Similarly the quality of fish available for capture may be degraded if the deleterious substance causes physical malady.
  - This effect may have a high magnitude of impact within the LSA and could persist for multiple seasons. Although this residual effect would occur infrequently (once) it may be only partially reversible and is therefore considered to be *Significant*. However, the likelihood of occurrence is low.

Table 8-1: Potential Effects

Potential Interaction	Mitigation	Potential Residual Effect	Comments
Air Quality			
Vessels will contribute air emissions that have the potential to exceed BC AAQOs or CAAQs. *Section 7.1*	▪ Vessels must adhere to MARPOL, Annex VI (Prevention of Air Pollution from Ships 2005) and Canada Shipping Act regulations which limit emissions from ship exhausts and provides mandatory technical and operational energy efficiency measures aimed at reducing greenhouse gas emissions from ships. ▪ Minimize maneuvering. ▪ Reduce speed as much as possible while maneuvering.	▪ Temporary exceedance of BC AAQO or CAAQS.	▪ Federal regulations (Canada Shipping Act) and international conventions (MARPOL) that limit air emissions are applicable to vessels in Canadian waters. ▪ The shipping industry is using lower sulphur fuels more commonly and is continually lowering engine emission rates of other air contaminants (in particular NOx) with use of new engine design, engine retrofits and use of fuel catalysts. As of January 1, 2015 the maximum sulphur content in fuel oil was decreased to 0.1% within the North American Emission Control Area (ECA) which extends 200 nautical miles from shore (RWDI 2013 in Tetra Tech EBA 2016b, page 4). ▪ Newer ships have more efficient engines and often have pollution control devices. Older ships may be retrofitted with new technologies. Local ports around the world are increasingly requiring specific control technologies such as cold ironing or the use of lower sulfur fuels and other emission-control technologies when ships are operated under port jurisdiction (Chul-hwan 2010). ▪ Speed reduction while approaching shore and navigating within ports reduces ship engine NOx emissions by reducing the load on the vessel's main engines and has been shown to reduce NOx emissions by 4 to 8% (Chul-hwan 2010). ▪ Air dispersion modelling (Appendix B) found that when vessels were anchored (the scenario that will occur most frequently in the Anchorage area) air quality objectives were generally met. Exceedances occurred during maneuvering (which accounts for a small portion of the time vessels are in the Anchorage area) and were concentrated directly over the vessel.
Water Quality			
Anchoring may disturb sediments and increase turbidity above BC AWQG. *Section 7.2.1*	▪ Vessels are expected to comply with *Practices and Procedures to be Followed by Ships in the Port Of Nanaimo* (NPA 2009), which include retaining sufficient crew to safely anchor and frequently checking position by more than one navigational method to ensure the ship is not dragging anchor. ▪ Minimize maneuvering/active use of engines and reduce vessel speed to avoid disturbance by propellers. ▪ Conduct turbidity monitoring (before, during and after vessel occupation) to establish background conditions and evaluate magnitude of temporary increases.	▪ Temporary exceedance of BC AWQG.	▪ Turbidity increases are anticipated to be temporary and localized. ▪ Background turbidity levels in the Anchorage area are unknown. Only relative changes to turbidity can be determined, based on changes before, during and after vessel occupation.
Vessels may introduce NIS and/or chemical residues to local waters through ballast water exchange. *Section 7.2.2*	▪ Vessels must conduct mid-ocean ballast water exchange as per Transport Canada (Ballast Water Control and Management Regulations pursuant to the Canada Shipping Act), PMV and NPA requirements. ▪ In accordance with the *Practices and Procedures to be Followed by Ships in the Port Of Nanaimo* (NPA 2009) and the NPA Ballast Water Exchange Policy, vessels should have their ballast water inspected by NPA officers or employees to ensure compliance. ▪ Conduct regular biological monitoring of the aquatic environment to detect potential presence of NIS and/or changes in other environmental conditions, including detection of chemical residues.	▪ None	▪ Ballast water may contain NIS and/or chemical residues despite best efforts as mid-ocean exchange is not always effective (Mire 2016b). ▪ The IMO, along with Canada and other countries, is advocating for use of approved ballast water management systems (such as filtration, deoxygenation or irradiation) to manage NIS. New technologies are continually being develop and installed to reduce the risk of NIS introduction. ▪ In addition to meeting the IMO standards for NIS, treated ballast water must be demonstrated not to contain chemicals that pose risk to human health or the environment (Scriven et al. 2015 in Mire 2016b).

Table 8-1: Potential Effects

Potential Interaction	Mitigation	Potential Residual Effect	Comments
Vessels may release pollutants such as sewage, garbage or oily water that can decrease water quality. *Section 7.2.2*	▪ It is expected that vessels will be maintained in good working order and comply with *Canada Shipping Act* regulations and MARPOL requirements to prevent the operational or accidental discharge of deleterious substances. ▪ Should a deleterious substance be accidentally released, it is expected that the vessel would have a shipboard emergency response plan, as well as an arrangement with a certified response organization that would quickly respond to a spill on the polluter's behalf, as per Transport Canada requirements. Rapid response is key to minimizing potential impacts.	▪ Exceedances of BC AWQG and the CCME Water Quality Guidelines for the Protection of Aquatic Life.	▪ Intentional and operational releases are prohibited by federal regulation (*Canada Shipping Act*, Vessel Pollution and Dangerous Chemicals Regulation) and international convention (MARPOL Annex I and II) ▪ Accidental releases are considered unlikely but effects and mitigation are discussed in Section 9.0.
Acoustic Environment			
Vessels will produce in-air and underwater sounds that may disturb people. *Section 7.3*	▪ Minimize maneuvering (vessels in transit are louder than anchored vessels). ▪ Application of RDN Bylaw No. 1046 (1996) prohibits noise disturbances from 22:00 to 08:00.	▪ None	▪ Vessels in transit are louder than those anchored. ▪ In-air noise impacts to people are not expected as modelled in-air sound levels (31 to 39 dBA) are below the best known guidelines for noise and below the likely ambient sounds levels for quiet rural areas (45 dBA) ▪ Underwater noise impacts to people is not expected. Modelled noise levels are below thresholds suggested by NURC (2006) and divers are not expected to occur within close proximity to vessels.
Light			
Vessels will contribute artificial light emissions (light spill) that may exceed applicable guidelines and disturb people. *Section 7.4*	▪ Vessels are expected to maintain lighting requirements as per CRC and IMO requirements. ▪ Vessels should conduct maneuvering during daylight hours when light movement will be less noticeable. ▪ Vessels are anticipated to remain anchored at the designated location (i.e., in the "center" of the anchorage), which will maintain an adequate distance to minimize light spill to shore.	▪ None	▪ All vessels are required to have certain navigational lights (CRC 2016). Vessels are unlikely to display extraneous lighting which can be contrary to these regulations and confusing to other boats. Additional lighting is generally restricted to that required for crew safety while moving on deck. ▪ Vessel lighting will be visible to onshore residents but is not expected to increase ambient lighting beyond CIE 2003 guidelines.
Terrestrial Mammals and Marine Birds			
The physical presence of vessels may disturb or harm terrestrial wildlife, specifically birds, by causing displacement or changes in behaviour. *Section 7.5.1*	▪ Establish standard routes for arrival and departure. ▪ Reduce vessel speed. ▪ Minimize maneuvering.	▪ Physical presence of vessels can cause temporary displacement or changes in behaviour (e.g., avoidance).	▪ Vessel strikes causing injury or mortality are considered unlikely because of species mobility and anticipated slow vessel speeds. ▪ Displacement or behavioural changes, if any, are anticipated to be temporary. Many species have shown capacity to habituate to vessel presence, especially if movements are slow and predictable. ▪ Recreational and commercial vessels, such as the ones that currently utilize the Anchorage area, have been shown to have a greater impact on seabirds than large vessels because of their faster and often more erratic movements.
Terrestrial wildlife may be disturbed by changes in ambient light conditions caused by artificial light contributions from vessels. *Section 7.5.2*	▪ Vessels are expected to maintain lighting requirements as per CRC and IMO requirements. ▪ Vessels should conduct maneuvering during daylight hours when light movement will be less noticeable. ▪ Encourage vessels to extinguish all non-essential lighting at night.	▪ None	▪ Vessels are unlikely to display extraneous lighting which can be contrary to the CRC and confusing to other boats. Additional lighting is generally restricted to that required for crew safety while moving on deck. ▪ Light spill from a typical tanker is estimated to be concentrated in the immediate vicinity of the vessel (2 lux) and decrease to levels (0.2 lux) similar to a clear night with a full moon.
Vessels will produce in air noise that may disturb terrestrial wildlife by causing adverse behavioural responses or altered behaviour. *Section 7.5.3*	▪ Apply Environment and Climate Change Canada (2013) guidelines to protect seabirds, such as: – Maintain a distance of at least 300 m from a sea bird colony; – Avoid any sharp or loud noises, do not blow horns or whistles except as required under CRC 2016; and – Maintain constant engine noise levels (by minimizing maneuvering).	▪ None.	▪ Noise disturbances to terrestrial wildlife and seabirds is expected to be minimal. Noise modelling indicates that the Anchorages are not likely to produce sounds above background levels.

Table 8-1: Potential Effects

Potential Interaction	Mitigation	Potential Residual Effect	Comments
Wildlife that use the foreshore or marine waters, especially marine birds, have potential to be negatively affected by deleterious substances released to the aquatic environment (physical contact or ingestion). *Section 7.5.4*	▪ It is expected that vessels will be maintained in good working order and comply with Canada Shipping Act regulations and MARPOL requirements to prevent the operational or accidental discharge of deleterious substances. ▪ Should a deleterious substance be accidentally released, it is expected that the vessel would have a shipboard emergency response plan, as well as an arrangement with a certified response organization that would quickly respond to a spill on the polluter's behalf, as per Transport Canada requirements. Rapid response is key to minimizing potential impacts.	▪ Terrestrial mammals and marine birds may come in contact with deleterious substance and be physically harmed. ▪ Terrestrial mammals and marine birds may be indirectly impacted by reduced habitat quality (including food sources).	▪ If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur. ▪ Accidental releases are considered unlikely but effects and mitigation are discussed in Section 9.0.
Marine Mammals			
Vessel movements have the potential to injure or kill marine mammals by directly striking individuals. *Section 7.6.1*	▪ *Marine Mammal and Sea Turtle Technical Memo*, prepared by Tetra Tech EMI (Zoidis 2016; Appendix F) recommends several measures that may be implemented by either the vessel or the host port: – Restrict vessel approach and departure speed to no greater than 10 knots. The BC Cetacean Sightings Network recommends slowing to less than 7 knots when within 400 m of a whale. – Require a bridge monitor to be onboard to watch for marine mammals during approaches and departures and during initial transit, consisting of a continuous lookout from the bridge, scanning with binoculars for cetaceans and pinnipeds (though during night operations, lights are not as part of the monitoring effort, due to issues relating to light for marine wildlife and birds). – Incoming and outgoing vessels should communicate with NPA harbor master or officer as well as with other vessels operating within the area to relay or receive the location and other relevant information for any listed species entering or occurring during approaches and departures, and will abide by instructions, including the possibility of reducing vessel speed or halting vessel movement until the animal leaves the vicinity. – Approaches and departures should be postponed or halted when marine mammals are within 100 m of the vessel. – No one associated with the vessels should attempt to feed, touch, pursue or otherwise intentionally interact with any listed marine species. – To the extent possible, when piloting vessels, vessel operators should adjust speed and/or alter course to remain at least 100 m from whales, and at least 50 m from other marine mammals, and will not pilot the vessel as to cause another vessel or object to approach within 100 m. – If despite efforts to maintain the distances and speeds described above, a marine mammal approaches the vessel, and only if the safety of the vessel, crew, and adjacent habitat is assured, put the engine in neutral until they animal moves away and then slowly (under 5 knots) move away to the prescribed distance. – Marine mammals should not be encircled or trapped between multiple vessels or between vessels and the shore. – Implement seasonal occupancy maximums – e.g., in the summer allow a maximum of 3 vessels anchored at a time and keeping 1 or 2 anchorages empty at all times in the summer. – Reduce the number of days ships are at anchor and allow no more than 5 days in a row, when possible. – Develop a site-specific Marine Mammal Monitoring and Mitigation Plan that addresses the resources in the area, and develop a discreet set of mitigations that the vessels would follow to minimize ship strike impacts including but not limited to, seasonal restrictions, staggering departures, arrivals, and occupancy, etc.	▪ Individuals may be injured or killed by ship strike.	▪ Increased vessel presence inherently increases the potential for ship strikes on marine mammals to occur. However, application of the mitigation measures reduces the likelihood of occurrence. ▪ Effect is permanent to the individual but may not have a population- or species-level effect.

Table 8-1: Potential Effects

Potential Interaction	Mitigation	Potential Residual Effect	Comments
	▪ Include the Anchorage area in the Enhancing Cetacean Habitat and Observation (ECHO) Program (PMV 2015). This initiative is led by PMV and aims to develop mitigation measures that will lead to a quantifiable reduction in potential threats to whales as a result of shipping activities, including ship collisions.		
The physical presence of the anchor chain in the water column can cause altered behaviour or displacement. *Section 7.6.1*	▪ None	▪ Anchor chain presence can cause temporary changes in marine mammal behaviour (i.e., avoidance) or temporary displacement.	▪ It is acknowledged that anchor chains in the water column could have an effect on marine mammals (Zoidis 2016, DFO 2014) but evaluation is limited by the lack of published research. ▪ Marine mammals are highly mobile and generally capable of avoiding a dropped anchor and chain. ▪ Avoidance behaviour is likely of negligible magnitude as marine mammals encounter and evade other obstacles. ▪ Potential displacement caused by presence of multiple chains would be temporary.
Vessels will contribute artificial light emissions (light spill) to the aquatic environment that may disturb marine mammals. *Section 7.6.2*	▪ Vessels are expected to maintain lighting requirements as per CRC and IMO requirements. ▪ Encourage vessels to disable all non-essential lighting at night.	▪ Artificial light spill to the water can cause temporary changes in marine mammal behaviour or displacement.	▪ All vessels are required to have certain navigational lights (CRC 2016). Vessels are unlikely to display extraneous lighting which can be contrary to these regulations and confusing to other boats. Additional lighting is generally restricted to that required for crew safety while moving on deck. ▪ Light spill to the aquatic environment is anticipated to be localized (i.e., near the surface in the immediate vicinity of the vessel). ▪ Any displacement would be temporary.
Vessels will produce sounds in-air and underwater that may disturb marine mammals, causing altered behaviour or displacement. *Section 7.6.3*	General noise mitigation: ▪ Minimize maneuvering (vessels in transit are louder than anchored vessels). ▪ Determine baseline noise conditions so potential noise impacts can be accurately monitored. ▪ Develop a site-specific Marine Mammal Monitoring and Mitigation Plan that addresses the resources in the area, and develop a discreet set of mitigations that the vessels would follow to minimize noise impacts including but not limited to, seasonal restrictions, staggering departures, arrivals, and occupancy, etc. ▪ Include the Anchorage area in the Enhancing Cetacean Habitat and Observation (ECHO) Program (PMV 2015). This initiative is led by PMV and aims to develop mitigation measures that will lead to a quantifiable reduction in potential threats to whales as a result of shipping activities, including noise disturbance. In-air mitigation: ▪ Avoid use of ship whistle, except as required under CRC 2016. ▪ Avoid the use of deck side loud hailers. ▪ Minimize use of power tools, generators etc. and avoid use in non-daylight hours. Underwater mitigation: ▪ Minimize number of generators running. ▪ Implement seasonal occupancy maximums – e.g., in the summer allow a maximum of 3 vessels anchored at a time and keeping 1 or 2 anchorages empty at all times in the summer. ▪ Limit the number of days ships are at anchor and allow no more than 5 days in a row, when possible.	In-Air Noise ▪ None Underwater Noise ▪ Underwater noise can cause behavioural changes (i.e., avoidance) or temporary displacement.	▪ Noise modelling suggests in-air noise generated by the Anchorages will be 40 to 50 dBA, which is not expected to negatively impact marine mammals. These values are below the levels NOAA (2016) considers to cause disturbance or injury. ▪ The NOAA (2016) exposure thresholds for marine wildlife 160 dB RMS for disturbance and 180 dB RMS for injury/hearing loss) would likely be masked by existing noise. Noise modelling suggests underwater noise may approach 160 dB RMS in the immediate vicinity of a vessel but would likely never exceed 180 dB RMS. ▪ Underwater noise generated by the Anchorages is not expected to cause permanent threshold shift effects (or MMPA Level A Harassment) but may cause temporary threshold shifts (MMPA Level B Harassment) such as behavioural changes. ▪ Continuous (often referred to as non-pulse) sounds such as those produced by shipping and dredging are not likely to cause mortality or injury to marine mammals, as they lack the rapid rise-time to maximum pressure that characterizes pulse noises (NOAA 2016). ▪ Local populations of marine mammals are likely accustomed to underwater noise as there is already abundant boat traffic in the area. Although the Anchorage-generated noise alone is not expected to have an adverse impact, the addition of another source in an already noisy environment could be negative.

Table 8-1: Potential Effects

Potential Interaction	Mitigation	Potential Residual Effect	Comments
Anchor drag may increase turbidity in the Anchorage area which can cause altered behaviour or displacement. *Section 7.6.4*	▪ Minimize maneuvering/active use of engines and reduce vessel speed to avoid disturbance by propellers. ▪ Conduct turbidity monitoring (before, during and after vessel occupation) to establish background conditions and evaluate magnitude of temporary increases.	▪ Increased turbidity can cause behavioural changes (i.e., avoidance) or temporary displacement.	▪ Turbidity increases are anticipated to be temporary and localized. ▪ Marine mammals frequently inhabit naturally turbid waters and many use non-visual systems such as sonar to perceive their environment. ▪ Marine mammals are highly mobile and would likely temporarily avoid areas with excessive turbidity.
Marine mammals have potential to be negatively affected by deleterious substances released to the aquatic environment (physical contact or ingestion). *Section 7.6.5*	▪ It is expected that vessels will be maintained in good working order and comply with Canada Shipping Act regulations and MARPOL requirements to prevent the operational or accidental discharge of deleterious substances. ▪ Should a deleterious substance be accidentally released, it is expected that the vessel would have a shipboard emergency response plan, as well as an arrangement with a certified response organization that would quickly respond to a spill on the polluter's behalf, as per Transport Canada requirements. Rapid response is key to minimizing potential impacts.	▪ Marine mammals may come in contact with deleterious substance and be physically harmed. ▪ Marine mammals and may be indirectly impacted by reduced habitat quality (including food sources).	▪ If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur. ▪ Accidental releases are considered unlikely but effects and mitigation are discussed in Section 9.0.
Fish and Aquatic Habitat			
The physical presence of the anchor chain in the water column can cause altered behaviour or displacement. *Section 7.7.1*	▪ None	▪ Anchor chain presence can cause changes in fish behaviour (i.e., avoidance) or temporary displacement.	▪ It is acknowledged that anchor chains in the water column could have an effect on marine mammals (Zoidis 2016, DFO 2014) but evaluation is limited by the lack of published research. ▪ Motile fish (e.g., finfish, sharks) and invertebrates most likely to encounter the chain are highly mobile and generally capable of avoiding it. ▪ Avoidance behaviour is likely of negligible magnitude as fish often encounter and evade other obstacles. ▪ Potential displacement causes by presence of multiple chains would be temporary.
Vessels will contribute artificial light emissions (light spill) to the aquatic environment that may disturb fish. *Section 7.7.2*	▪ Vessels are expected to maintain lighting requirements as per CRC and IMO requirements. ▪ Encourage vessels to disable all non-essential lighting at night.	▪ Artificial light spill to the water can cause changes in fish behaviour (e.g., displacement) ▪ Artificial light spill can cause increased risk of predation.	▪ All vessels are required to have certain navigational lights (CRC 2016). Vessels are unlikely to display extraneous lighting which can be contrary to these regulations and confusing to other boats. Additional lighting is generally restricted to that required for crew safety while moving on deck. ▪ Light spill to the aquatic environment is anticipated to be localized (i.e., near the surface in the immediate vicinity of the vessel). ▪ Any displacement would be temporary. ▪ It is anticipated that the vessels will not utilize unnecessary or high-intensity lighting that would attract fish (such as is used in some commercial fisheries). With limited attractant, schooling, and subsequently predation, is anticipated to be negligible.
Vessels will produce sounds underwater that may disturb fish by causing altered behaviour or displacement. *Section 7.7.3*	▪ Minimize maneuvering (vessels in transit are louder than anchored vessels). ▪ Minimize number of generators running. ▪ Implement seasonal occupancy maximums – e.g., in the summer allow a maximum of 3 vessels anchored at a time and keeping 1 or 2 anchorages empty at all times in the summer. ▪ Limit the number of days ships are at anchor and allow no more than 5 days in a row, when possible. ▪ Determine baseline noise conditions so potential noise impacts can be accurately monitored.	▪ Underwater noise can cause changes in fish behaviour (i.e., avoidance) or temporary displacement.	▪ Underwater noise emissions were modelled below levels that typically cause injury. ▪ There are no standards for behaviour response in fish but it is known that fish can exhibit responses to excessive noise. ▪ Modelling (Appendix C) suggests underwater noise generated by the Anchorages would be within the range of noise in a waterbody with boat traffic (Caltrans 2015).

Table 8-1: Potential Effects

<table>
<tr><th>Potential Interaction</th><th>Mitigation</th><th>Potential Residual Effect</th><th>Comments</th></tr>
<tr><td></td><td></td><td></td><td>Effects are anticipated to be localized and temporary. Fish are anticipated to respond and adapt to Anchorage-generated noise in a similar manner to existing responses.</td></tr>
<tr><td>Anchor scour may result in the disturbance or direct mortality of fish and/or the disturbance or destruction of fish habitat.
Section 7.7.4</td><td>Benthic recolonization may be possible if an area is left undisturbed for a sufficient period of time. A sequence of anchorage use is recommended by Mire (2016) to limit disturbances in areas that may be more sensitive (e.g., anchorages G4 and G5 are closer to reported kelp forests, eel grass beds and geoduck habitat) :
<table>
<tr><th>Number of Vessels Present Simultaneously</th><th>Vessel #1</th><th>Vessel #2</th><th>Vessel #3</th><th>Vessel #4</th><th>Vessel #5</th></tr>
<tr><td>1</td><td>G1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>G1</td><td>G3</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td>G1</td><td>G3</td><td>G2</td><td></td><td></td></tr>
<tr><td>4</td><td>G1</td><td>G3</td><td>G2</td><td>G4</td><td></td></tr>
<tr><td>5</td><td>G1</td><td>G3</td><td>G2</td><td>G4</td><td>G5</td></tr>
</table>
Should an Authorization under the Fisheries Act be required, a Habitat Offsetting Plan, pursuant to Section 35(2), would be developed in consultation with the appropriate regulatory agencies, public and First Nations stakeholders.</td><td>Anchor drag/scour will cause localized destruction of fish habitat.
Anchor drag/scour can cause temporary displacement or changes in behaviour (e.g., avoidance) for fish.
Anchor drag/scour will result in direct mortality of individual fish.</td><td>Effects on local populations of marine vegetation, infaunal and epifaunal invertebrates would be major and significant, resulting in severe reduction populations in the active Anchorage areas.
Finfish and motile invertebrates are anticipated to avoid the physical disturbance.
No species-level effects are anticipated as impacts will be localized.
No effects to kelp or eelgrass are anticipated as scour will mostly be limited to depths where vegetation does not grow (+40 m). Subsequently, fish use of this vegetation, such as herring spawning, is also not expected to be negatively impacted by scour.
Disturbance of the soft-bottom benthic habitat in the proposed Anchorage area would not contribute appreciably to the decline of resident species (Mire 2016).
Sequenced anchorage use will only reduce the duration of the effect, not eliminate it. Minimizing use at G4 and G5 would allow potential recolonization in between occupancy, which can support other ecological functions such as foraging, but as soon as an anchor is dropped the seafloor will be disturbed again.
“Serious harm to fish” is prohibited under Section 35 of the Fisheries Act. Serious harm to fish includes permanent alteration or destruction of fish habitat and death of fish. Activities causing serious harm to fish require an Authorization under subsection 35(2) of the Fisheries Act.</td></tr>
<tr><td>Sediments physically disturbed by anchors may increase turbidity, which has potential to harm fish or fish habitat.
Section 7.7.5</td><td>Minimize maneuvering/active use of engines and reduce vessel speed to avoid disturbance by propellers.
Conduct turbidity monitoring (before, during and after vessel occupation) to establish background conditions and evaluate magnitude of temporary increases.</td><td>Increased turbidity can cause altered behaviour (i.e., avoidance) or temporary displacement.</td><td>Turbidity increases are anticipated to be temporary.
Background turbidity levels in the Anchorage area are unknown. Only relative changes to turbidity can be determined, based on changes before, during and after vessel occupation.
Finfish and motile invertebrates may be temporarily displaced but are unlikely to experience injury or mortality as they are expected to leave areas with excessive turbidity.
Mortality may occur in immobile benthic organisms if they cannot remove sediments. However, impacts are expected to be localized and not affect populations beyond the Anchorage area.</td></tr>
<tr><td>Fish and fish habitat have potential to be negatively affected by deleterious substances released to the aquatic environment
(physical contact or ingestion).
Section 7.7.6</td><td>It is expected that vessels will be maintained in good working order and comply with Fisheries Act and Canada Shipping Act regulations as well as MARPOL requirements to prevent the operational or accidental discharge of deleterious substances.
Should a deleterious substance be accidentally released, it is expected that the vessel would have a shipboard emergency response plan, as well as an arrangement with a certified response organization that would quickly respond to a spill on the polluter's behalf, as per Transport Canada requirements. Rapid response is key to minimizing potential impacts.
Should monitoring conducted by the EC Canadian Shellfish Sanitation Program indicate increasing levels of contaminants additional, adaptive measures may be implemented such as:
– Monitoring by NPA officers to ensure vessels observe applicable regulations; and
– Temporary closure of anchorages.</td><td>Fish may come in contact with deleterious substance and be physically harmed.
Aquatic habitat quality may be reduced because of impacts to water quality, loss of aquatic vegetation and/or loss of forage fish.</td><td>If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur.
Accidental releases are considered unlikely but effects and mitigation are discussed in Section 9.0.</td></tr>
</table>

Table 8-1: Potential Effects

Potential Interaction	Mitigation	Potential Residual Effect	Comments
Aboriginal, Recreational and Commercial Fisheries			
Physical presence of vessels may displace fisheries, by being a navigational challenge to other boats or restricting access. *Section 7.8.1*	▪ None	▪ Fisheries can be temporarily displaced.	▪ Limited information was available to assess this effect. However, peak usage for the Anchorages is not anticipated to overlap peak fisheries usage. ▪ Any displacement is anticipated to be temporary.
Sewage, grey water, ballast water and other deleterious substances such as oily water have the potential to indirectly affect fisheries by impacting fish and fish habitat *Section 7.8.2*	▪ It is expected that vessels will be maintained in good working order and comply with Fisheries Act and Canada Shipping Act regulations as well as MARPOL requirements to prevent the operational or accidental discharge of deleterious substances. ▪ Should a deleterious substance be accidentally released, it is expected that the vessel would have a shipboard emergency response plan, as well as an arrangement with a certified response organization that would quickly respond to a spill on the polluter's behalf, as per Transport Canada requirements. Rapid response is key to minimizing potential impacts. ▪ Should monitoring conducted by the EC Canadian Shellfish Sanitation Program indicate increasing levels of contaminants additional, adaptive measures may be implemented such as: – Monitoring by NPA officers to ensure vessels observe applicable regulations; and – Temporary closure of anchorages.	▪ Quantity and quality of fish available may be reduced.	▪ If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur. ▪ Accidental releases are considered unlikely but effects and mitigation are discussed in Section 9.0.

Table 8-2: Residual Effects Characterization and Significance

Interaction	Residual Effect	Step 1				Step 2			Step 3
		Magnitude	Geographical Extent	Duration	Significance	Frequency	Reversibility	Significance	Likelihood
Air Quality									
Vessels will contribute air emissions that have the potential to exceed BC AAQOs or CAAQs.	▪ Temporary exceedance of BC AAQOs or CAAQs.	Moderate	LSA	Short Term	Not Significant	-	-	-	-
Water Quality									
Anchoring may disturb sediments and increase turbidity above BC AWQG.	▪ Temporary exceedance of BC AWQG.	High	LSA	Short Term	Not Significant	-	-	-	-
Vessels may release pollutants/ deleterious substances such as sewage, garbage or oily water that can decrease water quality.	▪ Exceedances of BC AWQG and the CCME Water Quality Guidelines for the Protection of Aquatic Life.	High	LSA	Medium Term	Potentially Significant	Once	Partially Reversible	***Significant***	Low
Terrestrial Wildlife and Marine Birds									
The physical presence of vessels may disturb or harm terrestrial wildlife, specifically birds, by causing displacement or changes in behaviour.	▪ Physical presence of vessels can cause temporary displacement or changes in behaviour (e.g., avoidance).	Low	Localized	Short Term	Not Significant	-	-	-	-
Wildlife that use the foreshore or marine waters, especially marine birds, have the potential to be negatively affected by deleterious substances released to the environment.	▪ Terrestrial mammals and marine birds may come in contact with deleterious substance and be physically harmed.	High	LSA	Medium Term	Potentially Significant	Once	Partially Reversible	***Significant***	Low
	▪ Terrestrial mammals and marine birds may be indirectly impacted by reduced habitat quality (including food sources).	High	LSA	Medium Term	Potentially Significant	Once	Partially Reversible	***Significant***	Low
Marine Mammals									
Vessel movements have the potential to injure or kill marine mammals by directly striking individuals.	▪ Individuals may be injured or killed by ship strike.	High	LSA	Medium Term	Potentially Significant	Once	Non Reversible	***Significant***	Low
The physical presence of the anchor chain in the water column can cause altered behaviour or displacement.	▪ Anchor chain presence can cause temporary changes in marine mammal behaviour (i.e., avoidance) or temporary displacement.	Moderate	Localized	Short Term	Not Significant	-	-	-	-
Vessels will contribute artificial light emissions (light spill) to the aquatic environment that may disturb marine mammals.	▪ Artificial light spill to the water can cause temporary changes in marine mammal behaviour (i.e., avoidance) or displacement.	Low	Localized	Short Term	Not Significant	-	-	-	-
Vessels will produce sounds in-air and underwater that may disturb marine mammals, causing altered behaviour or displacement.	▪ Underwater noise can cause behavioural changes (i.e., avoidance) or temporary displacement.	Low	Localized	Short Term	Not Significant	-	-	-	-
Anchor drag may increase turbidity in the Anchorage area which can cause altered behaviour or displacement.	▪ Increased turbidity can cause behavioural changes (i.e., avoidance) or temporary displacement.	Moderate	Localized	Short Term	Not Significant	-	-	-	-
Marine mammals have the potential to be negatively affected by deleterious substances released to the aquatic environment.	▪ Marine mammals may come in contact with deleterious substance and be physically harmed.	High	LSA	Medium Term	Potentially Significant	Once	Partially Reversible	***Significant***	Low
	▪ Marine mammals and may be indirectly impacted by reduced habitat quality (including food sources).	High	LSA	Medium Term	Potentially Significant	Once	Partially Reversible	***Significant***	Low

Table 8-2: Residual Effects Characterization and Significance

Interaction	Residual Effect	Step 1				Step 2			Step 3
		Magnitude	Geographical Extent	Duration	Significance	Frequency	Reversibility	Significance	Likelihood
Fish and Fish Habitat									
The physical presence of the anchor chain in the water column can cause altered behaviour or displacement.	▪ Anchor chain presence can cause changes in fish behaviour (i.e., avoidance) or temporary displacement.	Moderate	Localized	Short Term	Not Significant	-	-	-	-
Vessels will contribute artificial light emissions (light spill) to the aquatic environment that may disturb fish.	▪ Artificial light spill to the water can cause temporary changes in fish behaviour (i.e., avoidance) or displacement.	Low	Localized	Short Term	Not Significant	-	-	-	-
	▪ Artificial light spill can increase risk of predation.	Low	LSA	Short Term	Not Significant	-	-	-	-
Vessels will produce sounds underwater than may disturb fish by causing altered behaviour or displacement.	▪ Underwater noise can cause changes in fish behaviour (i.e., avoidance) or temporary displacement.	Low	Localized	Short Term	Not Significant	-	-	-	-
Anchor scour may result in the disturbance or direct mortality of fish and/or the disturbance or destruction of fish habitat.	▪ Anchor drag/scour will cause localized destruction of fish habitat.	High	Localized	Medium Term	Not Significant	-	-	-	-
	▪ Anchor drag/scour can cause temporary displacement or changes in behaviour (i.e., avoidance) for fish.	Moderate	Localized	Short Term	Not Significant	-	-	-	-
	▪ Anchor drag/scour will result in direct mortality of individual fish.	High	Localized	Medium Term	Not Significant	-	-	-	-
Sediments physically disturbed by anchors may increase turbidity which has potential to harm fish or fish habitat.	▪ Increased turbidity can cause changes in fish behaviour (i.e., avoidance) or temporary displacement.	Moderate	LSA	Short Term	Not Significant	-	-	-	-
Fish and fish habitat have potential to be negatively affected by deleterious substances released to the environment.	▪ Fish may come in contact with deleterious substance and be physically harmed.	High	LSA	Medium Term	Potentially Significant	Once	Partially Reversible	***Significant***	Low
	▪ Aquatic habitat quality may be reduced because of impacts to water quality, loss of aquatic vegetation and/or loss of forage fish.	High	LSA	Medium Term	Potentially Significant	Once	Partially Reversible	***Significant***	Low
Aboriginal, Recreational and Commercial Fisheries									
Physical presence of vessels may displace fisheries, by being a navigational challenge to other boats or restricting access.	▪ Fisheries may be temporarily displaced.	Moderate	Localized	Short Term	Not Significant	-	-	-	-
Sewage, grey water, ballast water and other deleterious substances such as oily water have the potential to indirectly affect fisheries by impacting fish and fish habitat	▪ Quantity and quality of fish available may be reduced.	High	LSA	Medium Term	Not Significant	Once	Partially Reversible	***Significant***	Low

9.0 ACCIDENTS AND MALFUNCTIONS

This section assesses the potential impacts of Anchorage related accidents (unexpected occurrence or unintended action) and malfunctions (failure of a piece of equipment or a system to function normally) on the environment. This EOA does not aim to evaluate all conceivable accidents or malfunctions but addresses only those with a reasonable probability to occur and that may have an environmental impact.

Potential accidents and malfunctions that could adversely affect the environment include:

- Accidental release of a deleterious substance while anchored or following drift/grounding;
- Physical disturbance of aquatic habitat following a grounding incident; and
- Collision with a marine mammal.

Anchorage-related accidents are more likely to be the result of human error, mostly failure to maintain appropriate bridge watch, than equipment failure. Certain environmental conditions may contribute to an increased risk of an accident occurring in the Anchorage area. Strong winds and currents intermittently occur which can result in vessels physically being pushed into shallow waters. Prevailing winds in the Anchorage area are generally parallel to the shoreline, blowing from the southeast in spring and winter and northwest in summer; wind speeds are typically between 1.5 km/h and 43.5 km/h (Weather Spark 2016). Tidal currents, which run parallel to shore, are not considered strong in the Anchorage area; ebb and flow currents typically run at 0.5 and 1 knot, respectively (Young 2015).

Table 9-1: Potential Interactions of Accidents and Malfunctions with VCs

VC	Accident or Malfunction		
	Accidental Release of Deleterious Substance while Anchored or Grounded	Physical Disturbance of Aquatic Habitat During Grounding	Collision with a Marine Mammal
Air Quality	x		
Water Quality	x		
Acoustic Environment			
Light			
Terrestrial Wildlife/Marine Birds	x		
Marine Mammals	x		x
Fish and Fish Habitat	x	x	

9.1 Accidental Release of a Deleterious Substance

Accidental release of a deleterious substance to the aquatic environment could occur while a vessel is anchored as the result of equipment failure or human error. A release could also occur if a vessel drifts, grounds and is damaged.

Most releases of a deleterious substance are hydrocarbon based (i.e., oil spill). “Light” oils, such as gasoline and diesel, evaporate quickly and have less of an impact than “heavy” oils but can cause physical damage or death to plants and animals with contact. Heavy oils, such as bunker fuel in ships, can be less acutely toxic than light oils but may cause long-term health effects because of their persistence.

The primary short-term effect of heavy oils is the physical smothering or coating that occurs with contact. Marine birds and wildlife at the water surface, like otters and pinnipeds, are most likely to come into contact with oils. Feathers and fur lose its insulation value when coated in oil which can cause hypothermia in the organism. Organisms may also become sick from ingesting the oils after trying to clean themselves. Inhaling oil vapors can cause damage to the central nervous system and internal organs. Oil may also smother organisms as it settles (e.g., benthic invertebrates) or washes ashore (e.g., Sandlance, snails, terrestrial wildlife).

Deleterious substances may also include raw sewage, garbage or gray water. If released, these substances have the potential to contaminate shellfish which could, in turn, result in a fisheries closure.

A risk assessment team, comprised of PPA, NPA, the Chamber of Shipping BC and the BC Coast Pilots, evaluated the potential for the Anchorages to pose a risk to safety, security and the environment (Young 2010). That assessment outlines the mitigation available to minimize the risk of accident:

- Pilotage
  - The Anchorage area is within a Compulsory Pilotage Area (Area 2). Vessels are required to follow planned passages to assigned anchorages under navigation of a licenced BC coast pilot. Pilots may be retained to stay on board the vessel in inclement weather and are also available on short notice for emergencies.
- Navigation Bridge Watch
  - Vessels must maintain bridge watch in compliance with regulations (e.g., *Canada Shipping Act*, Marine Personnel Regulations,). Ship navigators are required to monitor the ship's position and weather conditions and maintain a state of readiness capable of effectively reacting to changing situations.
- Administrative Control
  - The Anchorage area is proposed to be under the administrative control of NPA who currently manages 6 nearby anchorages. NPA has policies and procedures to manage anchorages and vessels in their jurisdiction (NPA 2007).
- Marine Domain Awareness
  - NPA utilizes the Marine Domain Awareness system which integrates Automatic Identification System (AIS), radar, high speed thermal and infra-red cameras and weather stations to produce real-time information to identify and monitor vessels. Sensors are also able to detect spills and deviations from traffic patterns. This system allows NPA to monitor vessel positions and alert navigators to potential movement outside an assigned anchor area.
- Vessel Traffic Monitoring
  - All large commercial vessels are monitored by Vessel Traffic Services (VTS) while in BC waters. VTS provides a means for ships and the Marine Communications and Traffic Services, managed by the Coast Guard, to exchange information (Canadian Coast Guard 2013).
- Tug Assistance
  - Tug assistance is available in the surrounding area, in the event of an emergency.

- Environmental Response
  - Response organizations certified by Transport Canada are available in the area. Western Canada Response Corporation has a “boom boat”, the Burrard Cleaner 6, stationed in Nanaimo (WCRC 2013).

Transport Canada commissioned a risk assessment for oil spills in marine waters (WSP Canada Inc. 2014) to inform its review of preparedness for and response to ship-source spills. This assessment determined that Pacific Coast, Sector 1, Subsector 5 had generally high to very high “Environmental Risk Index” – a combination of the probability of a spill occurring and the environmental sensitivity of the area. Subsector 5 encompasses the southern half of Vancouver Island, including the entire Strait of Georgia and PMV, Canada’s busiest port. Tetra Tech EBA notes that the scale of this assessment does not allow for separation between the busy intercoastal routes around southern Vancouver Island to PMV, where vessel traffic is greatest and spills are most likely to occur, and the less active waters nearer the Anchorage area.

Young (2010) determined that the probability of an accident resulting in environmental pollution was unlikely (defined as the event occurring over a period of 10 years) but that the severity of consequence was very high (defined as sustained medium term harm where damage lasts up to one month).

9.2 Physical Disturbance to Aquatic Habitat

Should a vessel drift and ground there would be physical disturbance to aquatic habitat in the shallow waters. Substrates would be disturbed with contact and suspended sediments would temporarily increase turbidity. Depending on the location of the grounding there is potential for aquatic vegetation and infaunal and epifaunal invertebrates (e.g., clam beds) to be destroyed. Motile organisms would likely be capable of avoiding a drifting vessel.

Vessels are require to maintain adequate bridge watch and are monitored through the Marine Domain Awareness, both of which are designed to prevent vessels from drifting outside a designated anchorage. Extreme environmental conditions could result in an unavoidable grounding but the climatic conditions within the mid-Strait of Georgia are historically moderate. The mitigation described in Section 9.1 is applicable to this scenario.

Physical disturbance of aquatic habitat would be localized and temporary. The likelihood of a vessel grounding and causing physical disturbance to aquatic habitat is considered low.

9.3 Collision with Marine Mammals

Collision with marine mammals is considered to be unlikely. The potential effects of ship strike on marine mammals are discussed in Section 7.6. Mitigation measures to reduce the likelihood of collisions are included in Table 8-1.

10.0 CUMULATIVE EFFECTS ASSESSMENT

A Cumulative Effects Assessment (CEA) recognizes the complex ways in which the effects of individual projects and activities interact and combine with each other over space and time. CEAA 2012, Subsection 19(1)(a) requires environmental assessments to include consideration of cumulative effects “that are likely to result from the project in combination with other projects or activities that have been or will be carried out" (Hegmann et al. 1999). There is no regulatory requirement to consider cumulative effects in this EOA.

While an individual effect may not be significant, a CEA considers the potential additive and synergistic effects in combination with past, existing or known planned activities in the vicinity of a project. Although the residual effects of an individual activity may be acceptable, the combined residual effects of several projects may result in unacceptable, significant effects. A project's contribution to cumulative effects is assessed based on its effects on a VC that are also affected by other uses.

For the purposes of this EOA, a high-level CEA has been conducted on the residual adverse effects (Table 8-1). This CEA does not consider the effects of accidents and malfunctions because they are considered to be hypothetical and significant adverse effects following a major accident or malfunction event have a very low probability of occurrence.

10.1 Boundaries

Spatial Boundary

This CEA is limited to other projects or activities and effects that occur within the Anchorage area or LSA, as well as the Nanaimo Harbour. Projects or activities occurring in this area are most likely to interact with the Anchorages. The RSA was not considered for the CEA because it was assumed that the vessels included in the Anchorages would be utilizing the RSA regardless. That is, even if the Anchorages did not occur, those vessels would still be present somewhere in the Strait of Georgia because their ultimate destination was PMV; the Anchorage only shifts their temporary locations. Therefore, the Anchorages do not contribute to cumulative impacts on a regional scale.

Temporal Boundaries

The temporal boundary established begins with the current conditions and extends to known future actions. Known future actions were limited to projects in the spatial boundary that were existing or were public knowledge.

10.2 Included Projects

The list of Included Projects (Table 10-1) is intended as an example to demonstrate the types and relative density of projects that could contribute activities that cumulatively effect the VCs.

Table 10-1: Additional Projects Included in Cumulative Effects Assessment

Category	Example	Primary Activity
Industrial	▪ Harmac Pacific ▪ Duke Point Industrial Park ▪ Coastland Wood Industries ▪ Western Forest Products ▪ Seaspan Coastal Intermodal Terminal ▪ Nanaimo Assembly Wharf ▪ Nanaimo Shipyard	Industrial activities include: shipping, moorage, marine fuel station, boat repair and maintenance, warehouse and container handling, manufacturing, log booming, maintenance dredging.
Ferries	▪ Duke Point ▪ Gabriola ▪ Departure Bay	Daily passenger and car ferry service. Vessels operating out of Duke Point and Departure Bay have capacities of 1193 to 1604 passengers and 290 to 370 cars, with maximum speeds of up to 23 knots. On the Gabriola Island route, the Quinsam has a capacity of 400 people and 70 cars, with a maximum speed of 12 knots. Ferry terminals may conduct maintenance dredging and infrastructure upgrades, including works in water such as pile driving.

Table 10-1: Additional Projects Included in Cumulative Effects Assessment

Category	Example	Primary Activity
Marinas	Nanaimo Harbour ▪ Stone's Marina & Boatyard ▪ Townsite Marina ▪ Newcastle Marina ▪ Waterfront Suites & Marina ▪ Anchorage Marina ▪ NPA Marina ▪ Cameron Island	Local marinas provide moorage and fuel services for small recreational and commercial vessels. Because of the expense and permitting associated with dredging, as well as the small size of vessels using them, it is unlikely that small, private marinas will undergo maintenance dredging. Re-development or upgrading of existing marinas is probable but expansion is unlikely given the already highly developed nature of the area and the limited space available in the LSA and Nanaimo Harbour.
	Gabriola Island ▪ Silva Bay Resort & Marina ▪ Page's Resort & Marina	
Seaplanes	▪ Harbour Air ▪ Sunshine Coast Air ▪ Seair Seaplanes	Seaplane activity in the Nanaimo harbor includes flight, taxing, docking and fueling.
Other	Boats anchoring in Nanaimo Harbour	Boats anchor in the Nanaimo harbor near Newcastle Island and Protection Island.

10.3 Summary of Cumulative Effects

The potential interactions, mitigation measures and adverse residual effects of the Anchorages and other projects with natural environment are summarized in Table 10-2.

Other projects are currently contributing activities that affect the VCs identified for the Anchorages (Table 10-1). These activities represent existing conditions that are the baseline conditions for this CEA. The existing conditions (e.g., volume of vessel traffic, patterns of use, new marine construction or capital dredging) are not expected to change significantly over the duration of the temporal boundary. While minor increases in vessel traffic may occur, future conditions are anticipated to be essentially similar to the current conditions.

A cumulative effect is possible where a residual effect of the Anchorages (Table 8-1) overlaps with the contributions of other activities. If the addition of the Anchorages to the other activities causes a considerable change to the existing condition of a VC, a residual cumulative effect occurs.

Residual effects of the Anchorages were determined to be either Not Significant or unlikely to occur (Table 8-2). Therefore, when the residual effects of the Anchorages were combined with other projects and activities, there were no residual cumulative effects (Table 10-2).No additional mitigation measures beyond those recommended for the Anchorages (Table 8-1) are recommended.

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Table 10-2: Cumulative Effects Assessment

Residual Effects of Anchorages	Potential Residual Effects from Other Projects	Potential Cumulative Effect	Additional Mitigation Measures (applied to Anchorages)	Residual Cumulative Effect
Air Quality				
Vessel emissions can cause a temporary exceedance of BC AAQOs or CAAQs.	Other projects, such as vessel traffic, construction activities and onshore operations, will contribute air emissions.	Combined emissions may result in decreased air quality with BC AAQOs or CAAQ guidelines being exceeded more frequently or with greater magnitude.	None	None ▪ Local air quality is not expected to change significantly from existing conditions because overall volume of vessel traffic in area is unlikely to increase significantly. Further, regulations and ongoing advances in technology are expected to continue lowering engine emission rates.
Water Quality				
Anchoring may disturb sediments which can cause a temporary exceedance of BC AWQG.	Other vessel traffic (recreational, commercial and that associated with industrial activities) will disturb sediments during activities such as anchoring, dredging or pile driving.	Combined sediment disturbances may result in decreased water quality with BC AWQG guidelines being exceeded more frequently or with greater magnitude.	None	None ▪ Volume of boat traffic is not expected to change significantly from current conditions, therefore no significant changes to anchoring is expected. ▪ Dredging, pile driving or other construction activities required permits. Environmental Management Plans (EMP), which include Best Management Practices (BMP) to minimize environmental effects, are usually a condition of the permits. ▪ Turbidity typically subsides quickly in areas subjected to tides and strong currents. ▪ Turbidity from construction activities typically short term and intermittent.
Vessels may release pollutants such as sewage, garbage or oily water that can decrease water quality and result in an exceedance of BC AWQG and CCME Water Quality Guidelines for the Protection of Aquatic Life.	Other vessel traffic may release pollutants that decrease water quality.	Combined releases may result in decreased water quality with BC AWQG and CCME Water Quality Guidelines being exceeded more frequently or with greater magnitude.	None	None ▪ Intentional releases of deleterious substances are prohibited and accidental releases are considered to be unlikely. ▪ Volume of boat traffic is not expected to change significantly from current conditions, therefore no significant changes to water quality is expected.
Terrestrial Wildlife and Marine Birds				
Physical presence of vessels can cause temporary displacement or changes in behaviour (e.g., avoidance).	Physical presence of other vessel traffic or infrastructure may cause temporary displacement or changes in behaviour.	Combined physical presence of vessel traffic may result in increased displacement or avoidance behaviour.	None	None ▪ Volume of vessel traffic is not expected to change significantly from current conditions. Wildlife in the area are habituated to the current traffic and behavioural responses are anticipated to be similar. ▪ Displacement, if any, is anticipated to be temporary and intermittent.
Terrestrial mammals and marine birds may be physically harmed by contact with deleterious substances released to the aquatic environment.	Other vessels may release deleterious substances to the aquatic environment which can physically harm terrestrial mammals and marine birds.	Combined presence of vessels increases the potential for a release of deleterious substances to occur which increases potential for physical harm.	None	None ▪ Volume of vessel traffic is not expected to change significantly from current conditions so potential for release of deleterious substances is not expected to increase.

Table 10-2: Cumulative Effects Assessment

Residual Effects of Anchorages	Potential Residual Effects from Other Projects	Potential Cumulative Effect	Additional Mitigation Measures (applied to Anchorages)	Residual Cumulative Effect
				▪ If vessels comply with the applicable regulations and conventions, no intentional or operational releases are anticipated to occur. Accidental releases are considered unlikely (Section 9.0).
Terrestrial mammals and marine birds may be indirectly impacted by reduced habitat quality caused by a release of deleterious substances.	Other vessels may release deleterious substances to the aquatic environment which can reduce habitat quality for terrestrial mammals and marine birds.	Combined presence of vessels increases the potential for a release of deleterious substances that could reduce habitat quality.	None	None ▪ Volume of vessel traffic is not expected to change significantly from current conditions so potential for release of deleterious substances is not expected to increase. ▪ If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur. Accidental releases are considered unlikely (Section 9.0).
Marine Mammals				
Marine mammals may be injured or killed by ship strike.	Other vessels have the potential to strike marine mammals while in transit.	Individual marine mammals have potential to be injured or killed by collision with vessels.	None	None ▪ While increased vessel traffic inherently increases the risk of collision, overall volume of vessel traffic is not expected to change significantly from current conditions. ▪ Public education and support for voluntary guidelines to maintain lower speeds and watch for marine mammals is increasing, reducing the risk for collision. ▪ Occurrence is unlikely and expected to be intermittent.
Anchor chain presence can cause temporary changes in marine mammal behaviour (e.g., avoidance) or temporary displacement.	Anchor and chains dropped by other vessels can cause temporary changes in marine mammal behaviour (e.g., avoidance) or temporary displacement.	An anchor chain “forest” may occur if vessels anchor in the same area at the same time, increasing the need for marine mammals to exhibit avoidance behaviour and increasing the potential for displacement.	None	None ▪ Volume of vessel traffic and pattern of usage (i.e., where anchoring is occurring) is not expected to change significantly from current conditions. Therefore, it is anticipated that marine mammal response to anchor chains and their potential to be displaced will be similar.
Artificial light spill to the water can cause temporary changes in marine mammal behaviour (e.g., avoidance) or displacement.	Lights from other projects can cause temporary changes in marine mammal behaviour (e.g., avoidance) or displacement.	Ambient light levels underwater may increase because of artificial light spill from all vessels, causing behavioural changes or displacement.	None	None ▪ Volume of vessel traffic and pattern of usage (i.e., number and intensity of lights on boats) is not expected to change significantly from current conditions. Therefore it is anticipated that there will be no significant changes to ambient light levels underwater. Marine mammals are likely to exhibit similar responses.
Underwater noise can cause behavioural changes (e.g., avoidance) or temporary displacement.	Other vessels can generate underwater noise that can cause behavioural changes (e.g., avoidance) or temporary displacement.	Underwater noise levels may cause behavioural changes or temporary displacement.	None	None ▪ Volume of vessel traffic and the sound level they produce is not expected to change significantly from current conditions. Therefore it is anticipated that there will be no significant changes to underwater noise. Marine mammals are likely to exhibit similar responses.

Table 10-2: Cumulative Effects Assessment

Residual Effects of Anchorages	Potential Residual Effects from Other Projects	Potential Cumulative Effect	Additional Mitigation Measures (applied to Anchorages)	Residual Cumulative Effect
Increased turbidity can cause behavioural changes (e.g., avoidance) or temporary displacement.	Other vessel traffic (recreational, commercial and that associated with industrial activities) will disturb sediments during activities such as anchoring, dredging or pile driving. Propeller movement can also contribute to turbidity as small vessels are more likely to occur in shallow water where bottom sediments may be disturbed. Disturbed sediments can increase turbidity which has potential to cause behavioural changes (e.g., avoidance) or temporary displacement.	Combined sediment disturbances by dropped anchors and propeller movement may increase turbidity and cause behavioural changes or temporary displacement.	None	None ▪ Volume of boat traffic is not expected to change significantly from current conditions. Turbidity increases because of anchoring or propeller movement are anticipated to remain similar to current levels. ▪ Dredging, pile driving or other construction activities required permits. Environmental Management Plans (EMP), which include Best Management Practices (BMP) to minimize environmental effects, are usually a condition of the permits. ▪ Turbidity typically subsides quickly in areas subjected to tides and strong currents. ▪ Turbidity increases are typically short term and intermittent.
Marine mammals may be physically harmed by contact with deleterious substances released to the aquatic environment.	Other vessels may release deleterious substances to the aquatic environment which can physically harm marine mammals.	Combined presence of vessels increases the potential for a release of deleterious substances to occur which increases potential for physical harm.	None	None ▪ Volume of vessel traffic is not expected to change significantly from current conditions so potential for release of deleterious substances is not expected to increase. ▪ If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur. Accidental releases are considered unlikely (Section 9.0).
Marine mammals may be indirectly impacted by reduced habitat quality caused by a release of deleterious substances.	Other vessels may release deleterious substances to the aquatic environment which can reduce habitat quality for marine mammals.	Combined presence of vessels increases the potential for a release of deleterious substances that could reduce habitat quality.	None	None ▪ Volume of vessel traffic is not expected to change significantly from current conditions so potential for release of deleterious substances is not expected to increase. ▪ If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur. Accidental releases are considered unlikely (Section 9.0).
Fish and Aquatic Habitat				
Anchor chain presence can cause changes in fish behaviour (e.g., avoidance) or temporary displacement.	Anchor and chains dropped by other vessels can cause temporary changes in marine mammal behaviour (e.g., avoidance) or temporary displacement.	An anchor chain "forest" may occur if vessels anchor in the same area at the same time, increasing the need for fish to exhibit avoidance behaviour and increasing the potential for displacement.	None	None ▪ Volume of vessel traffic and pattern of usage (i.e., where anchoring is occurring) is not expected to change significantly from current conditions. Therefore, it is anticipated that fish response to anchor chains and their potential to be displaced will be similar.

Table 10-2: Cumulative Effects Assessment

Residual Effects of Anchorages	Potential Residual Effects from Other Projects	Potential Cumulative Effect	Additional Mitigation Measures (applied to Anchorages)	Residual Cumulative Effect
Artificial light spill to the water can cause temporary changes in fish behaviour (e.g., avoidance) or displacement.	Lights from other projects can cause temporary changes in fish behaviour (e.g., avoidance) or displacement.	Ambient light levels underwater may increase because of artificial light spill from other project sources (e.g., vessels, marinas) causing behavioural changes or displacement.	None	None ▪ Neither the volume of vessel traffic and pattern of usage (i.e., number and intensity of lights on boats) nor the density of marina infrastructure (and its associated lighting devices) is expected to change significantly from current conditions. Therefore it is anticipated that there will be no significant changes to ambient light levels underwater. Fish are likely to exhibit similar responses.
Artificial light spill can increase risk of predation.	Lights from other projects (e.g., other vessels, marina lighting) can attract fish and increase risk of predation.	Artificial light spill produced by other projects (e.g., vessels, marinas) to the underwater environment may attract fish and increase their potential for predation.	None	None ▪ Neither the volume of vessel traffic and pattern of usage (i.e., number and intensity of lights on boats) nor the density of marina infrastructure (and its associated lighting devices) is expected to change significantly from current conditions. Therefore it is anticipated that there will be no significant changes to the potential for predation.
Underwater noise can cause changes in fish behaviour (e.g., avoidance) or temporary displacement.	Other vessels can generate underwater noise that can cause behavioural changes (e.g., avoidance) or temporary displacement.	Underwater noise levels may cause behavioural changes or temporary displacement	None	None ▪ Volume of vessel traffic and the sound level they produce is not expected to change significantly from current conditions. Therefore it is anticipated that there will be no significant changes to underwater noise. Fish are likely to exhibit similar responses.
Anchor drag/scour will cause localized destruction of fish habitat.	Anchors dropped by other vessels will create scour areas. Other project activities, such as dredging or marine construction, also have potential to destroy fish habitat.	Areas of fish habitat may be disturbed or destroyed.	None	None ▪ The area of habitat disturbed or destroyed by other projects is not expected to change significantly from existing conditions (i.e., no new disturbances are projected). ▪ Volume of vessel traffic and pattern of usage (i.e., where anchoring is occurring) is not expected to change significantly from current conditions. Therefore, habitat disturbances or destruction caused by current projects is not anticipated to differ from existing conditions. ▪ New dredging projects are not known in the LSA or Nanaimo harbor but would require a DFO Authorization, which would likely include provisions of habitat offsetting.
Anchor drag/scour can result in disturbance (e.g., avoidance) of fish.	Anchors dropped by other vessels will create scour areas. Other project activities, such as dredging or marine construction, also have potential to disturb fish.	Individual fish may be disturbed or displaced.	None	None ▪ Volume of vessel traffic and pattern of usage (i.e., where anchoring is occurring) is not expected to change significantly from current conditions. Therefore, habitat disturbances or displacement caused by current projects is not anticipated to differ from existing conditions.

Table 10-2: Cumulative Effects Assessment

Residual Effects of Anchorages	Potential Residual Effects from Other Projects	Potential Cumulative Effect	Additional Mitigation Measures (applied to Anchorages)	Residual Cumulative Effect
				▪ New dredging projects are not known in the LSA or Nanaimo harbor but would require a DFO Authorization, which may include provisions for benthic organism salvage. ▪ Impact to local populations or species is not anticipated to be significant.
Anchor drag/scour will result in mortality of individual fish.	Anchors dropped by other vessels will create scour areas. Other project activities, such as dredging or marine construction, also have potential to disturb fish.	Individual fish will be killed.	None	▪ Volume of vessel traffic and pattern of usage (i.e., where anchoring is occurring) is not expected to change significantly from current conditions. Therefore, fish mortality caused by current projects is not anticipated to differ from existing conditions. ▪ New dredging projects are not known in the LSA or Nanaimo harbor but would require a DFO Authorization, which may include provisions for benthic organism salvage. ▪ Impact to local populations or species is not anticipated to be significant.
Increased turbidity can cause changes in fish behaviour (i.e., avoidance) or temporary displacement.	Other vessel traffic (recreational, commercial and that associated with industrial activities) will disturb sediments during activities such as anchoring, dredging or pile driving. Propeller movement can also contribute to turbidity as small vessels are more likely to occur in shallow water where bottom sediments may be disturbed. Disturbed sediments can increase turbidity which has potential to cause behavioural changes (e.g., avoidance) or temporary displacement.	Combined sediment disturbances by dropped anchors and propeller movement may increase turbidity and cause behavioural changes or temporary displacement.	None	None ▪ Volume of boat traffic is not expected to change significantly from current conditions. Turbidity increases because of anchoring or propeller movement are anticipated to remain similar to current levels. ▪ Dredging, pile driving or other construction activities required permits. Environmental Management Plans (EMP), which include Best Management Practices (BMP) to minimize environmental effects, are usually a condition of the permits. ▪ Turbidity typically subsides quickly in areas subjected to tides and strong currents. ▪ Turbidity increases are typically short term and intermittent.
Fish may be physically harmed by contact with deleterious substances released to the aquatic environment.	Other vessels may release deleterious substances to the aquatic environment which can physically harm fish.	Combined presence of vessels increases the potential for a release of deleterious substances to occur which increases potential for physical harm.	None	None ▪ Volume of vessel traffic is not expected to change significantly from current conditions so potential for release of deleterious substances is not expected to increase. ▪ If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur. Accidental releases are considered unlikely (Section 9.0).

Table 10-2: Cumulative Effects Assessment

Residual Effects of Anchorages	Potential Residual Effects from Other Projects	Potential Cumulative Effect	Additional Mitigation Measures (applied to Anchorages)	Residual Cumulative Effect
Fish may be indirectly impacted by reduced habitat quality caused by a release of deleterious substances.	Other vessels may release deleterious substances to the aquatic environment which can reduce habitat quality for marine mammals.	Combined presence of vessels increases the potential for a release of deleterious substances that could reduce habitat quality.	None	None ▪ Volume of vessel traffic is not expected to change significantly from current conditions so potential for release of deleterious substances is not expected to increase. ▪ If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur. Accidental releases are considered unlikely (Section 9.0).
Aboriginal, Recreational and Commercial Fisheries				
Fisheries may be temporarily displaced.	Other project activities (e.g., physical presence of other vessel traffic or infrastructure, dredging or marine construction projects) may cause temporary displacement of fisheries.	Fisheries may be temporarily displaced.	None	None ▪ Fisheries are not expected to be impacted by the combined effects of other projects and the Anchorage. Fisheries collocate with other recreational and commercial vessels. No significant changes to in-water infrastructure that may impede navigation or increase displacement are known. ▪ Activities that may cause more considerable displacement, such as dredging, would be temporary.
Quantity and quality of fish available may be reduced because of a release of deleterious substances to the aquatic environment.	Other project activities (e.g., other vessels, dredging marine construction) may release deleterious substances to the aquatic environment which can reduce the quantity and quality of fish available to the fisheries.	Quantity and quality of fish available to the fisheries may be reduced.	None	None ▪ Volume of vessel traffic is not expected to change significantly from current conditions so potential for release of deleterious substances is not expected to increase. ▪ If vessels comply with the applicable regulations and conventions no intentional or operational releases are anticipated to occur. Accidental releases are considered unlikely (Section 9.0).

11.0 FOLLOW-UP

Follow-up programs are recommended for non-designated projects by CEAA 2012 to verify predictions of environmental effects identified in the environmental assessment and to determine the effectiveness of the recommended mitigation measures (Canadian Environmental Assessment Agency 2012a). The Anchorages do not have a legislated requirement to conduct follow-up.

Several agencies, including the PPA, NPA, Chamber of Shipping BC and the BC Coast Pilots, have together recommended that the Anchorages be reviewed after 12 months to confirm its suitability for permanent use (Young 2016). Tetra Tech EBA recommends that this review include an inventory of environmental conditions at that time and a comparison to baseline conditions to evaluate actual Anchorage impacts.

12.0 SUMMARY AND CONCLUSIONS

This EOA was conducted for due diligence purposes to assess potential Anchorage interactions with the natural environment and was intended to provide a framework for regulatory approvals that may be required in the future. It did not include an evaluation of health, heritage, economic, aesthetics or other social factors, except where specifically requested by PPA. Cumulative effects of the Anchorages with other projects was limited to a high-level assessment. Public and First Nations consultation was not included in the scope of this EOA.

Quantitative assessment of the Anchorage area was largely absent within this high-level EOA. Publicly available resources, such as government and non-government organization databases and published scientific reports, were relied on heavily to provide baseline conditions and inform effect interactions. Every attempt was made to apply the best information available and specific, relevant data to the Anchorages. Where possible, expert advice was requested and applied.

The results of this EOA indicate that, with application of appropriate mitigation measures, most Anchorage-VC interactions result in residual effects that are ***not significant***. Negative environmental effects are generally localized and/or short term.

Tetra Tech EBA notes that although anchor drag/scour causing localized destruction of fish habitat and individual fish mortality was found to be *Not Significant* based on the established methodology (Section 6.0) “serious harm to fish” is prohibited under Section 35 of the *Fisheries Act.* Serious harm to fish includes permanent alteration or destruction of fish habitat. Activities causing serious harm to fish require an Authorization under subsection 35(2) of the *Fisheries Act*.

Several ***significant*** adverse residual effects were identified, though with a low likelihood of occurrence:

- Marine mammals may be killed or injured by ship strike. Because several sensitive marine mammal species are potentially present in the Anchorage area, and because marine mammals generally have low reproductive rates, loss of an individual could have implications for local populations (e.g., loss of a mature female Killer Whale from the endangered Southern Resident population limits potential growth/recovery of that population).
- VCs (i.e., water quality, terrestrial mammals and marine birds, marine mammals, fish and aquatic habitat and Aboriginal, recreational and commercial fisheries) may be significantly impacted if a deleterious substance is released to the aquatic environment. Intentional and operational releases of deleterious substances are prohibited by federal and provincial regulations as well as international conventions and accidental releases are anticipated to be both infrequent and unlikely.

Although these residual effects would be *significant*, they are deemed unlikely to occur. Accordingly, the PPA may consider these *significant* residual effects to be acceptable.

Tetra Tech EBA recognizes that there is a lack of specific, quantitative information for most VCs. There is potential that expert advice or quantitative information, should it become available, would change the effects characterization and significance assessment results.

Further, the lack of Public/First Nations consultation, leaves potential for significant effects to occur within social components, including those assessed within the EOA (i.e., noise, light and fisheries). Consultation may identify concerns and subsequent investigation may determine that Anchorage activities have significant adverse residual impacts on social components.

13.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
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FIGURES

Figure 1 Anchorage Area
Figure 2 Local Study Area
Figure 3 Regional Study Area
Figure 4 Light Spill

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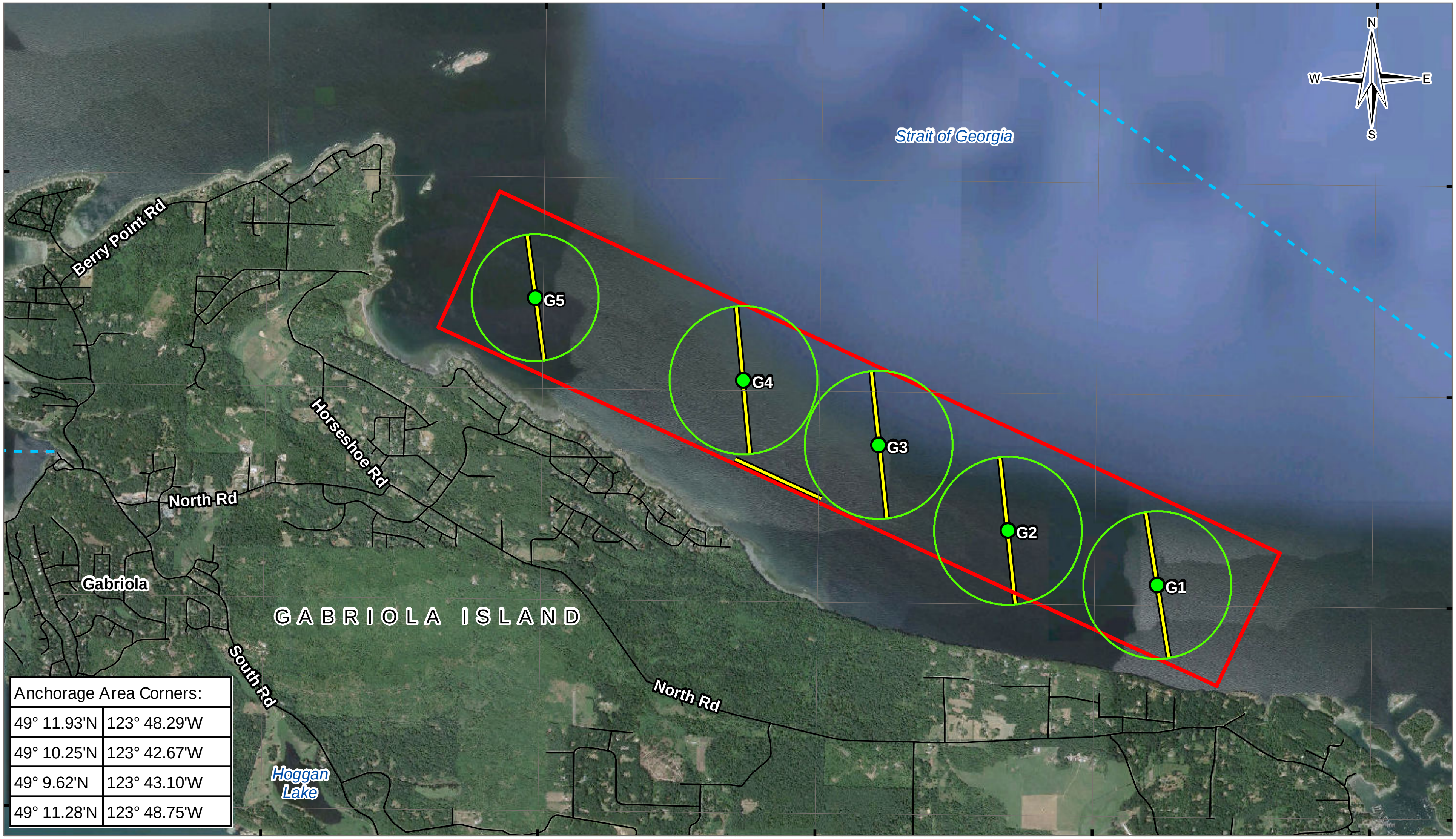

Anchorage Area Corners:	
49° 11.93'N	123° 48.29'W
49° 10.25'N	123° 42.67'W
49° 9.62'N	123° 43.10'W
49° 11.28'N	123° 48.75'W

LEGEND

- Anchorage Area
- Anchor Location
- Anchor Radius
- ROV Transect
- Road
- Ferry Route

NOTES
Base data source:
Imagery from Google; Nanaimo (2016)

STATUS
ISSUED FOR REVIEW

Scale: 1:50,000
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Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure01_ProjectArea.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

ENVIRONMENTAL ASSESSMENT NEW ANCHORAGES GABRIOLA ISLAND, BC

Anchorage Area

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	SW	0

OFFICE	DATE
Tt EBA-VANC	April 18, 2016

Figure 1

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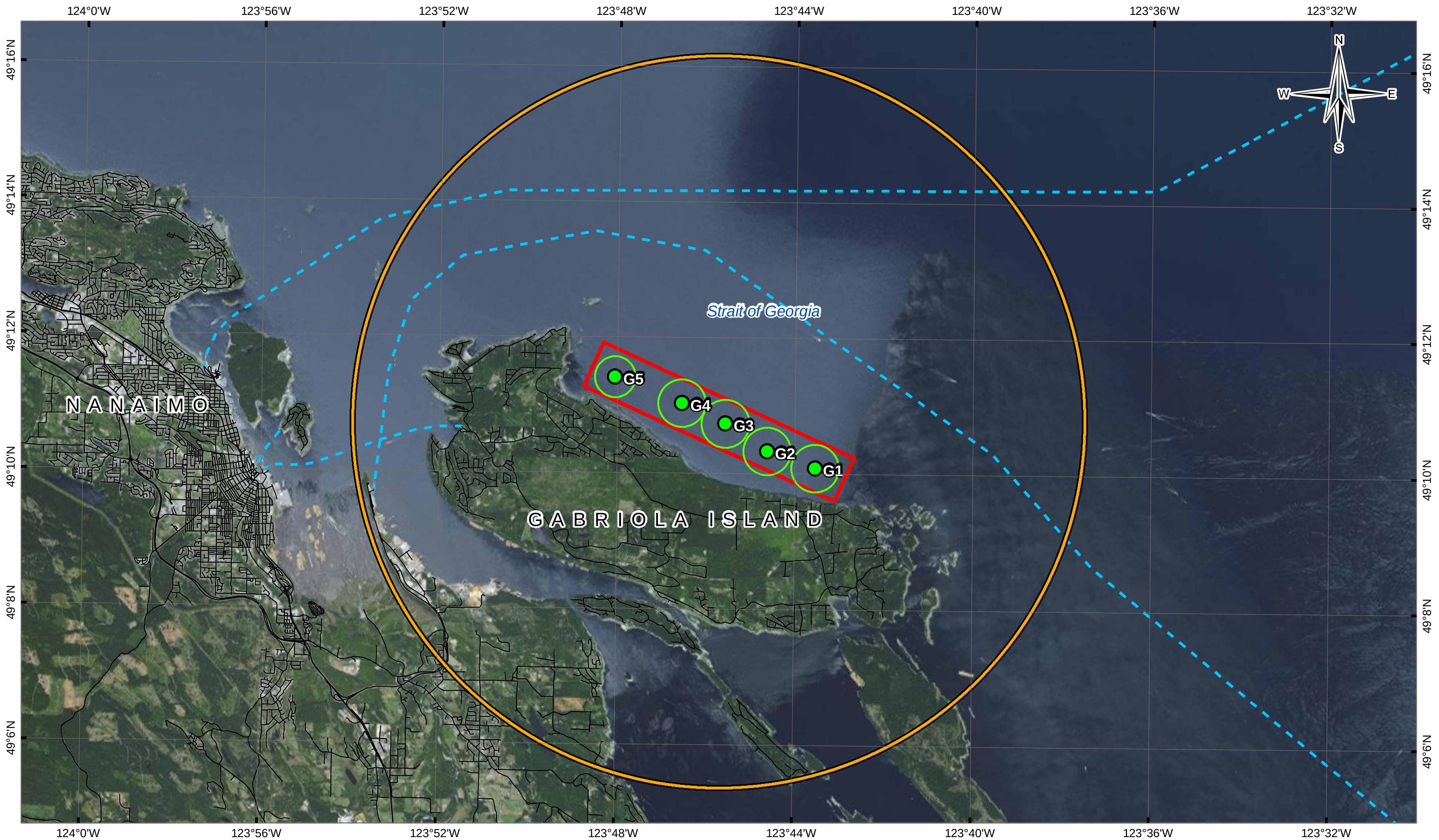

LEGEND

- Anchorage Area
- Local Study Area
- Anchor Location
- Anchor Radius
- Road
- Ferry Route

NOTES
Base data source:
Imagery from Google; Nanaimo (2016)

STATUS
ISSUED FOR REVIEW

Scale: 1:150,000
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Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure02_LocalStudyArea.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

ENVIRONMENTAL ASSESSMENT NEW ANCHORAGES GABRIOLA ISLAND, BC

Local Study Area

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	SW	0

OFFICE	DATE
Tt EBA-VANC	April 18, 2016

Figure 2

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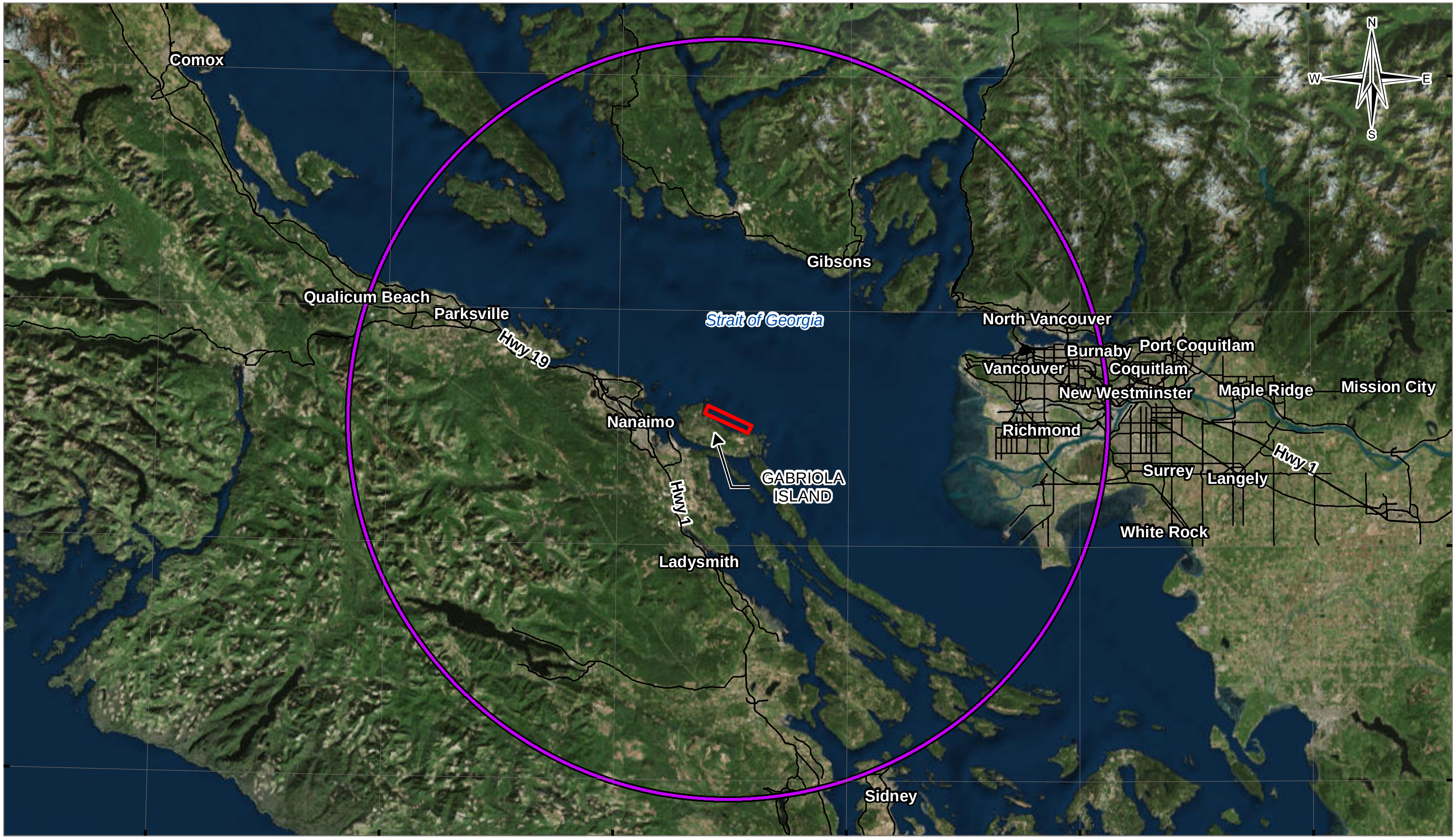

LEGEND

- Anchorage Area
- Regional Study Area
- Road

NOTES
Base data source:
Imagery from ESRI; GeoEye; DigitalGlobe (various dates)

Scale: 1:900,000
20 10 0 20
Kilometres

PROJECTION UTM Zone 10
DATUM NAD83

FILE NO. VENV03029-01_Figure03_RegionalStudyArea.mxd

CLIENT Pacific Pilotage Authority

TETRA TECH EBA

ENVIRONMENTAL ASSESSMENT NEW ANCHORAGES GABRIOLA ISLAND, BC

Regional Study Area

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	SW	0

OFFICE	DATE
Tt EBA-VANC	April 18, 2016

Figure 3

STATUS
ISSUED FOR REVIEW

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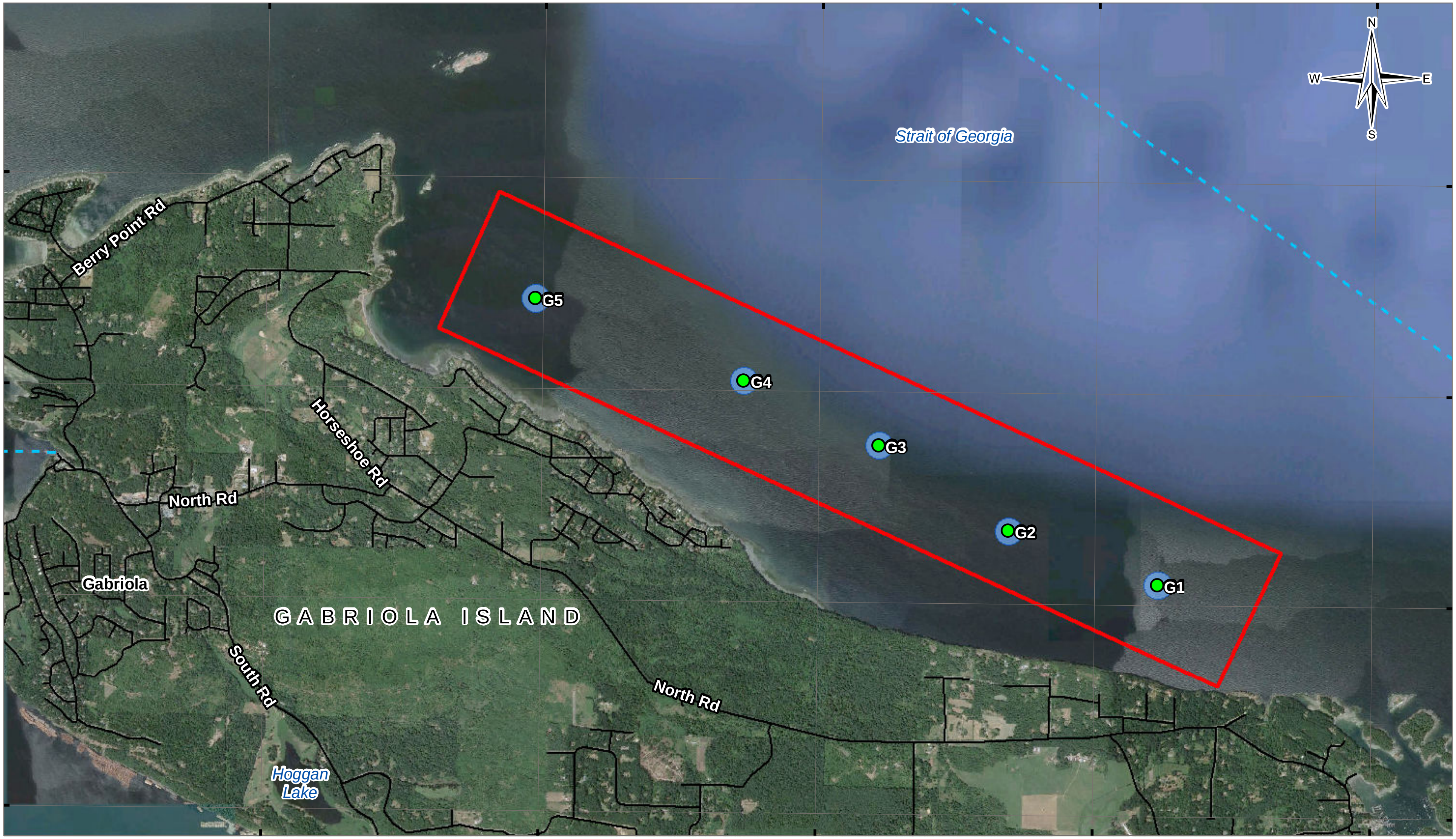

LEGEND

- Anchorage Area
- Light Spill
- Anchor Location
- Road
- Ferry Route

NOTES
Base data source:
Imagery from Google; Nanaimo (2016)

STATUS
ISSUED FOR REVIEW

Scale: 1:50,000

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Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure04_LightSpill.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

ENVIRONMENTAL ASSESSMENT NEW ANCHORAGES GABRIOLA ISLAND, BC

Light Spill

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	SW	0

OFFICE	DATE
Tt EBA-VANC	April 18, 2016

Figure 4

APPENDIX A
TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

NATURAL SCIENCES

This report incorporates and is subject to these "General Conditions".

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3.0 STANDARD OF CARE

Services performed by Tetra Tech EBA for the Report have been conducted in accordance with the Services Agreement, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Report.

Tetra Tech EBA professionals are bound by their ethical commitments to act within the bounds of all pertinent regulations. In certain instances, observations by Tetra Tech EBA of regulatory contravention may require that regulatory agencies and other persons be informed. The client agrees that notification to such bodies or persons as required may be done by Tetra Tech EBA in its reasonably exercised discretion.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of Tetra Tech EBA.

4.0 ENVIRONMENTAL ISSUES

The ability to rely upon and generalize from environmental baseline data is dependent on data collection activities occurring within biologically relevant survey windows.

5.0 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with Tetra Tech EBA with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for Tetra Tech EBA to properly provide the services contracted for in the Services Agreement, Tetra Tech EBA has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

6.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of this Report, Tetra Tech EBA may have relied on information provided by persons other than the Client.

While Tetra Tech EBA endeavours to verify the accuracy of such information, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

7.0 GENERAL LIMITATIONS OF REPORT

This Report is based solely on the conditions present and the data available to Tetra Tech EBA at the time the data were collected in the field or gathered from publically available databases.

The Client, and any Authorized Party, acknowledges that the Report is based on limited data and that the conclusions, opinions, and recommendations contained in the Report are the result of the application of professional judgment to such limited data.

The Report is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present at or the development proposed as of the date of the Report requires a supplementary investigation and assessment.

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design or scope, in consideration of the level of the environmental baseline information that was reasonably acquired to facilitate completion of the scope.

The Client acknowledges that Tetra Tech EBA is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of property, the decisions on which are the sole responsibility of the Client.

8.0 JOB SITE SAFETY

Tetra Tech EBA is only responsible for the activities of its employees on the job site and was not and will not be responsible for the supervision of any other persons whatsoever. The presence of Tetra Tech EBA personnel on site shall not be construed in any way to relieve the Client or any other persons on site from their responsibility for job site safety.

APPENDIX B

DIESEL EXHAUST AIR DISPERSION STUDY FOR THE PROPOSED GABRIOLA ANCHORAGES (TETRA TECH EBA 2016B)

TETRA TECH EBA

OQM | Organizational Quality Management Program

Diesel Exhaust Air Dispersion Study for the Proposed Gabriola Anchorages



PRESENTED TO

Pacific Pilotage Authority

MARCH 2016
ISSUED FOR USE
ENV.VENV03029-01

Tetra Tech EBA Inc.
Suite 1000 – 10th Floor, 885 Dunsmuir Street
Vancouver, BC V6C 1N5 CANADA
Tel 604.685.0275 Fax 604.684.6241

EXECUTIVE SUMMARY

Pacific Pilotage Authority (PPA) proposes to designate five anchorage locations (Table 1.1) for deep sea shipping vessels, with lengths up to 300 meters off the Strait of Georgia side of Gabriola Island. This report presents the results of an air dispersion modelling study performed by Tetra Tech EBA, Inc. (Tetra Tech) in support of the Environmental Assessment. The purpose of the study was to determine the local impacts from diesel generator exhaust while vessels are at anchor and while maneuvering in the vicinity of the designated moorages. Air dispersion modelling was conducted with CALPUFF, a multi-layered, multi-species, non-steady state Gaussian dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport.

Two activity scenarios were considered: one which vessels were anchored at the designated moorage locations, running only auxiliary engines, and one which a single vessel was maneuvering in the designated anchorage using 3% main engine load while four vessels were anchored. The scenarios considered emissions of the main criteria air contaminants (CAC) for typical vessel types that call at shipping ports through the region. Vessel statistics and emission factors were taken from '*2005 – 2006 BC Ocean-Going Vessel Emissions Inventory*' (COS 2007).

The findings of this modelling study suggest that when vessels are at anchor within the moorage, emissions from an individual ship do not result in exceedance of ambient air quality objectives. The highest impacts are due to emissions of NO_x. When the moorage is full, NO_2 concentrations were predicted to slightly exceed the BC ambient air quality objective in the vicinity of the vessels but not over land.

When a container-type vessel is maneuvering within the moorage, ambient air quality objectives were predicted to have been exceeded over water in the moorage area for both NO_2 and SO_2. On Gabriola Island, maximum predicted NO_2 concentrations exceeded the ambient air quality objective for NO_2 and impinged on the ambient air quality objective for SO_2.

TABLE OF CONTENTS

EXECUTIVE SUMMARY I

1.0 INTRODUCTION 1

2.0 STUDY DESCRIPTION 1
- 2.1 Vessel Characterization 3
- 2.2 Vessel Emissions 3
- 2.3 Modelled Scenarios 5
  - 2.3.1 Seasonality & Diurnal Pattern 6
- 2.4 Exhaust Parameters 7

3.0 CALPUFF 8
- 3.1 CALMET 8
  - 3.1.1 Domain and Grid Resolution 8
  - 3.1.2 Surface, Upper Air and Overwater Meteorology 9
  - 3.1.3 Terrain Elevation and Land Use Characterization 10
  - 3.1.4 CALMET Switch Settings 10
- 3.2 CALPUFF Settings 10
  - 3.2.1 Receptor Grid 10
  - 3.2.2 Ozone Limiting Method for NO_2 Conversion 11
  - 3.2.3 Wet and Dry Deposition 11

4.0 AMBIENT AIR QUALITY 11

5.0 MODEL RESULTS 12

6.0 CONCLUSION 13

7.0 CLOSURE 14

REFERENCES 15

LIST OF TABLES IN TEXT

Table 2.0: Coordinates of Proposed Gabriola Island Moorages 1
Table 2.1: Ocean-Going Vessel Characterization calling at B.C. Ports 3
Table 2.2: Ocean-Going Vessel Emission Factors for Main and Auxiliary Engines and Boilers using HFO 4
Table 2.3: Activity-Specific Emission Rates by Vessel Type in kg/hr (Sum of All Engines and Boilers) 5
Table 2.4: Modelled Vessel Type Moorage Locations 5
Table 2.5: Average Stack and Exhaust Parameters for Vessels at Anchor and Maneuvering 7
Table 3.1: Meteorological Surface Stations, Buoys and NARR Grid Points Used in CALMET 9
Table 4.1: Observed Background Concentrations and BC Ambient Air Quality Objectives (in µg/m^3) 12
Table 4.2: Regional Background Concentrations (in µg/m^3) 12
Table 5.1: Maximum Predicted Concentration at Any Receptor – at Anchor Scenario (in µg/m^3) 13

LIST OF FIGURES IN TEXT

Figure 2.1: Project Area and Proposed Anchorage Locations 2
Figure 2.2: January 2012 (left) and June 2012 (right) Wind Roses for Entrance Island 6
Figure 2.3: Comparison of CALMET Modelled Mixing Heights offshore Gabriola Island - January and June 2012 7
Figure 2.4: CALMET Modelled Mixing Height Offshore Gabriola Island Related to Wind Speed 7
Figure 3.1: CALMET Model Domain (1 km Grid Resolution) 8
Figure 3.1: CALPUFF Receptor Grid 11

APPENDIX SECTIONS

FIGURES

Figure 5.1 Five Vessels at Anchor Scenario - Maximum 1-Hr NO_2 Concentration at Ground Level
Figure 5.2 Five Vessels at Anchor Scenario - Maximum 1-Hr SO_2 Concentration at Ground Level
Figure 5.3 Five Vessels at Anchor Scenario - Maximum 1-Hr CO Concentration at Ground Level
Figure 5.4 Five Vessels at Anchor Scenario - Maximum 1-Hr VOC Concentration at Ground Level
Figure 5.5 Five Vessels at Anchor Scenario - Maximum 24-Hr PM_{10} Concentration at Ground Level
Figure 5.6 Five Vessels at Anchor Scenario - Maximum 24-Hr $PM_{2.5}$ Concentration at Ground Level
Figure 5.8 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 1-Hr NO_2 Concentration at Ground Level
Figure 5.9 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 1-Hr SO_2 Concentration at Ground Level
Figure 5.10 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 1-Hr CO Concentration at Ground Level
Figure 5.11 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 1-Hr VOC Concentration at Ground Level
Figure 5.12 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 24-Hr PM_{10} Concentration at Ground Level
Figure 5.13 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 24-Hr $PM_{2.5}$ Concentration at Ground Level

APPENDICES

Appendix A Tetra Tech's Services Agreement and General Conditions

ACRONYMS & ABBREVIATIONS

CAC	Criteria Air Contaminants
CARB	California Air Resources Board
CO	Carbon Monoxide
COS	Chamber of Shipping
EC	Environment Canada
ECA	North American Emission Control Area
GLCC	Global Land Cover Characterization
HFO	Heavy Fuel Oil (or Bunker Fuel)
kWh	Kilowatt hours
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MoE	B.C. Ministry of Environment
NARR	North American Regional Reanalysis
NDBC	National Data Buoy Center (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
O_3	Ground Level Ozone
PCO	Pollution Control Objectives
$PM_{2.5}$	Particulate Matter < 2.5 microns
PM_{10}	Particulate Matter < 10 microns
PPA	Pacific Pilotage Authority
SO_2	Sulfur Dioxide
SRTM1	Shuttle Radar Topography Mission (Terrain Data)
US EPA	United States Environmental Protection Agency
USGS	United States Geological Service
VOC	Volatile Organic Compounds
VTOSS	Vessel Traffic Operation Support System (Coast Guard)

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LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Pacific Pilotage Authority and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Pacific Pilotage Authority, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions are provided in Appendix A of this report.

1.0 INTRODUCTION

Pacific Pilotage Authority (PPA) proposes to designate five anchorage locations for deep sea shipping vessels, with lengths up to 300 meters (m), off the Strait of Georgia side of Gabriola Island. This report presents the results of an air dispersion modelling study performed by Tetra Tech EBA, Inc. (Tetra Tech) in support of the Environmental Assessment. The purpose of the study was to determine the local impacts from diesel generator exhaust while vessels are at anchor and while maneuvering in the vicinity of the designated moorages.

The modelled scenarios considered emissions of main criteria air contaminants (CAC) for typical vessel types that call at shipping ports through the region. Vessel statistics and emission factors were taken from '*2005 – 2006 BC Ocean-Going Vessel Emissions Inventory*' (COS 2007) describing a study carried out by The Chamber of Shipping in collaboration with Environment Canada, Metro Vancouver (fm. Greater Vancouver Regional District) and other key stakeholders. The report, audited by SENES Consultants Ltd., contains an accurate and comprehensive inventory of regional vessel behaviour and emission estimates over the period April 1, 2005 to March 31, 2006 (COS 2007).

Air dispersion modelling was conducted with CALPUFF, a multi-layered, multi-species, non-steady state Gaussian dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport. The CALPUFF outputs presented in this report describe the maximum predicted concentrations of CACs at ground level over the duration of the simulations.

2.0 STUDY DESCRIPTION

There has been an increasing demand for deep sea anchorages along the southern BC coast as the cargo tonnage throughput in Vancouver's ports has increased significantly. If there are no available moorages in either Port Metro Vancouver or the Nanaimo Port Authority, designated anchorages along Vancouver Island and the Gulf Islands are used. Navigating the channels which lead to many of these moorages increases both transit time and the risk of grounding or a collision. Additionally, vessel sizes have increased such that some moorages can no longer accommodate them. Establishing the proposed moorages on the Strait of Georgia side of Gabriola Island will provide easier accessibility and maneuverability and will accommodate vessels up to 300 m in length.

The locations of the proposed Gabriola moorages are shown in Figure 2.1. The coordinates are listed in Table 2.0.

Table 2.0: Coordinates of Proposed Gabriola Island Moorages

Moorage ID	Geographic Coordinate System – NAD83	
	Latitude	Longitude
G-1	49.1683°	-123.7258°
G-2	49.1725°	-123.7438°
G-3	49.1791°	-123.7595°
G-4	49.1842°	-123.7758°
G-5	49.1905°	-123.8010°

The purpose of the air quality study was to determine the impact on air quality in the vicinity of Gabriola Island as a result of diesel engine exhaust emissions from anchored and maneuvering vessels. Vessels may remain at anchor for several hours during the day or overnight. Maneuvering would occur for only a short period of time while arriving at and leaving anchor.

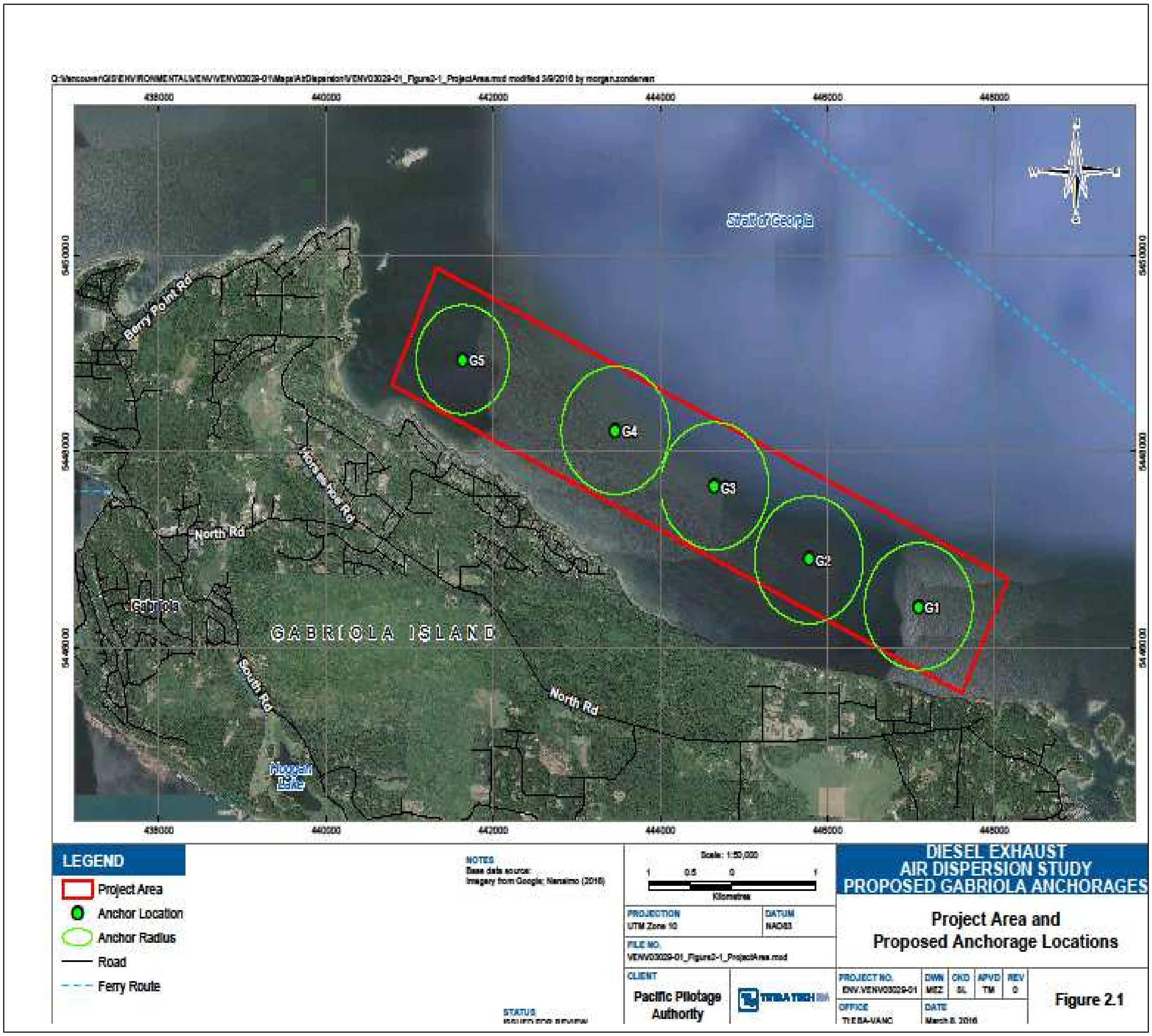

Figure 2.1: Project Area and Proposed Anchorage Locations

A vessel's power system consists of a main engine and one or more auxiliary engines and boiler. While the main engine provides propulsion during underway and maneuvering activity, other shipboard power usage, such as electricity for lights, cabin air conditioning, refrigeration, and hot water are generated from auxiliary engines and boilers. While at anchor, main engines are not running however auxiliary engines run at a 30% to 70% load. Due to their large engine capacities and diesel consumption, vessels can generate significant emissions of particulate matter ($PM_{2.5}$ and PM_{10}), oxides of nitrogen (NO and NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and volatile organic compounds (VOC) in the exhaust.

2.1 Vessel Characterization

It is expected that a variety of ocean-going carrier vessels could anchor at the proposed moorages. The '*2005 – 2006 BC Ocean-Going Vessel Emissions Inventory*' (COS 2007) contains a comprehensive inventory of statistics for vessels calling at regional ports over the period April 1, 2005 to March 31, 2006. The inventory was compiled from a combination of Coast Guard Vessel Traffic Operation Support System (VTOSS) tracking data and survey data collected by the COS. The tracking data contained detailed information on vessel locations and speeds which were used to determine the frequency of port calls (arranged by category of vessel type) time in mode (underway, maneuvering, at birth or at anchor) and main engine load factors. The survey responses provided individual data on engine, boiler and fuel characteristics which were then used to determine average main and auxiliary engine power and load factors (vessel speed in a particular operational mode divided by the maximum vessel speed) by mode, boiler fuel usage, and fuel sulphur content for different categories of vessels. The COS data relevant to this study is summarized in Table 2.1.

Table 2.1: Ocean-Going Vessel Characterization calling at B.C. Ports

Vessel Category	*% Of Vessels	Average Main Engine Power Rating (kW)	Average Total Auxiliary Power Used (kW)		Boiler Fuel Consumption (tonne/hr)	
			Underway	At Anchor	Underway	At Anchor
Bulk Vessel	55%	8113	520	359	0.08	0.07
Container Ship	15%	32251	1348	1074	0.14	0.15
General Cargo	12%	9072	655	621	0.07	0.11
Motor Vehicle Carrier	8%	10294	830	757	0.07	0.07

*Tanker 8%, Other 3%
Source: 2005 – 2006 BC Ocean-Going Vessel Emissions Inventory (COS 2007)

The tracking and survey data compiled by COS indicates that the majority of vessels calling at regional ports are bulk vessels, carrying loose materials such as grain. Container vessels, carrying their entire load in standard steel-reinforced containers, general cargo vessels, carrying large items not suitable for transport in containers, such as textiles, large equipment and machinery, and motor vehicle carriers make up 15%, 12% and 8% of vessel traffic respectively. Oil tankers, comprising 8% of vessel traffic, were not considered as an appropriate vessel type for moorage at Gabriola Island due to their size and potential restrictions and therefore were not included in the air quality study.

Container ships have by far the largest main engine capacity of all vessel types. They were also reported as having the highest auxiliary power usage and boiler fuel consumption. In terms of load factors, COS determined the average main engine load to be 3% for all vessel types when maneuvering.

2.2 Vessel Emissions

Unlike diesel engines in trucks and land-based equipment, very few ocean-going vessel engines have been tested for the purpose of developing emissions factors. For diesel engines, an emission factor relates the amount of air contaminant released in exhaust gas based on engine power or fuel consumption. COS 2007 describes a series of power-based emission factors for both main and auxiliary engines on ocean-going carrier vessels based on an Entec UK Limited (2002) report '*Quantification of Emissions from Ships Associated with Ship Movements Between Ports in the European Community*'. Adjustments were made for emission factors for PM and CO, based on a 2005 study by the California Air Resources Board (CARB) '*Emissions Estimation Methodology for Ocean-Going Vessels*'.

Emissions of SO_2 in diesel exhaust directly relate to the amount of sulphur in the diesel fuel. Based on the COS survey data, in nearly all circumstances, main engines operated on heavy fuel oil (HFO), or bunker fuel, while underway. Approximately 13% of vessels reported switching to a lighter fuel such as marine diesel oil (MDO) or marine gas oil (MGO) as it approached port/anchor to lower emissions in near shore areas. As only a small number of vessels had reporting switching, and as better technologies are allowing vessels to remain on HFO, the conservative assumption was made in this study that vessels remain on HFO while maneuvering. Within the North American Emission Control Area (ECA) which extends 200 nautical miles from shore, the maximum sulphur content in fuel oil was decreased to 0.1% starting January 1, 2015 (RWDI 2013). The SO_2 emission factor defined in COS 2007 is for a sulfur content of 1%. For conservatism, the emission factor was not adjusted in this study.

The emission factors used in the air quality study are listed in Table 2.2 as a function of engine power utilized for main engines in maneuvering mode and auxiliary engines in all modes, and as a function of fuel consumption for boilers. The factors represent the highest of the reported speed ratings for each vessel type and assume 100% HFO.

Table 2.2: Ocean-Going Vessel Emission Factors for Main and Auxiliary Engines and Boilers using HFO

Contaminant	Main Engine in Maneuvering Mode[1] (kg/kWh)	Auxiliary Engine(s) in All Modes[2] (kg/kWh)	Boilers (kg/tonne fuel)
NOx	52.85	14.7	12.3
*SO_2	12.26	4.2	20
CO	9.34	1.1	4.6
VOC	10.33	0.4	0.38
PM_{10}	4.24	1.11	1.3
$PM_{2.5}$	3.82	1	1.17[3]

[1] EF for slow-speed rated 2-stroke main engine
[2] EF for medium-speed rated auxiliary engine(s)
[3] assumed as 90% of PM_{10}
* assumed diesel sulfur content of 1%
Source: 2005 – 2006 BC Ocean-Going Vessel Emissions Inventory (COS 2007)

Using the emission factors shown in Table 2.2, total emissions for each vessel type was determined for each contaminant using the equation:

$$E = (ME \times LF \times EF_{act}) + (AE \times EF_{act}) + (BO \times EF_{fuel})$$

where: E = hourly contaminant-specific emission rate (in kg/hr);

ME = main engine maximum continuous power rating (kW) (Table 2.1);

LF = load factor for the main engine (0% for vessels at anchor, 3% while maneuvering)

EF_{act} = activity based emission factor (kg/kWh) (Table 2.2);

AE = average auxiliary engine(s) power usage (kW) (Table 2.2);

BO = boiler fuel consumption rate (tonnes/hr) (Table 2.1);

EF_{fuel} = fuel based emission factor (kg/tonne fuel) (Table 2.2);

In absence of stack data, the ratio of NO to NO_2 in the emitted NO_x was assumed to be 90% NO and 10% NO_2, typical of diesel engines. NO converts to NO_2 in the ambient air in the presence of ground level ozone (O_3) (Section 3.2.2). The emission rates for each contaminant assumed for the study are listed in Table 2.3.

Table 2.3: Activity-Specific Emission Rates by Vessel Type in kg/hr (Sum of All Engines and Boilers)

	NO	NO_2	SO_2	CO	VOC	PM_{10}	$PM_{2.5}$
At Anchor							
Bulk Vessel	4.75	0.53	1.51	0.39	0.14	0.40	0.36
Container Ship	14.21	1.58	4.51	1.18	0.43	1.19	1.07
General Cargo	8.22	0.91	2.61	0.68	0.25	0.69	0.62
Motor Vehicle Carrier	10.02	1.11	3.18	0.83	0.30	0.84	0.76
Maneuvering							
Bulk Vessel	18.46	2.05	5.17	2.85	2.72	1.61	1.45
Container Ship	63.86	7.10	17.53	10.52	10.53	5.60	5.04
General Cargo	21.61	2.40	6.09	3.26	3.07	1.88	1.69
Motor Vehicle Carrier	25.67	2.85	7.27	3.80	3.52	2.23	2.01

Table 2.3 shows that container vessels emit the most and that for all vessels, emission rates while maneuvering are on the order of 5 to 10 times higher than while at anchor, due to use of the main engine.

2.3 Modelled Scenarios

Based on vessel traffic frequency statistics, shown in Table 2.1, it was assumed that at full anchorage the most likely scenario would be two vessels of the bulk vessel type, with one each of general cargo, container ship and motor vehicle carrier. The moorage location of each vessel type was arbitrarily assigned (Table 2.4).

Table 2.4: Modelled Vessel Type Moorage Locations

Moorage Location	Vessel Type
G-1	Bulk Vessel
G-2	Motor Vehicle Carrier
G-3	General Cargo
G-4	Container Ship
G-5	Bulk Vessel

Models were run for two different scenarios. The first scenario assumed vessels were at anchor, using only auxiliary power and boilers. Each vessel was modelled separately to provide the predicted impacts of a single occupied moorage. Individual runs were then summed together in post-processing to provide the worst-case cumulative impact. The second scenario assumed a vessel was maneuvering in the designated moorage location, using 3% of main engine capacity, in addition to auxiliary engines and boilers. As it is a low likelihood that two vessels would be maneuvering in the moorages at the same time, the assumed worst-case cumulative impact was a single vessel maneuvering while four other vessels were at anchor using auxiliary engines. The maneuvering vessel was selected to be the one with the highest emission rates, i.e. a container ship.

2.3.1 Seasonality & Diurnal Pattern

To capture seasonal differences in atmospheric dispersion characteristics, the scenarios were modelled over the entire months of January, representing typical winter meteorological conditions, and June, representing typical summer meteorological conditions. The ability of the air to mix and dilute contaminants at the surface through vertical dispersion is affected by several meteorological factors. Higher wind speeds enhance atmospheric turbulence and mixing which increases the vertical movement of air, and hence dispersion, reducing concentrations at the surface. Winds are generally higher during winter in the region due to more frequent synoptic events and occasional outflows. Figure 2.2, wind roses for January and June 2012, depicting the frequency of occurrence of wind speed and direction recorded at Environment Canada station Entrance Island, located 2 km northeast of the moorage area, illustrates this seasonality with higher wind speeds (shaded red) occurring in January. The figures also show a very strong along-shore predominance to wind direction, aligned with the Strait of Georgia.

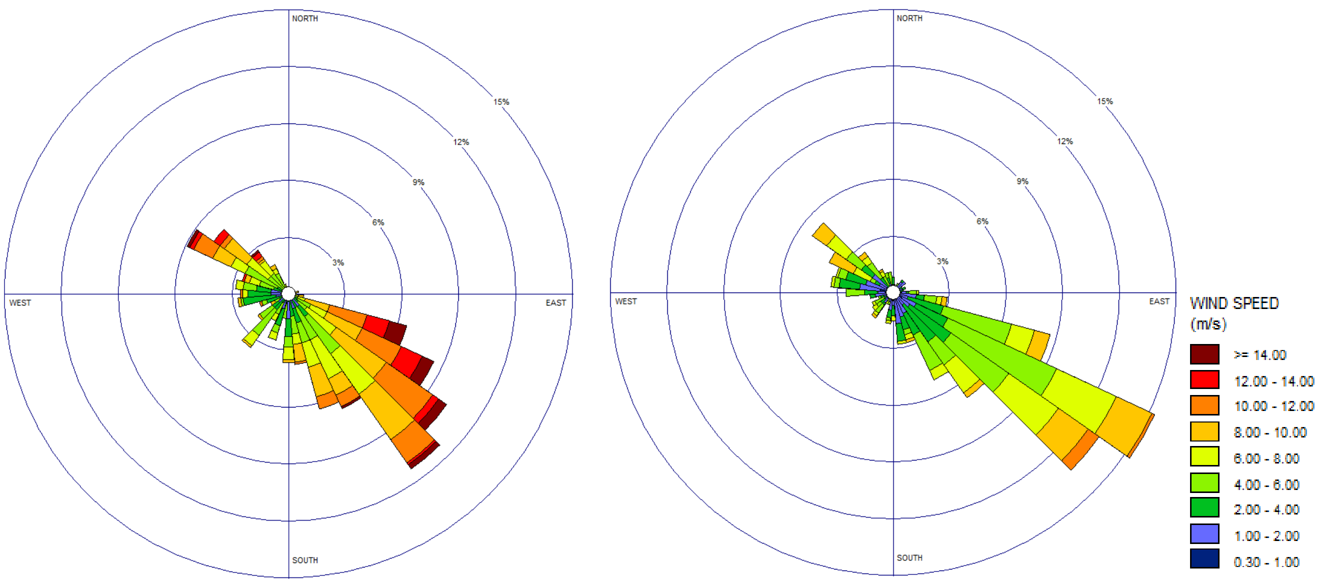

Figure 2.2: January 2012 (left) and June 2012 (right) Wind Roses for Entrance Island

In addition to winds, mixing is also enhanced by strong incident solar radiation which heats the ground and warms the air near the surface causing it to rise. The mixing height, defined as the top of the layer of the lower atmosphere within which ground level contaminants are readily mixed, is generally lower in winter than in summer due to a lower sun angle, less daylight hours and on the BC South Coast, more cloud cover. Figure 2.3 illustrates CALMET (described further in Section 3.1) modelled mixing heights over water in the study area over the first four days of January (blue) and June (orange) 2012. The plots indicate that mixing heights over water in the study area do not significantly vary with season due in part to the general maritime climate which modifies seasonal extremes but mostly to water's low surface albedo (absorbs solar radiation rather than reflects it). As a result a strong diurnal pattern to mixing height typically observed over land (high in the day, low at night) is absent with fluctuations occurring due to wind speed induced turbulence (Figure 2.4).

It would be expected therefore that dispersion would be slightly greater during January due to higher wind speeds than in June, however the overall seasonal difference is not strong. The worst-case dispersion conditions (calm, low mixing height) could theoretically occur in either month.

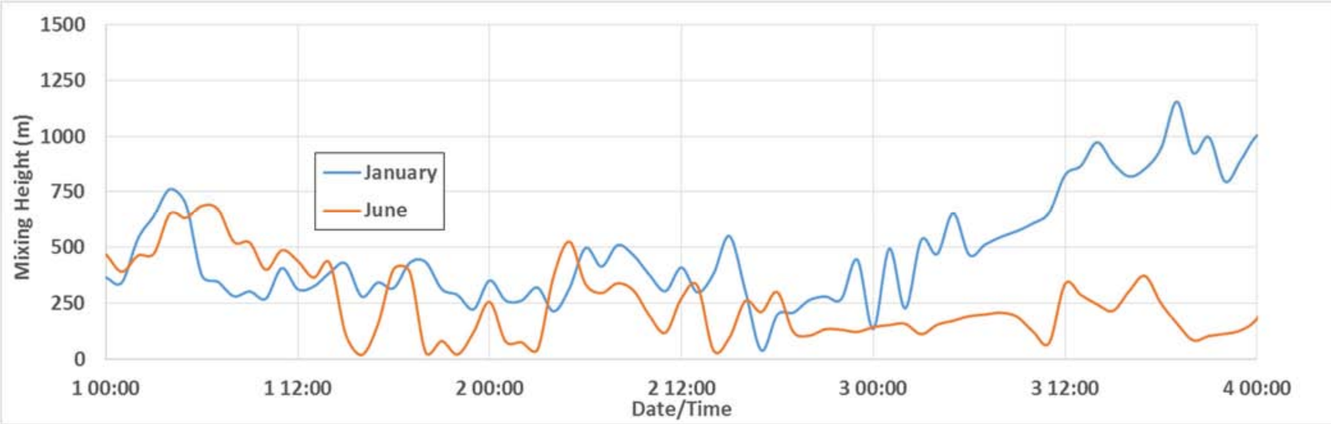

Figure 2.3: Comparison of CALMET Modelled Mixing Heights offshore Gabriola Island - January and June 2012

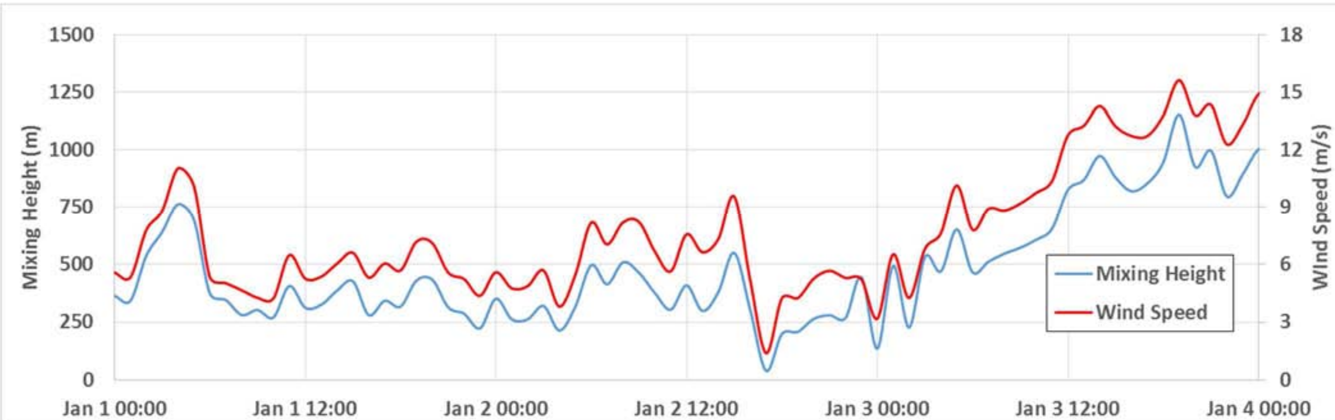

Figure 2.4: CALMET Modelled Mixing Height Offshore Gabriola Island Related to Wind Speed

2.4 Exhaust Parameters

Exhaust stack parameters used in modelling the scenarios represent a bulk average for marine vessels, as recommended by the United States Environmental Protection Agency (US EPA), California Air Resources Board, and Environment Canada (RWDI 2013).

Table 2.5: Average Stack and Exhaust Parameters for Vessels at Anchor and Maneuvering

Parameter	Value
Stack Height (m)	37
Stack Diameter (m)	0.8
Exit Velocity (m/s)	25
Exit Temperature (K)	555.2
sigma-Z (initial vertical rise parameter) (m)	10

Source: RWDI 2013

The design of individual vessels varies greatly. Exhaust stacks were therefore modelled as single point sources, 37 m tall. The modelling did incorporate downwash from the stack which can draw down the plume when the exhaust exit velocity is less than 1.5 times the wind speed, or 12.5 m/s, which was infrequent. Potential plume downwash from adjacent vessels was not modelled as the moorages are separated by over 1 km and would have a minimal effect if any.

3.0 CALPUFF

The airborne transport of the criteria air contaminants was modelled using CALPUFF, an advanced, multi-layered, multi-species, non-steady-state Gaussian puff air dispersion modeling system that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport. CALPUFF is recommended by the B.C. Ministry of Environment for complex, non-steady state meteorological conditions found in coastal situations.

The main components of the CALPUFF modeling system are CALMET (a diagnostic three-dimensional meteorological model), CALPUFF (an air quality dispersion model), and a post-processing package (CALPOST). In addition to these components, there are numerous other processors that are used to prepare geophysical (land use and terrain) and meteorological data (surface, upper air, precipitation, and buoy data).

3.1 CALMET

CALMET's multi-layered diagnostic meteorological module contains algorithms for calculating kinematic effects of terrain, slope and coastal flows and terrain blocking on the wind field and constructs a three-dimensional temperature and stability profile using interpolation schemes. The output from CALMET is used in CALPUFF as the meteorological forcings on the stack emissions. A brief description of the development of the CALMET model for this study is described in this section.

3.1.1 Domain and Grid Resolution

The study utilized an archived one-year QA/QCed CALMET meteorological data file (October 1, 2011 to September 30, 2012). The modelled area covers a large portion of the BC south coast including the Strait of Georgia, Juan de Fuca Strait, southern Vancouver Island, the Sunshine Coast and part of Metro Vancouver. The grid resolution was 1 km.

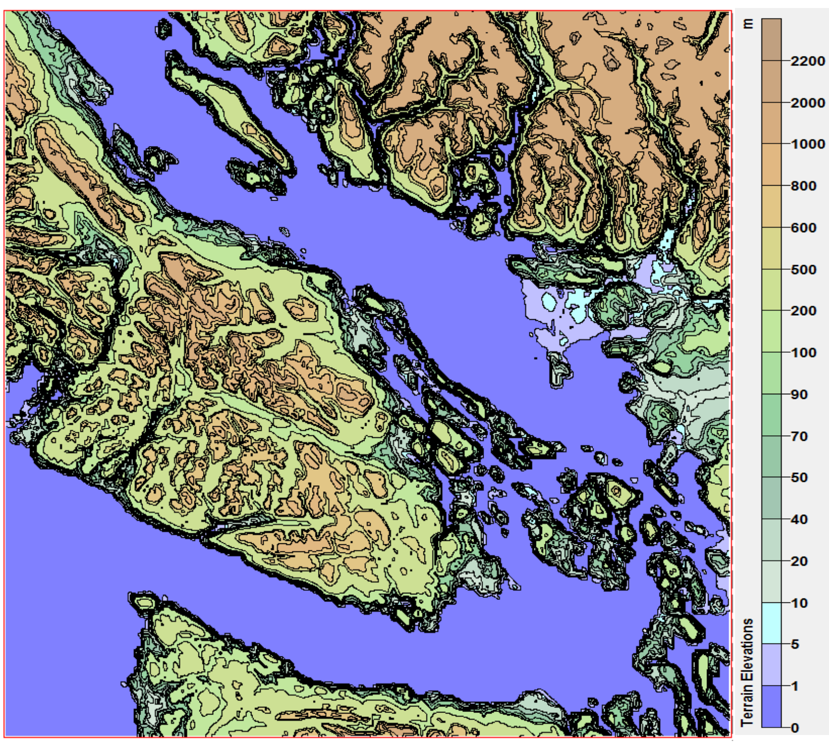

Figure 3.1: CALMET Model Domain (1 km Grid Resolution)

3.1.2 Surface, Upper Air and Overwater Meteorology

CALMET performed a dynamic interpolation of observational data to provide a grid of surface winds for CALPUFF using hourly observational data from a series of representative coastal Environment Canada (EC) and National Oceanic and Atmospheric Administration (NOAA, USA) meteorological stations and Department of Fisheries and Oceans (DFO) and National Data Buoy Center (NDBC, USA) buoys as well as three North American Regional Reanalysis (NARR) modelled grid points southwest of Vancouver Island (Table 3.1).

Table 3.1: Meteorological Surface Stations, Buoys and NARR Grid Points Used in CALMET

Meteorological Station/Buoy	Location	Body	Latitude	Longitude
Howe Sound – Pam Rocks	Howe Sound	EC	49.488 N	123.299 W
Point Atkinson	West Vancouver	EC	49.330 N	123.265 W
Vancouver Int'l Airport	Richmond	EC	49.195 N	123.182 W
Pitt Meadows A	Pitt Meadows	EC	49.216 N	122.683 W
Halibut Bank Buoy	Strait of Georgia	EC	49.340 N	123.727 W
New Dungeness Buoy	Juan de Fuca Strait	NDBC	48.336 N	123.159 W
Neah Bay Buoy	Juan de Fuca Strait	NDBC	48.494 N	124.728 W
Sentry Shoal Buoy	Strait of Georgia	EC	49.92 N	125.0 W
Kelp Reefs	Haro Strait	EC	48.548 N	123.236 W
Campbell River	N Vancouver Is.	EC	49.952 N	125.467 W
Grief Point	Sunshine Coast	EC	49.805 N	124.525 W
Discovery Island	Haro/Juan de Fuca Strait	EC	48.424 N	123.225 W
Sand Heads	Strait of Georgia	EC	49.106 N	123.303 W
Saturna Island	Boundary Pass	EC	48.783 N	123.045 W
Ballenas Island	Strait of Georgia	EC	49.350 N	124.158 W
Entrance Island	Strait of Georgia	EC	49.217 N	123.800 W
Race Rocks	S Vancouver Is.	EC	48.299 N	123.531 W
Sheringham Point	SW Vancouver Is.	EC	48.377 N	123.921 W
Sisters Island	Strait of Georgia	EC	49.487 N	124.435 W
Comox A	N Vancouver Is.	EC	49.717 N	124.900 W
North Cowichan	Vancouver Island	EC	48.817 N	123.717 W
Cherry Point	Washington State	NOAA	48.863 N	122.758 W
Bellingham Airport	Washington State	NOAA	48.794 N	122.537 W
Port Angeles	N Olympic Peninsula	NOAA	48.117 N	123.417 W
Port Townsend	NE Olympic Peninsula	NOAA	48.112 N	122.758 W
Smith Island	E. Juan de Fuca Strait	NOAA	48.317 N	122.843 W
Skagit Regional Airport	Washington State	NOAA	48.317 N	122.843 W
Orcas Island Airport	San Juan Islands	NOAA	48.466 N	122.416 W
Friday Harbor	San Juan Islands	NOAA	48.522 N	123.023 W
Whidbey Island	Washington State	NOAA	48.350 N	122.666 W
Everett/Paine Field	Washington State	NOAA	47.907 N	122.280 W
Arlington Municipal Airport	Washington State	NOAA	48.160 N	122.158 W
Tatoosh Island	NW Olympic Peninsula	NOAA	48.383 N	124.733 W

Meteorological Station/Buoy	Location	Body	Latitude	Longitude
NARR Pt205_60	Mouth of Juan de Fuca	NARR	48.567 N	125.383 W
NARR Pt230_60	Mouth of Juan de Fuca	NARR	48.433 N	125.010 W
NARR Pt230_10	Offshore O. Peninsula	NARR	48.067 N	125.466 W

Legend: EC: Environment Canada; NDBC: National Data Buoy Center (USA); NOAA – National Oceanic and Atmospheric Administration (USA); NARR: North American Regional Reanalysis.

Twice-daily upper air soundings taken at NOAA station Quillayute, Washington (47.94 °N, 124.56 °W) were used to provide the model inputs for a vertical profile of winds, temperature and pressure. Where a sounding was missing, temporal substitution was the preferred method, substituting the previous or following day's sounding taken at the same time of day. The basis for the applicability of a temporal substitution was upper air soundings taken at EC station Port Hardy as an indicator of changing conditions. On the few occasions that changing conditions were observed at Port Hardy and an upper air sounding was missing at Quillayute, spatial substitution was used, taking the entire sounding from Port Hardy and applying it to Quillayute.

3.1.3 Terrain Elevation and Land Use Characterization

SRTM1 (USA) and 1:50,000 Canadian Digital Elevation Data (Canada) at ~30 m resolution were downloaded along with USGS Global Land Cover Characterization (GLCC) data (resolution ~1 km).

3.1.4 CALMET Switch Settings

In general, model settings were chosen in accordance with Tables 6.1 and 6.2 of *'British Columbia Air Quality Dispersion Modelling Guideline*' (BC MOE 2015). Where expert judgment was required, choices were evaluated that resulted in the most representative surface layer wind field.

3.2 CALPUFF Settings

Model settings were chosen in accordance with Table 7.1 of *'British Columbia Air Quality Dispersion Modelling Guideline*' (BC MOE 2015).

3.2.1 Receptor Grid

The receptor grid covered a 50 x 50 km area with 250 m spacing centered slightly southwest of the proposed moorages to capture any regional effects in onshore areas (Figure 3.1). Although a large area was covered, the study focused on the impacts near Gabriola Island and within in the moorage area.

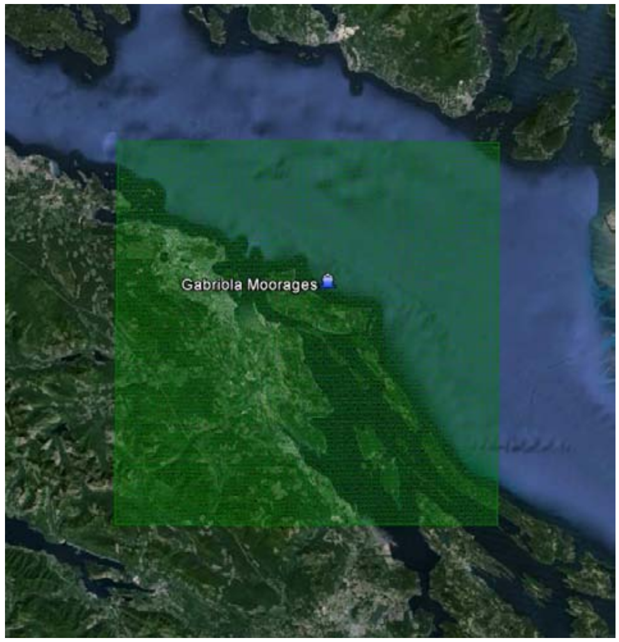

Figure 3.1: CALPUFF Receptor Grid

3.2.2 Ozone Limiting Method for NO_2 Conversion

CALPUFF contains atmospheric chemistry modules which consider, among other transformations, the conversion of emitted NO_x to NO_2 in the atmosphere by means of a reaction with atmospheric ozone (O_3). Average monthly ozone concentrations were entered into CALPUFF based on 2010-2013 monitoring data at Nanaimo Labieux monitoring station in order to more accurately reflect local transformation rates. As recommended in BC MoE 2015, the RIVAD/ISOROPPIA scheme was used.

3.2.3 Wet and Dry Deposition

Depositional algorithms for both particles and gases was enabled in CALPUFF. The algorithms predict the natural depletion of nitrogen, sulfur and particulate matter in the air as they settle to the ground. Depositional parameters were established using guidance from '*Air Dispersion Modelling of Toxic Pollutants in Urban Areas – Guidance, Methodology and Example Applications*' (USEPA 1999) with reference to '*Marine Air Quality and Greenhouse Gas Marine Transportation Technical Report for the Trans Mountain Pipeline ULC*' (RDWI 2013).

The modelling study was concerned with the airborne concentrations of criteria air contaminants related to vessel moorage. While including the gravitational settling algorithms in CALPUFF more accurately depicts natural plume depletion and avoids over-prediction of concentrations, dry deposition rates onto water, soils and vegetation has not been analyzed.

4.0 AMBIENT AIR QUALITY

To provide a baseline of the ambient air quality in the study area, hourly air quality data was obtained from monitoring stations nearest the study area - Nanaimo Labieux (for NO_2) and Duncan Cairnsmore (for $PM_{2.5}$) - that provided somewhat reasonable representative data (Table 4.1). Table 4.1 also lists the BC Ambient Air Quality Objectives for species relevant to the study. For other CACs not monitored in the area, average annual background levels are provided at three locations through the region in Table 4.2.

Table 4.1: Observed Background Concentrations and BC Ambient Air Quality Objectives (in µg/m^3)

Contaminant	Average Background Concentration		B.C. Air Quality Objective/PCOs*	Averaging Period
	January	June		
CO	See Table 4.2		14,300[c]	1 Hour
NO_2	18.5[a]	9.7[a]	188	1 Hour
$PM_{2.5}$	16[b]	4[b]	25	24 Hour
PM_{10}	See Table 4.2		50	24 Hour
SO_2	See Table 4.2		200	1 Hour

[a] Observed at Nanaimo Labieux Station (2010 – 2013)
[b] Observed at Duncan Cairnsmore Station (2010 – 2013)
[c] most stringent Level A
* Pollution Control Objectives were rescinded in 2006, but levels are used for reference purposes.

Table 4.2: Regional Background Concentrations (in µg/m^3)

	Averaging Period	Burrard Inlet (Urban)	Victoria Area (Urban)	Cheeka Peak, WA (Coastal, Rural)
TSP	24 Hour	36.2	34.7	21.4
PM10	24 Hour	20.1	19.3	11.9
CO	1 Hour	605	1360	259
SO_2	1 Hour	26.3	14.9	2.3
*VOC	1 Hour	8.8	n/a	1.6

*Average of benzene, toluene, ethylbenzene and xylene
*Source: RWDI 2013

5.0 MODEL RESULTS

CALPUFF's post processor provided maximum predicted concentrations for each species over averaging times consistent with the BC Ambient Air Quality Objectives (Table 4.1) for each modelled scenario. Figures 5.1 to 5.6 are plots for each respective species/averaging time showing the maximum concentration at each receptor for the cumulative at anchor scenario. The figures do not represent a snap shot of concentrations at a given time, rather they are a conglomerate of predicted maximums for all simulated hours (January and June 2012). The scenarios are also not intended to represent anchorage occurring for a duration of one-month, rather they are depicting the potential extent of air quality impacts for all meteorological conditions which occurred in the given month.

The figures show that the highest levels are generally predicted overwater in the moorage area. The general dispersion pattern is a result of the predominant winds through the area keeping higher concentrations over water. Small pockets of elevated NO_2 are observed on Gabriola Island however they are well below the air quality objective. Concentrations for all other species are below ambient baseline.

Figures 5-7 through 5-12 are plots of predicted maximums for the maneuvering a container ship while four vessels are moored scenario. Due to the use of the main engine, maximum concentrations are generally higher and can affect a much larger area. NO_2 was predicted to potentially exceed the ambient air quality objective of 188 µg/m^3 on Gabriola Island while SO_2 concentrations impinged on the ambient air quality objective 200 µg/m^3 and exceeded at one location within the moorage. VOCs were shown to be elevated over ambient. PM levels are below ambient.

Figure 5.7 shows the maximum predicted 1 hour NO_2 for both the single container vessel at anchor and the cumulative at anchor scenarios plotted with a slightly lower cutoff (20 µg/m^3) and different shading to illustrate the dispersion behaviour. Higher levels, well below the ambient air quality objective of 188 µg/m^3 are generally predicted offshore in the moorage area with small areas impinging onto shore.

Table 5.1 lists the maximum ground-level concentration predicted by CALPUFF at any receptor point for each of the individual vessel at anchor scenarios and the two cumulative scenarios.

Table 5.1: Maximum Predicted Concentration at Any Receptor – at Anchor Scenario (in µg/m^3)

Modelled Scenario	NO_2	SO_2	PM_{10}	$PM_{2.5}$	CO	VOC
	1-hr	1-hr	24-hr	24-hr	1-hr	1-hr
Bulk Carrier Moored at G-1	98	32	0.64	0.58	8.3	3.0
Vehicle Carrier Moored at G-2	85	18	0.78	0.71	4.7	1.7
Cargo Vessel Moored at G-3	98	32	0.64	0.57	8.3	3.0
Container Vessel Moored at G-4	176	79	1.0	0.92	21	7.6
Bulk Carrier Moored at G-5	47	19	0.36	0.32	4.9	1.1
Cumulative Full Moorage at Anchor	194	79	1.1	1.0	21	7.6
Full Moorage with Container Vessel Maneuvering	620	308	4.8	4.3	186	186

6.0 CONCLUSION

The modelling conducted in this report represents an assessment of the potential air quality impacts from diesel exhaust from the proposed Gabriola Moorages. The assessment analyzed impacts for both anchoring and maneuvering scenarios, using audited vessel statistics and emission factors for regional commercial vessel behaviour contained in the Chamber of Shipping comprehensive 2007 report. The study assumed that various deep sea vessel types would anchor at the moorage with the number of each type of ship moored based off of regional vessel traffic statistics.

The findings of this modelling study suggest that when vessels are at anchor within the moorage, emissions from an individual ship do not result in exceedance of ambient air quality objectives. The highest impacts are due to emissions of NO_x. When the moorage is full, NO_2 concentrations were predicted to slightly exceed the BC ambient air quality objective in the vicinity of the vessels but not over land.

When a container-type vessel is maneuvering within the moorage, ambient air quality objectives were predicted to have been exceeded for both NO_2 and SO_2. Based on the COS data, the container category of vessels have the highest emission rates of the four vessel types considered in this study due to a large main engine capacity and a higher auxiliary engine load than the other vessels.

SO_2 emissions are a function of the sulfur content in the fuel. The COS emission factors provided for SO_2 are relative to a sulfur content of 1%. Within the North American Emission Control Area (ECA) which extends 200 nautical miles from shore, the maximum sulphur content in fuel oil was decreased to 0.1% starting January 1, 2015 (RWDI 2013). If this regulation is followed, SO_2 concentrations would be one tenth lower than those predicted.

7.0 CLOSURE

We trust this report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
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FIGURES

Figure 5.1 Five Vessels at Anchor Scenario - Maximum 1-Hr NO_2 Concentration at Ground Level

Figure 5.2 Five Vessels at Anchor Scenario - Maximum 1-Hr SO_2 Concentration at Ground Level

Figure 5.3 Five Vessels at Anchor Scenario - Maximum 1-Hr CO Concentration at Ground Level

Figure 5.4 Five Vessels at Anchor Scenario - Maximum 1-Hr VOC Concentration at Ground Level

Figure 5.5 Five Vessels at Anchor Scenario - Maximum 24-Hr PM_{10} Concentration at Ground Level

Figure 5.6 Five Vessels at Anchor Scenario - Maximum 24-Hr $PM_{2.5}$ Concentration at Ground Level

Figure 5.8 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 1-Hr NO_2 Concentration at Ground Level

Figure 5.9 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 1-Hr SO_2 Concentration at Ground Level

Figure 5.10 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 1-Hr CO Concentration at Ground Level

Figure 5.11 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 1-Hr VOC Concentration at Ground Level

Figure 5.12 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 24-Hr PM_{10} Concentration at Ground Level

Figure 5.13 One Vessel Maneuvering Four Vessels at Anchor Scenario - Maximum 24-Hr $PM_{2.5}$ Concentration at Ground Level

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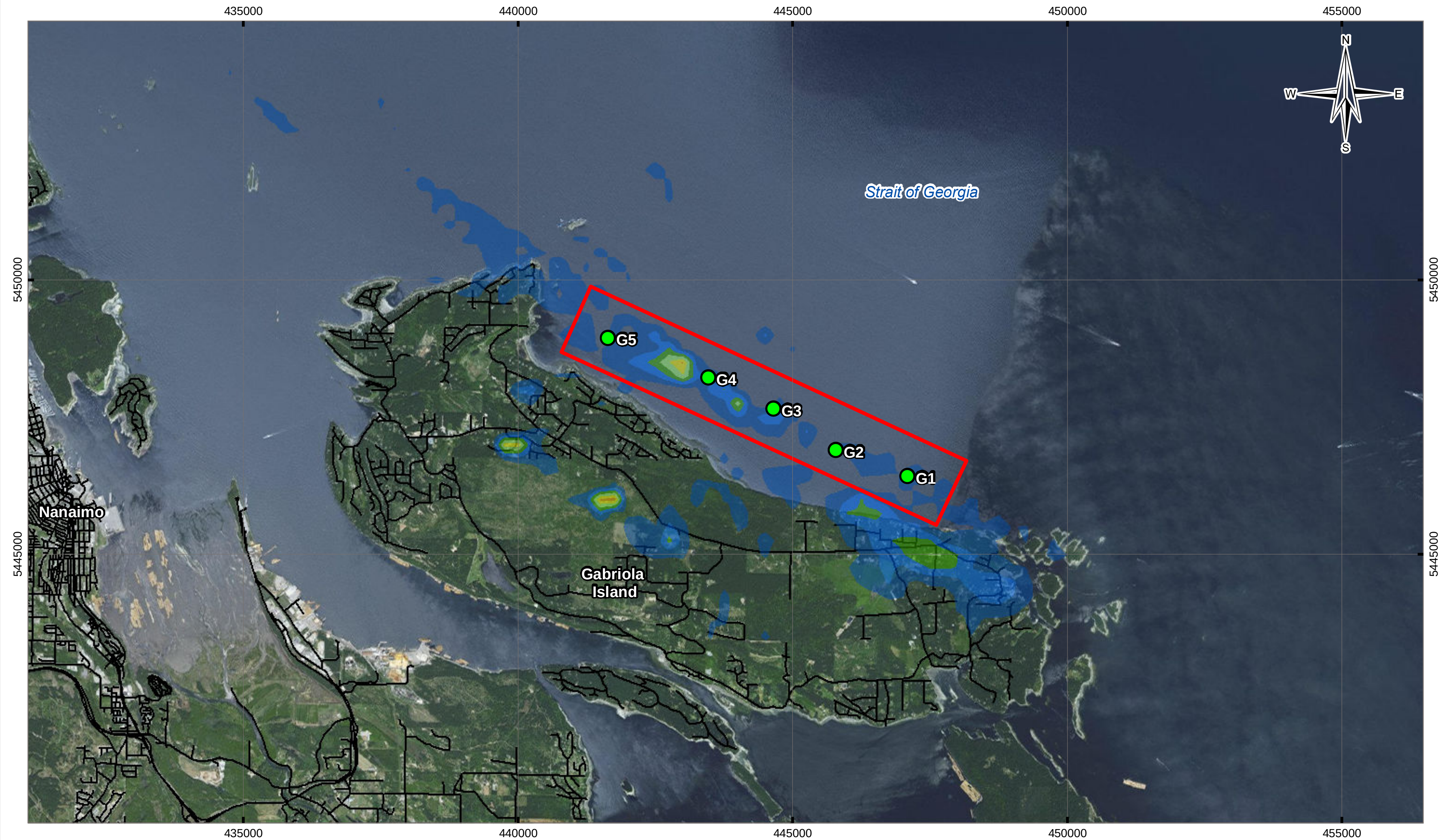

LEGEND

- Project Area
- Anchor Location
- Road

NO_2 Concentration

- < 50
- 50 - 75
- 75 - 100
- 100 - 125
- 125 - 150
- 150 - 175
- 175 - 200

NOTES

1. Base data source:
Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2

Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-1_FullNO.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

Five Vessels at Anchor Scenario - Maximum 1-Hr NO_2 Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 8, 2016

Figure 5.1

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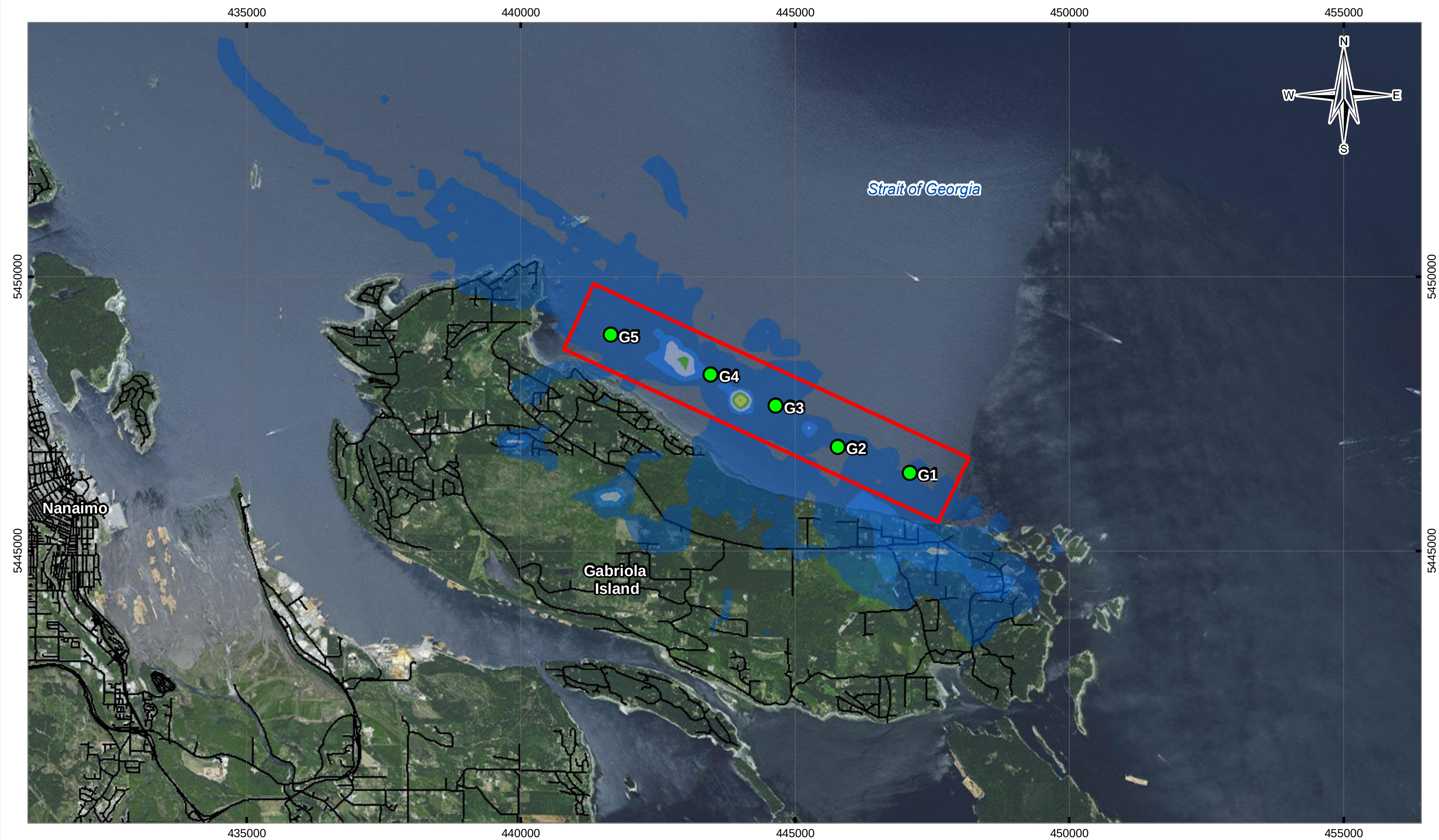

LEGEND

- Project Area
- Anchor Location
- Road

SO_2 Concentration

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80

NOTES

1. Base data source:
Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2

Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-2_FullSO.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

Five Vessels at Anchor Scenario - Maximum 1-Hr SO_2 Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 8, 2016

Figure 5.2

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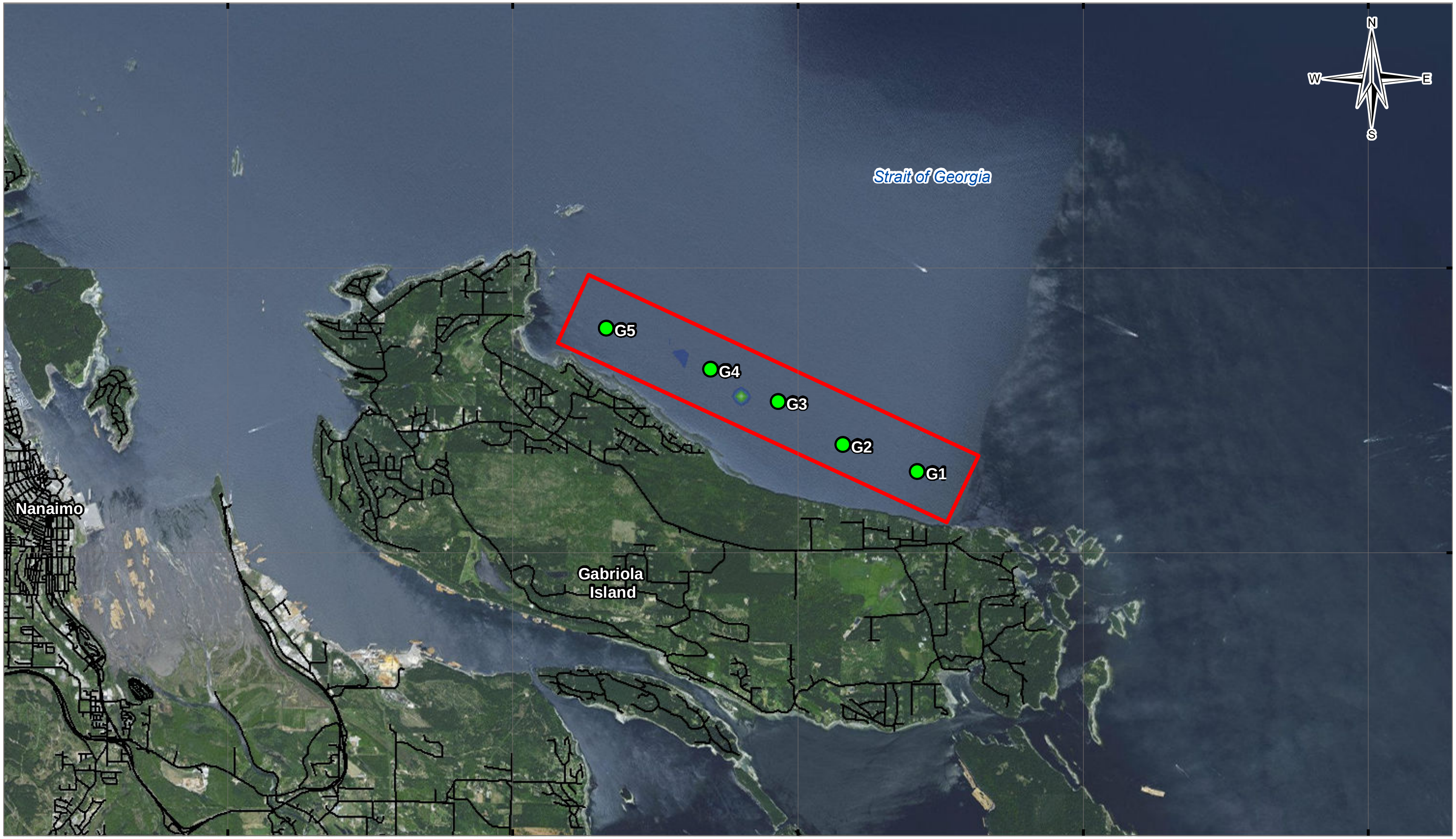

LEGEND

Project Area
Anchor Location
Road

CO Concentration

- < 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- 18 - 21

NOTES

1. Base data source:
Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

Scale: 1:100,000

2 1 0 2

Kilometres

STATUS
ISSUED FOR REVIEW

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-3_FullCO1.mxd

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Pacific Pilotage Authority

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DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

Five Vessels at Anchor Scenario - Maximum 1-Hr CO Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 8, 2016

Figure 5.3

Q:\Vancouver\GIS\ENVIRONMENTAL\VENV\VENV03029-01\Maps\AirDispersion\VENV03029-01_Figure5-4_FullVOC.mxd modified 3/9/2016 by morgan.zondervan

LEGEND

- Project Area
- Anchor Location
- Road

VOC Concentration

- < 2
- 2 - 4
- 4 - 6
- 6 - 7.6

NOTES

1. Base data source: Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2
Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-4_FullVOC.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

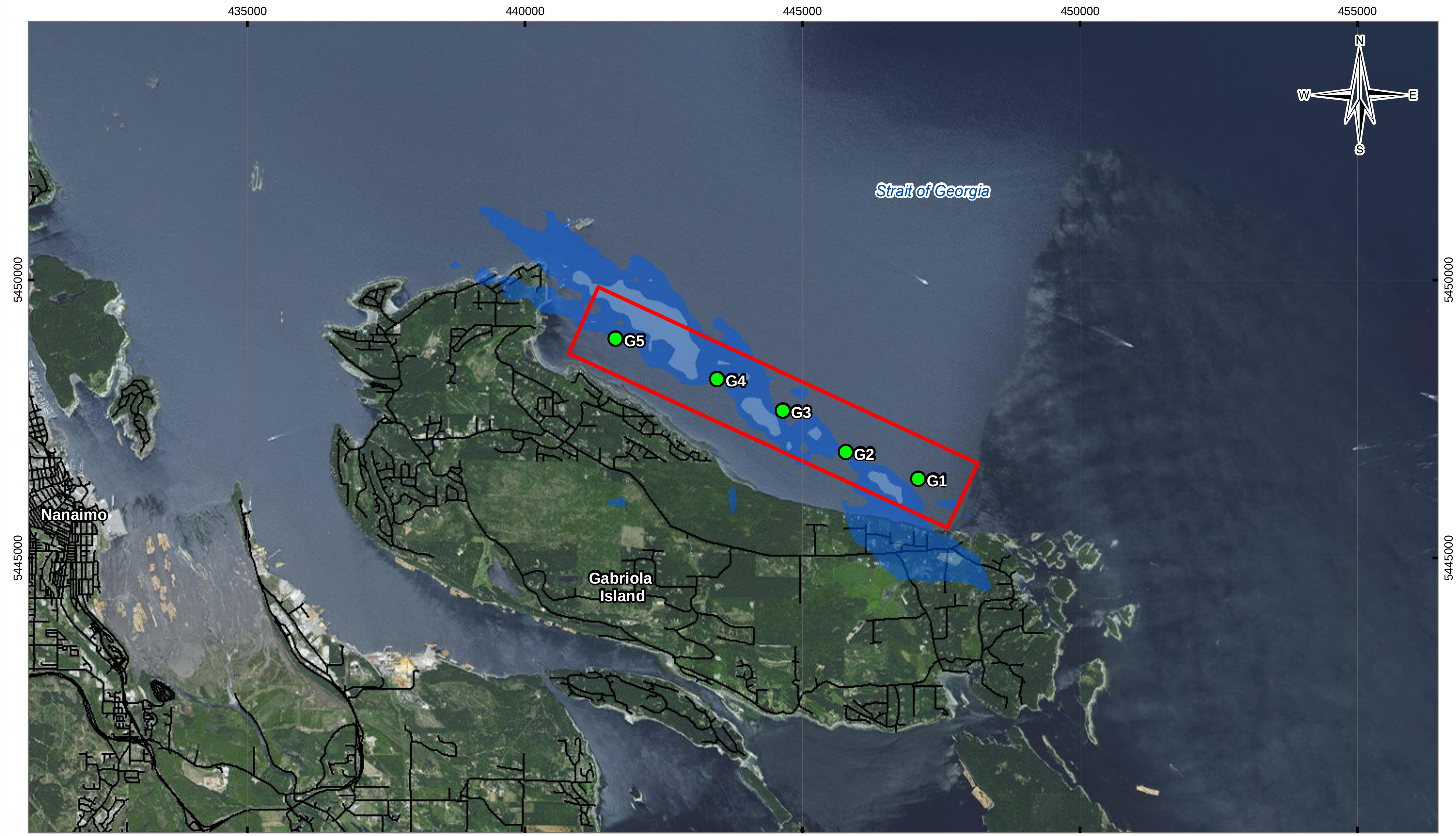
Five Vessels at Anchor Scenario - Maximum 1-Hr VOC Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 9, 2016

Figure 5.4

Q:\Vancouver\GIS\ENVIRONMENTAL\VENV\VENV03029-01\Maps\AirDispersion\VENV03029-01_Figure5-5_FullPM10.mxd modified 3/9/2016 by morgan.zondervan



LEGEND

Project Area
Anchor Location
Road

PM_{10} Concentration

- 0 - 0.5
- 0.5 - 0.75
- 0.75 - 1.13

NOTES

1. Base data source:
Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2
Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-5_FullPM10.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

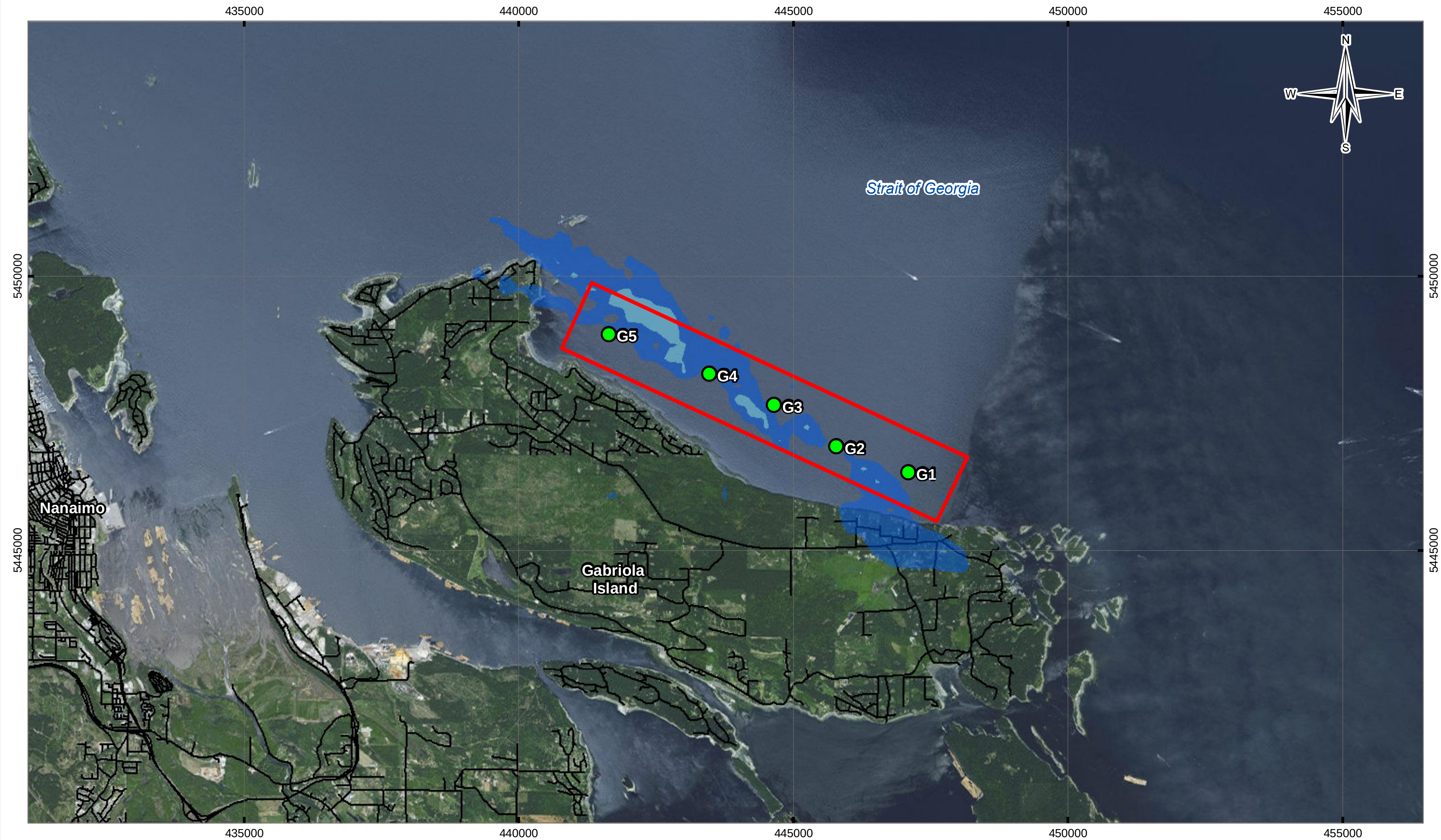
Five Vessels at Anchor Scenario - Maximum 24-Hr PM_{10} Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 9, 2016

Figure 5.5

Q:\Vancouver\GIS\ENVIRONMENTAL\VENV\VENV03029-01\Maps\AirDispersion\VENV03029-01_Figure5-6_FullPM2-5.mxd modified 3/9/2016 by morgan.zondervan



LEGEND

- Project Area
- Anchor Location
- Road

$PM_{2.5}$ Concentration

- 0 - 0.5
- 0.5 - 0.75
- 0.75 - 1.02

NOTES

1. Base data source: Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2

Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-6_FullPM2-5.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

Five Vessels at Anchor Scenario - Maximum 24-Hr $PM_{2.5}$ Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 9, 2016

Figure 5.6

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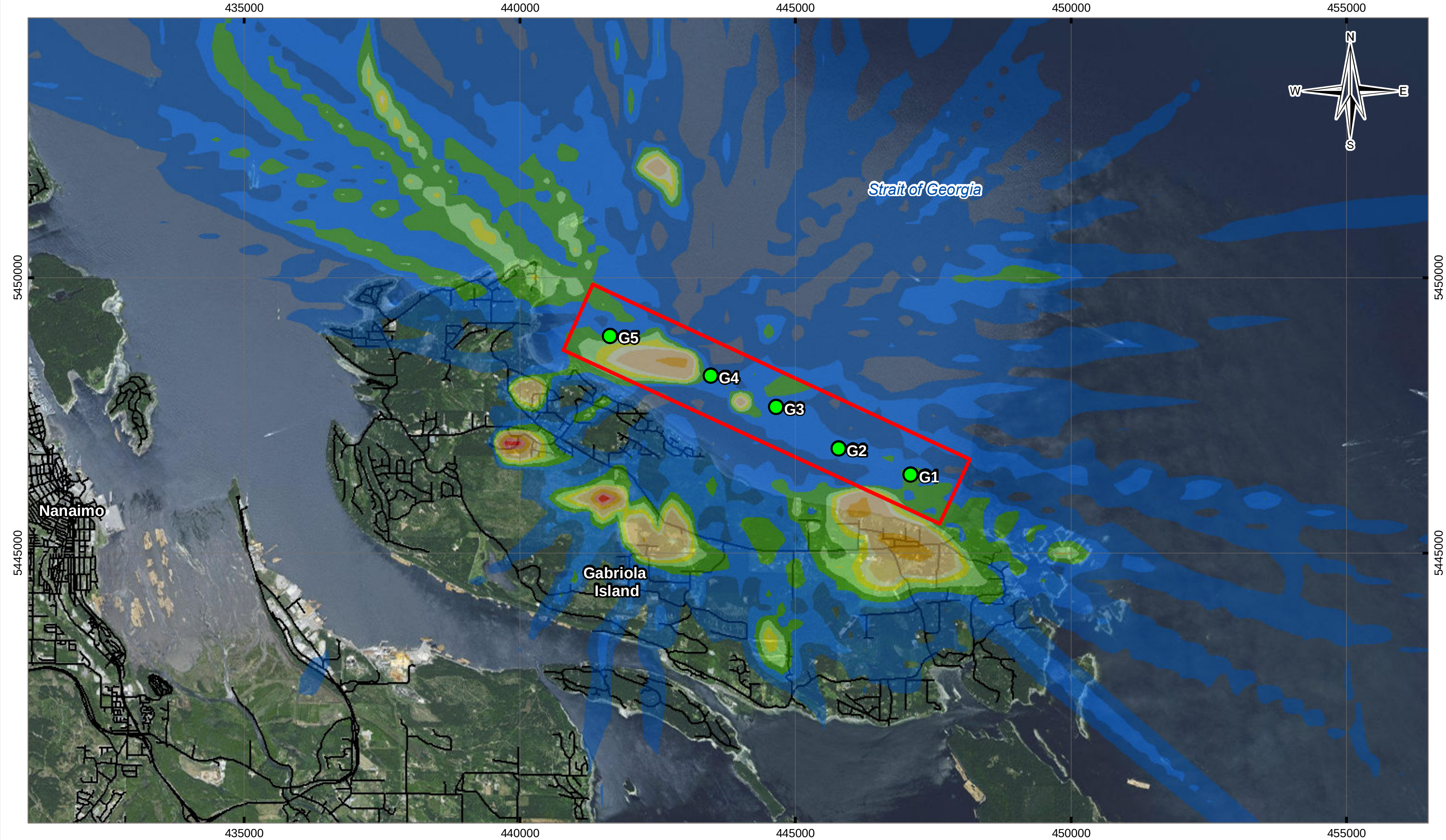

LEGEND

- Project Area
- Anchor Location
- Road

NO_2 Concentration

- < 50
- 50 - 75
- 75 - 100
- 100 - 125
- 125 - 150
- 150 - 175
- 175 - 200
- 200 - 300
- 300 - 400
- 400 - 500
- 500 - 620

NOTES

1. Base data source: Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

Scale: 1:100,000

2 1 0 2

Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-8_OneNO.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

STATUS
ISSUED FOR REVIEW

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

One Vessel Maneuvering - Four Vessels at Anchor Scenario - Maximum 1-Hr NO_2 Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 9, 2016

Figure 5.7

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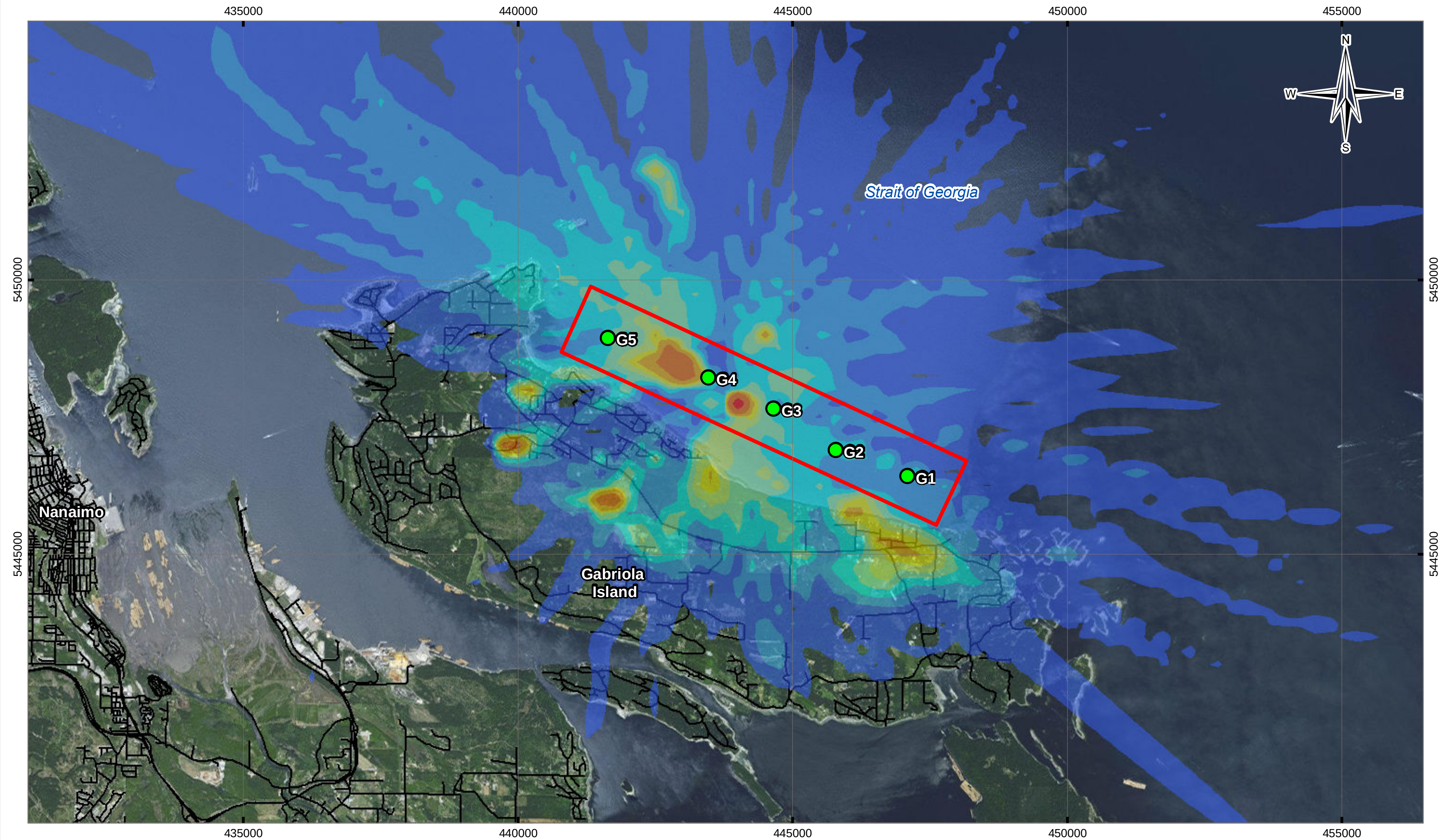


LEGEND

- Project Area
- Anchor Location
- Road

SO_2 Concentration

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 100
- 100 - 200
- 200- 310

NOTES

1. Base data source: Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2

Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-9_OneSO.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

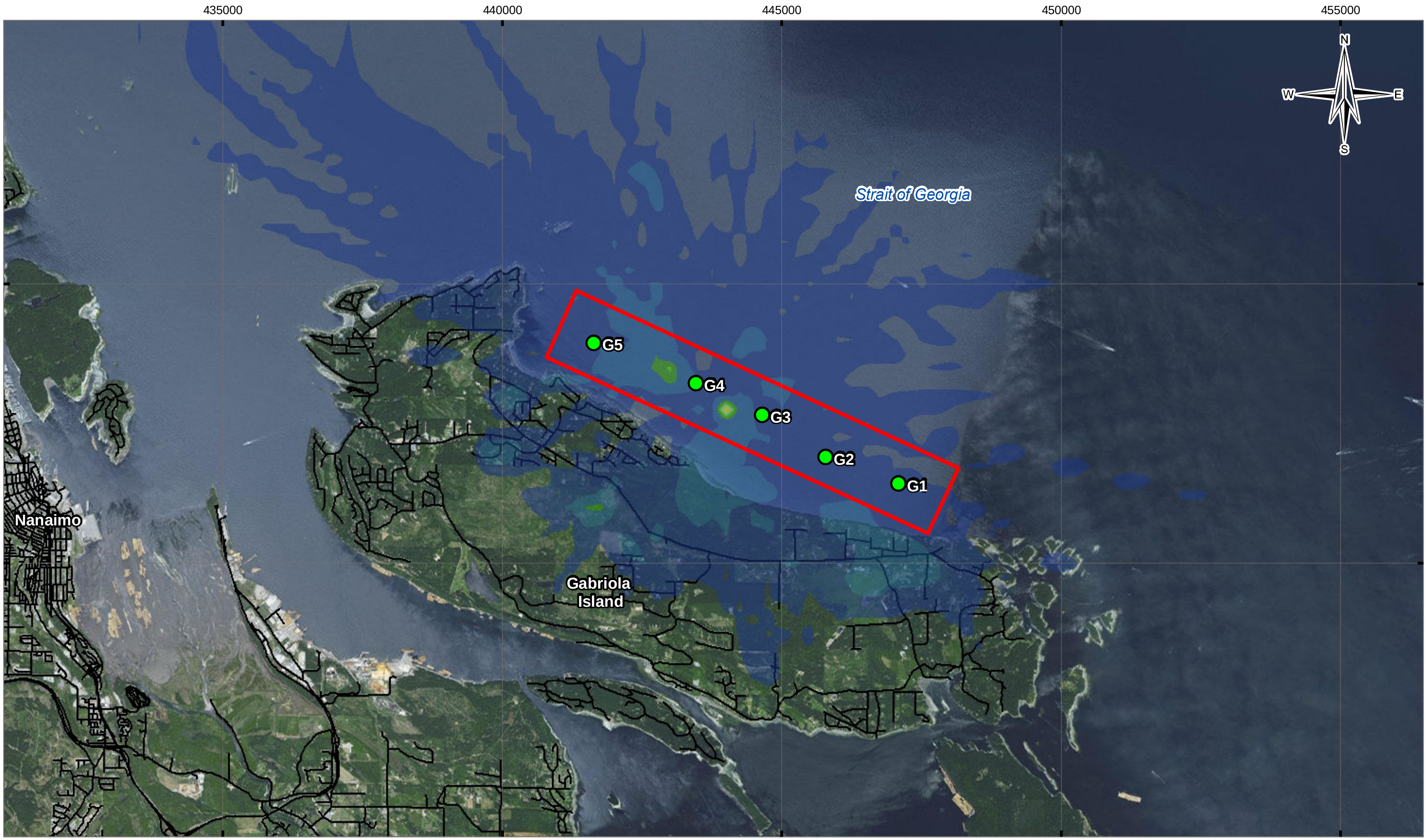
One Vessel Maneuvering - Four Vessels at Anchor Scenario - Maximum 1-Hr SO_2 Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 9, 2016

Figure 5.8

Q:\Vancouver\GIS\ENVIRONMENTAL\VENV\VENV03029-01\Maps\AirDispersion\VENV03029-01_Figure5-10_OneCO1.mxd modified 3/9/2016 by morgan.zondervan



LEGEND

- Project Area
- Anchor Location
- Road

CO Concentration

- < 10
- 10 - 25
- 25 - 75
- 75 - 100
- 100 - 125
- 125 - 150
- 150 - 185

NOTES

1. Base data source: Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2

Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-10_OneCO1.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

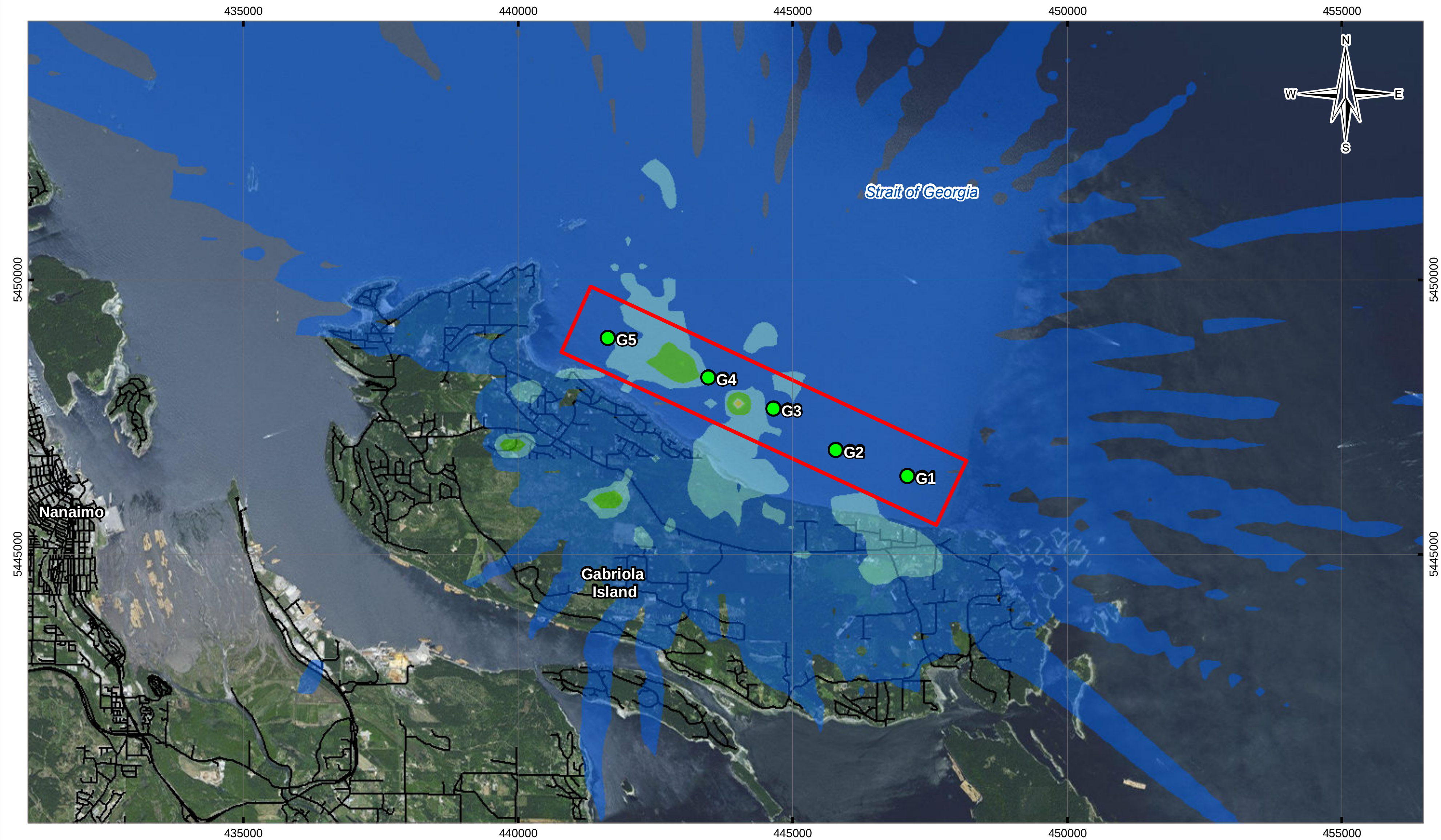
One Vessel Maneuvering - Four Vessels at Anchor Scenario - Maximum 1-Hr CO Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 9, 2016

Figure 5.9

Q:\Vancouver\GIS\ENVIRONMENTAL\VENV\VENV03029-01\Maps\AirDispersion\VENV03029-01_Figure5-11_OneVOC.mxd modified 3/9/2016 by morgan.zondervan



LEGEND

- Project Area
- Anchor Location
- Road

VOC Concentration

- < 5
- 5 - 25
- 25 - 50
- 50 - 100
- 10 - 125
- 125 - 150
- 150 - 185

NOTES

1. Base data source:
Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2

Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-11_OneVOC.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

One Vessel Maneuvering - Four Vessels at Anchor Scenario - Maximum 1-Hr VOC Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 9, 2016

Figure 5.10

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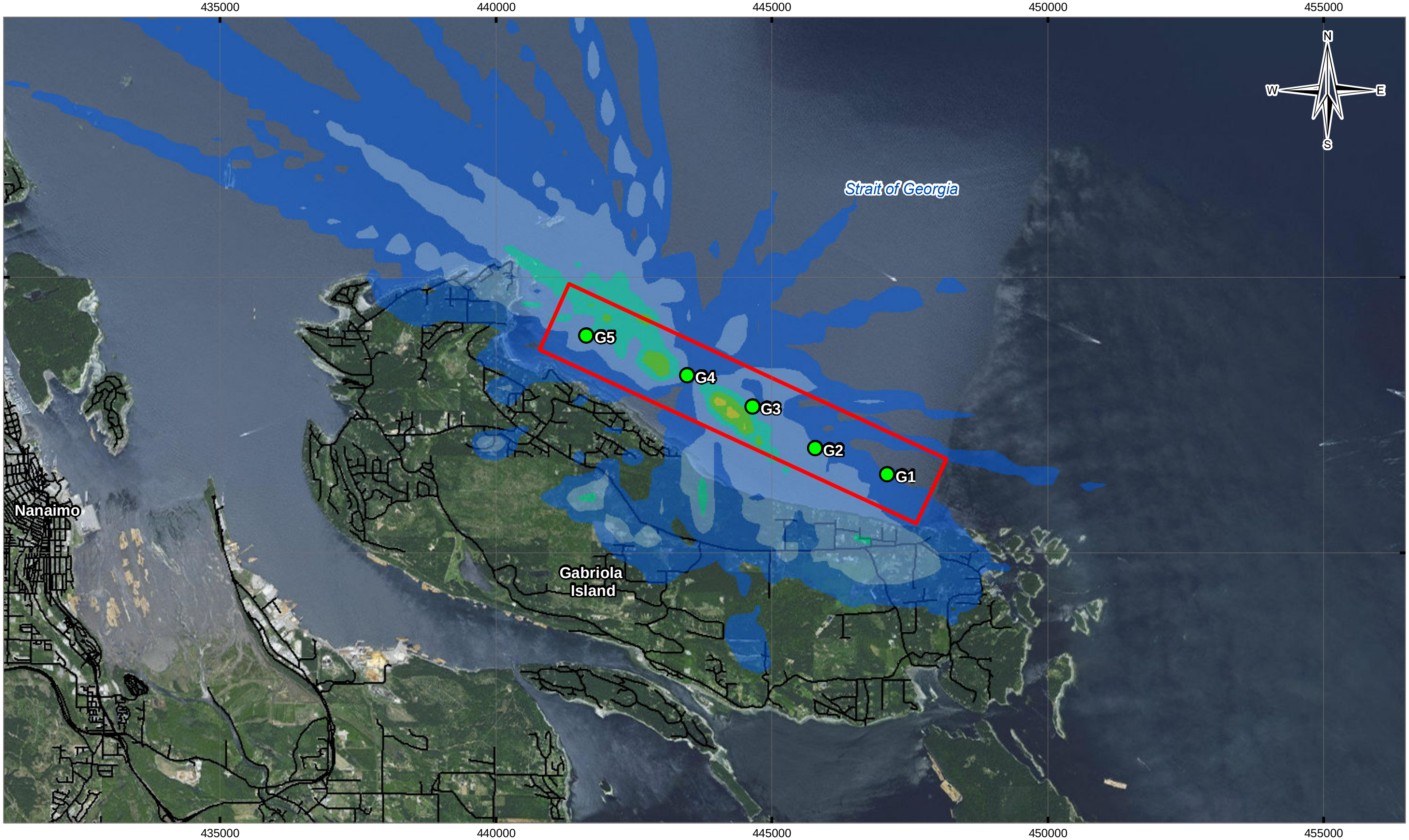


LEGEND

- Project Area
- Anchor Location
- Road

PM_{10} Concentration

- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 4.8

NOTES

1. Base data source: Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2
Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
VENV03029-01_Figure5-12_OnePM10.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

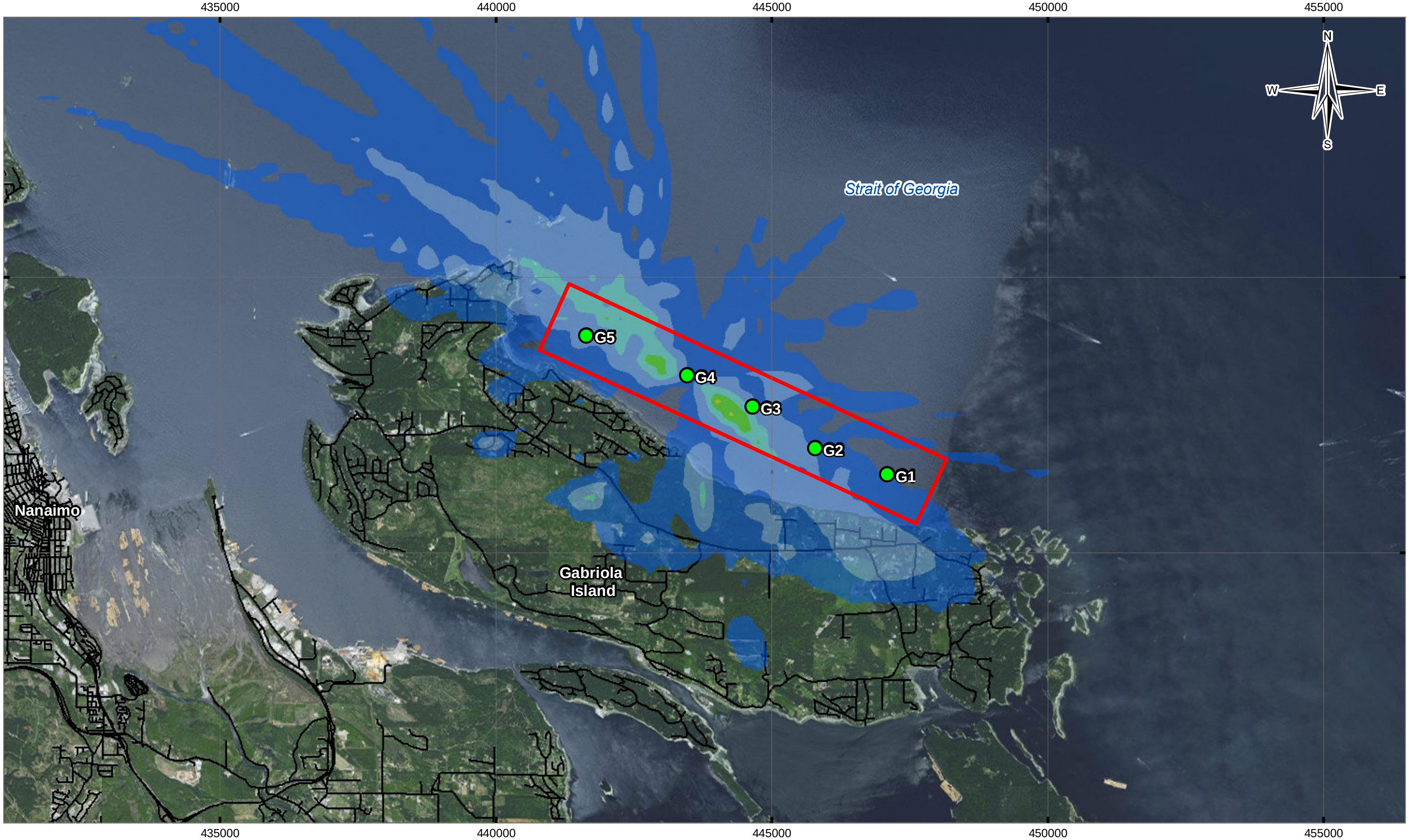
One Vessel Maneuvering - Four Vessels at Anchor Scenario - Maximum 24-Hr PM_{10} Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE	DATE
Tt EBA-VANC	March 9, 2016

Figure 5.11

Q:\Vancouver\GIS\ENVIRONMENTAL\VENV\VENV03029-01\Maps\AirDispersion\VENV03029-01_Figure5-13_OnePM2-5.mxd modified 3/9/2016 by morgan.zondervan



LEGEND

- Project Area
- Anchor Location
- Road

$PM_{2.5}$ Concentration

- < 0.5
- 0.5 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 4.4

NOTES

1. Base data source: Imagery from ESRI;CNES/Airbus DS (2009)
2. Vessel statistics and emission factors adopted from *'2005 – 2006 BC Ocean-Going Vessel Emissions Inventory'* Chamber of Shipping 2007.

STATUS
ISSUED FOR REVIEW

Scale: 1:100,000

2 1 0 2

Kilometres

PROJECTION
UTM Zone 10

DATUM
NAD83

FILE NO.
VENV03029-01_Figure5-13_OnePM2-5.mxd

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Pacific Pilotage Authority

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DIESEL EXHAUST AIR DISPERSION STUDY PROPOSED GABRIOLA ANCHORAGES

One Vessel Maneuvering - Four Vessels at Anchor Scenario - Maximum 24-Hr $PM_{2.5}$ Concentration at Ground Level

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	TM	0

OFFICE
Tt EBA-VANC

DATE
March 9, 2016

Figure 5.12

APPENDIX A

TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

NATURAL SCIENCES

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORTS AND OWNERSHIP

This report pertains to a specific site, a specific development or activity, and/or a specific scope of work. The report may include plans, drawings, profiles and other supporting documents that collectively constitute the report (the "Report").

The Report is intended for the sole use of Tetra Tech EBA's Client (the "Client") as specifically identified in the Tetra Tech EBA Services Agreement or other Contract entered into with the Client (either of which is termed the "Services Agreement" herein). Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Report when it is used or relied upon by any party other than the Client, unless authorized in writing by Tetra Tech EBA.

Any unauthorized use of the Report is at the sole risk of the user. Tetra Tech EBA accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Report.

Where Tetra Tech EBA has expressly authorized the use of the Report by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these General Conditions as well as any limitations on liability contained in the Services Agreement with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these General Conditions and the Services Agreement prior to making any use of the Report. Any use made of the Report by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Report and any other form or type of data or documents generated by Tetra Tech EBA during the performance of the work are Tetra Tech EBA's professional work product and shall remain the copyright property of Tetra Tech EBA.

The Report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of Tetra Tech EBA. Additional copies of the Report, if required, may be obtained upon request.

2.0 ALTERNATIVE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of the Report or any drawings or other project-related documents and deliverables (collectively termed Tetra Tech EBA's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original. Tetra Tech EBA will archive the original signed and/or sealed version for a maximum period of 10 years.

Both electronic file and hard copy versions of Tetra Tech EBA's Instruments of Professional Service shall not, under any circumstances, be altered by any party except Tetra Tech EBA. Tetra Tech EBA's Instruments of Professional Service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

3.0 STANDARD OF CARE

Services performed by Tetra Tech EBA for the Report have been conducted in accordance with the Services Agreement, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Report.

Tetra Tech EBA professionals are bound by their ethical commitments to act within the bounds of all pertinent regulations. In certain instances, observations by Tetra Tech EBA of regulatory contravention may require that regulatory agencies and other persons be informed. The client agrees that notification to such bodies or persons as required may be done by Tetra Tech EBA in its reasonably exercised discretion.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of Tetra Tech EBA.

4.0 ENVIRONMENTAL ISSUES

The ability to rely upon and generalize from environmental baseline data is dependent on data collection activities occurring within biologically relevant survey windows.

5.0 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with Tetra Tech EBA with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for Tetra Tech EBA to properly provide the services contracted for in the Services Agreement, Tetra Tech EBA has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

6.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of this Report, Tetra Tech EBA may have relied on information provided by persons other than the Client.

While Tetra Tech EBA endeavours to verify the accuracy of such information, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

7.0 GENERAL LIMITATIONS OF REPORT

This Report is based solely on the conditions present and the data available to Tetra Tech EBA at the time the data were collected in the field or gathered from publically available databases.

The Client, and any Authorized Party, acknowledges that the Report is based on limited data and that the conclusions, opinions, and recommendations contained in the Report are the result of the application of professional judgment to such limited data.

The Report is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present at or the development proposed as of the date of the Report requires a supplementary investigation and assessment.

It is incumbent upon the Client and any Authorized Party, to be knowledgeable of the level of risk that has been incorporated into the project design or scope, in consideration of the level of the environmental baseline information that was reasonably acquired to facilitate completion of the scope.

The Client acknowledges that Tetra Tech EBA is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of property, the decisions on which are the sole responsibility of the Client.

8.0 JOB SITE SAFETY

Tetra Tech EBA is only responsible for the activities of its employees on the job site and was not and will not be responsible for the supervision of any other persons whatsoever. The presence of Tetra Tech EBA personnel on site shall not be construed in any way to relieve the Client or any other persons on site from their responsibility for job site safety.

APPENDIX C

UNDERWATER AND IN-AIR NOISE MODELING STUDY (KALAPINSKI, VARNIK AND PELLERIN 2016)

UNDERWATER AND IN-AIR NOISE MODELING STUDY

FOR THE
PACIFIC PILOTAGE AUTHORITY
GABRIOLA ANCHORAGES PROJECT

STRAIT OF GEORGIA
GABRIOLA ISLAND, BRITISH COLUMBIA

March 2016

PREPARED FOR:
Tetra Tech EBA
Unit 1 - 4376 Boban Dr.
Nanaimo, BC V9T 6A7

PREPARED BY:
Tetra Tech CES
160 Federal Street
3rd Floor
Boston MA 02110

TABLE OF CONTENTS

Section Page

1.0 INTRODCUTION 1

2.0 TERMINOLOGY 3

3.0 UNDERWATER NOISE MODELING SCENARIOS 4

4.0 UNDERWATER SOUND PROPAGATION MODELING 5

5.0 UNDERWATER NOISE MODELING RESULTS 6

6.0 IN-AIR NOISE ASSESSEMENT 11

7.0 REFERENCES 15

LIST OF FIGURES

Figure

Figure 1 – Project Area and Proposed Anchorage Locations 2

Figure 2 – Auditory M-weighting functions for low-frequency (LF), mid-frequency (MF) and high-frequency (HF) cetaceans. (NOAA 2015) 3

Figure 3 – Seasonal Sound Speed Profiles (Summer – Spring – Winter – Fall) 6

Figure 4 –Transmission Loss at 500 Hz from Anchorage Site G-3 7

Figure 5 – Maximum Over-Depth Underwater Sound Levels | Vessels at Anchorage 9

Figure 6 – Maximum Over-Depth Underwater Sound Levels | Vessel in Transit 10

Figure 7 – Received In-Air Sound Levels | Vessels at Anchorage 14

LIST OF TABLES

Table

Table 1 – Summary of Proposed Designated Gabriola Anchorage Positions 1

Table 2 – Sound Pressure Levels and Comparison to Relative Human Loudness Thresholds 4

Table 3 – Underwater Noise Modeling Scenarios 5

Table 4 – Distances to Maximum-Over-Depth Sound Level (m) | Vessel at Anchorage and Transiting ... 8

Table 5 – In-Air Noise Modeling Setup Parameters 11

Table 6 – Received In-Air Noise Levels at Points of Interest 12

LIST OF ACRONYMS

Acronym or Abbreviation	Full Phrase
μPa	microPascal
ANSI	American National Standards Institute
CadnaA	Datakustik Computer-Aided Noise Abatement Program
dB	decibels
dBA	A-weighted decibel
dBL	unweighted or linear decibels
EA	Environmental Assessment
ESA	Endangered Species Act
ft	feet
GDEM	Generalized Digital Environmental Model
HF	high frequency cetaceans
Hz	hertz
IMO	International Maritime Organization
ISO	Organization for International Standardization
kHz	kilohertz
km	kilometer
L_P	sound pressure level
LF	low frequency cetaceans
m	meter
m/s	meters per second
MF	mid-frequency cetaceans
NAD	North American Datum
NMFS	National Marine Fisheries Service
NIST	National Institute of Standard and Technology
NSA	Noise Sensitive Area
PE	Parabolic Equation
PPA	Pacific Pilotage Authority
RMS	root mean square
SPL	sound pressure level
SSP	sound speed profile
Tetra Tech	Tetra Tech, Inc.
TL	transmission loss
UTM	Universal Transverse Mercator

Suggested citation:

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1.0 INTRODUCTION

Pacific Pilotage Authority (PPA) proposes to allow large deep sea vessels, with lengths up to 300 meters (m), to anchor off Gabriola Island in the Strait of Georgia. This report presents the in-air and underwater acoustic propagation modeling study performed by Tetra Tech, Inc. (Tetra Tech) in support of the Environmental Assessment (EA).

The underwater acoustic propagation model accounted for the variation of the bathymetry, geoacoustic properties of the sea bottom, and seasonal variations of the sound speed profile in the water column. Five sound speed profiles were considered (December, February, April, May and October), notionally bracketing the upper and lower propagation bounds (longest and shortest propagation distances) in terms of the acoustic footprint. The acoustic source levels for the vessels in transit and while at standby on anchorage were estimated using best practices based on realistic proxies, suitably scaled where appropriate. The type, size, and propulsion power of typical vessels that may utilize the Gabriola anchorage were considered in these estimations.

The primary sources of in-air noise on a vessel at anchorage that give rise to noise onshore can be divided into three categories:

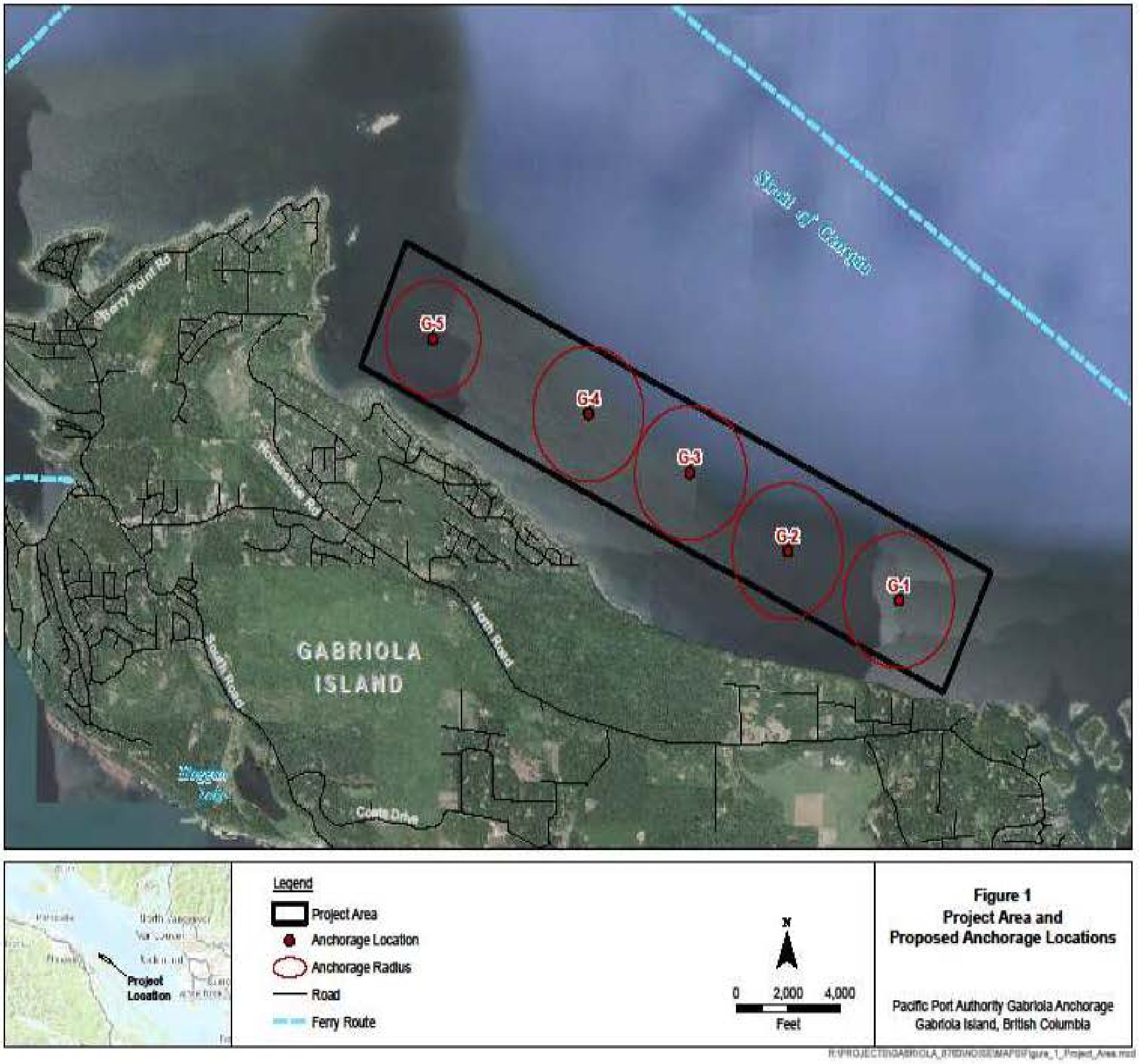
- Diesel generator and engine exhaust
- Ventilation inlets/outlets
- Secondary noise sources, e.g. pumps, and refrigerated equipped containers

The diesel generator is used to generate power on board the vessel. During anchorage stay, it will most often be the predominant continuous source of noise radiating from the ship to the surroundings. The study considered a standard container ship equipped with a diesel generator and main engine with exhaust outlets positioned at 35 m distance above the water surface. Summarized in Table 1, a total of 5 anchorage positions were included in the modeling analyses to simulate the associated in-air and underwater acoustic fields.

Table 1 – Summary of Proposed Designated Gabriola Anchorage Positions

ID	Water Depth at Anchorages	Geographic Coordinate System – NAD83 UTM10N		Closest Separation Distance to Gabriola Island	Maximum Length of Vessel
		Easting	Northing		
G-1	~35m	447090	5446422	1 km	300 m
G-2	~50m	445783	5446898	1 km	300 m
G-3	~40m	444648	5447651	1.4 km	300 m
G-4	~25m	443463	5448219	1.2 km	300 m
G-5	~60m	441637	5448942	800 m	260 m

Figure 1 – Project Area and Proposed Anchorage Locations



2.0 TERMINOLOGY

The level of sound at a receiver location is dependent on the radiated sound power of the noise sources. The received sound pressure levels include the effects of transmission loss (TL) via geometric divergence between source and receptor and the propagation and attenuation characteristics of the medium through which the sound passes, with water and underlying sediment being a very efficient conductor of sound. Water transmits sound about four times more efficiently than air does.

Sound levels in both water and sound in air are reported in decibels (dB), which are logarithmic units. An inherent property of the logarithmic decibel scale is that the sound pressure levels of two separate sources are not directly additive. A decibel is defined as the ratio between a measured value and a reference value and a logarithmic scale is formed by taking 20 times the logarithm (base 10) of the ratio of two pressures: the measured sound pressure divided by a reference sound pressure. However, there is a difference of 63 dB when comparing measurement scales in water and air and 26 dB of this difference is due to conventional choices of the sound reference level. The reference sound for underwater sound pressure is 1 micro-Pascal (µPa); however, in-air sound uses a reference of 20 µPa. The remaining disparity relates to differences in the acoustic impedance, density and compressibility of air and water.

The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves. Since the human ear does not perceive every frequency with equal loudness, broadband sound levels are often adjusted with a weighting filter. For human hearing, the weighting system is called A-weighted. This study examined the 1/3 octave bands from 31 Hertz (Hz) to 8,000 Hz (8 kHz) in terms of linear (or unweighted) decibels (dBL). Third octaves bands are a series of electronic filters used to separate sound into discrete frequency bands, making it possible to know how sound energy is distributed over species-specific audible ranges. In-air modeling results are presented in terms of dBA and referenced to 20 µPa, to better reflect human hearing response. The A-weighting downwardly adjusts sound pressure levels below 1 kHz and above 4 kHz. Underwater noise modeling results are presented in terms of linear decibels, referred to as dBL and referenced to 1 µPa. Underwater sound levels may also be weighted according to marine mammal functional hearing groups using audiograms based on hearing sensitivities of species in these groups: low frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, and pinnipeds. This is commonly referred to as M-weighting. M-weighting is used to adjust the expected acoustic impact on a per-frequency basis. Weighting functions for low-frequency cetaceans (LF), mid-frequency cetaceans (MF) and high frequency cetaceans (HF) are presented below in Figure 2.

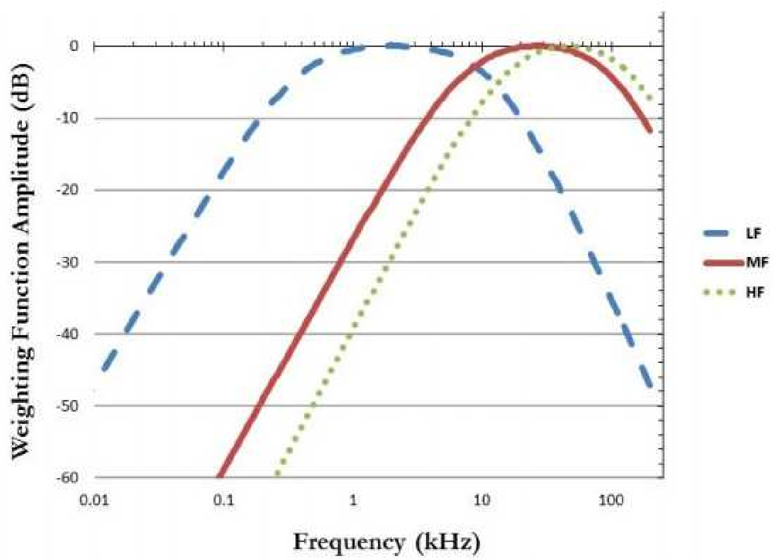


Figure 2 – Auditory M-weighting functions for low-frequency (LF), mid-frequency (MF) and high-frequency (HF) cetaceans. (NOAA 2015)

When comparing the absolute loudness of sound in air and in water, a sound pressure level of 160 dB occurring in air can cause tissue damage to the ears of humans. However, underwater 160 dB is equivalent to approximately 100 dB in-air, which is the sound level immediately adjacent to a large farm tractor. Similarly a level of 125 dB underwater water is equivalent to approximately 65 dB in air. This is the level one would hear when engaged in a normal conversation (Leonard 2007). To help further demonstrate this relationship, Table 2 provides the corresponding values of sound pressure in air and in water having the same intensities at a frequency of 1 kiloHertz (kHz) as it relates to human-perceived loudness. This comparison does not account for the frequency dependent hearing capabilities of various aquatic species (e.g., fish species) or individual hearing response mechanisms.

Table 2 – Sound Pressure Levels and Comparison to Relative Human Loudness Thresholds

Pressure in Air re 20 µPa/Hz	Pressure in Water re 1µPa/Hz	Relative Loudness (human perception of different reference sound pressure levels in air)
0	62	Threshold of Hearing
58	120	Generally Low Level but Potentially Audible Depending on the Existing Acoustic Environment
120	182	Uncomfortably Loud
140	202	Threshold of Pain
160	222	Threshold of Direct Damage

Source: Kinsler and Frey 1962

3.0 UNDERWATER NOISE MODELING SCENARIOS

The underwater acoustic modeling methodology considered scenarios based on descriptions of the expected operations activities. The following scenarios were developed (Table 3):

- **Scenario 1**: Vessels at anchorage all five anchorage positions (G1-G5) concurrently; and
- **Scenario 2**: One vessel transiting within the anchorage area.

The major source of noise from vessels is propulasion. Other sources include other rotating machinery such as main engines, gearboxes, generators, and fans. These components produce structure-borne vibrations, which are transmitted through the hull of the vessel. Other noise sources during transiting include vortex shedding from the hull and noise associated with the vessel wake, but these sources are generally considered secondary at the lower speeds the vessels will be transiting in the anchorage area.

A literature review was conducted in order to identify source level measurements from comparable equipment performing similar activities. Source levels for these proxy noise sources were used as model input parameters. The modeling scenarios and sound source levels (dB re 1µPa·m) are given in Table 3.

Table 3 – Underwater Noise Modeling Scenarios

Scenario	Description	Geographic Coordinate System NAD83 UTM10N	Source Level (dB re 1µPa·m)	Source
Scenario 1	Vessels at Anchorage Positions G1 – G5	Varies – see Table 1	141 dB*	Generator
Scenario 2	Vessel Transiting within Anchorage Area	444648, 5447650 to 445245, 5449556	171 dB	Vessel Movement

*Modeled as a distributed area source – 300m vessel length

4.0 UNDERWATER SOUND PROPAGATION MODELING

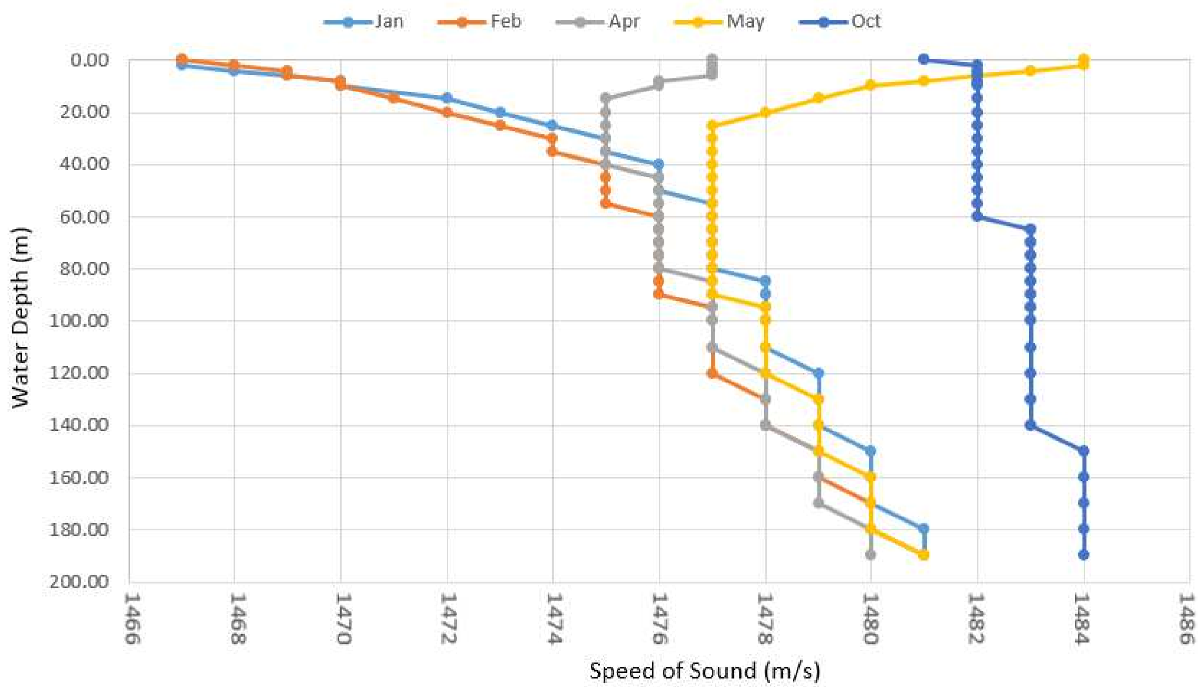
The underwater sound propagation model estimates the sound field generated and can be used to determine the distances from the operational scenarios to biologically significant acoustic thresholds. The modeling methodology includes a set of algorithms that calculate transmission loss based on a number of factors including the distance between the source and receiver along with basic underwater sound propagation parameters. Underwater sound propagation parameters can be modified for the specific geographic region of interest, including the expected water column sound speed profile (SSP), the bathymetry, and the bottom geo-acoustic properties, to produce site-specific estimates of the radiated sound field as a function of range and depth. The acoustic model is used to predict the directional transmission loss from source locations corresponding to receiver locations. The received level at any 3-dimensional location away from the source is calculated by combining the source level and transmission loss, both of which are direction dependent. Underwater acoustic transmission loss and received underwater sound levels are a function of depth, range, bearing, and environmental properties. The output values can be used to compute or estimate specific noise metrics relevant to safety and behavioral guidelines, by filtering for frequency-dependent marine mammal hearing capabilities.

The hydroacoustic screening-level acoustic modeling analysis was completed using a Parabolic Equation for Sound propagation (PE) and Cylindrical Spreading. The PE method is widely used by sound engineers and marine biologists due to its adaptability to describe complex acoustic scenarios in the underwater environment. It assumes that outgoing energy dominates over scattered energy, and computes the solution for the outgoing wave equation. Cylindrical spreading assumes energy radiates at a logarithmic rate. Both approximations use to provide two-dimensional transmission loss values in range and depth. In other words, computation of the transmission loss as a function of range and depth within a given radial plane is carried out independently of neighboring radials (reflecting the assumption that sound propagation is predominantly away from the source).

Various factors influence sound propagation including sea state, SSP, bathymetry and bottom geo-acoustic properties. To account for reflection from the sea surface, a sea state corresponding to a smooth sea surface was assumed (i.e., reflection coefficient with a magnitude of -1). While a rough sea surface would increase scattering (and hence transmission loss) at higher frequencies, the scale of surface roughness is insufficient to have a very significant effect on sound propagation at the lower frequencies where most of vessel sound energy resides. Seasonality within sound speed profiles can have a significant impact on underwater sound propagation. Changes in direction of the sound due to changes of sound velocity are known as refraction, which can produce many complex sound paths. Water column SSPs were calculated from profiles downloaded from the U.S. Naval Oceanographic Office's Generalized Digital Environmental Model (GDEM) database. The profiles in GDEM are based on historical observations of global temperature and salinity from the U.S. Navy's Master Oceanographic Observational Data Set. Figure 3 presents the seasonal sound speed profiles established through measurements in the vicinity of the Project area.

For geometrically shallow water, sound propagation is dominated by boundary effects. Sound propagation in shallow water is strongly influenced by the geoacoustic properties of the seafloor. Bathymetry and sediment data were obtained. In the proposed anchorage area, the upper layer of the seabed is sand. Sediments throughout the Georgia Strait are compositionally known to be very similar. A typical speed of sound value of sand is 1650 m/s, although it does depend on the grain size. Since there is no detailed information about the exact conditions in the area, this standard value was used. Analysis has been included to model to a first approximation shear wave conversion at the sea floor.

Figure 3 – Seasonal Sound Speed Profiles (Summer – Spring – Winter – Fall)



5.0 UNDERWATER NOISE MODELING RESULTS

In general, noise propagation underwater is complex, with many factors being superimposed to create the actual sound field, especially at low frequencies where shallow water is known to have high temporal and spatial variability (Etter, 1996 and Katsnelson, 2012). The sound propagation model was run with the scenario, source levels, and environmental parameterization described in previous sections. It is important to note that the findings here are indicative only, and the conclusions have been made based on the information available.

There is very limited information on individualized acoustic signatures of stationary vessels at anchorage, but are generally considered low level sound sources, and typically have tones at 30 or 60 Hz, or both, which are the two tones that are seen most consistently in underwater noise measurement data.

The scope of hydroacoustic modeling analysis was initially intended to be limited to the review of noise impacts from vessels stationary at anchorage. Additional noise modeling was done for a vessel transiting the anchorage area. During transit, every vessel has a unique frequency signature which changes with speed. Vessel propeller noise is prominent at frequencies below 1 kHz; however, cavitation caused by propellers increases underwater noise levels at higher vessel speeds. In general, underwater noise generated during vessel transiting is orders or magnitude greater than a stationary vessel.

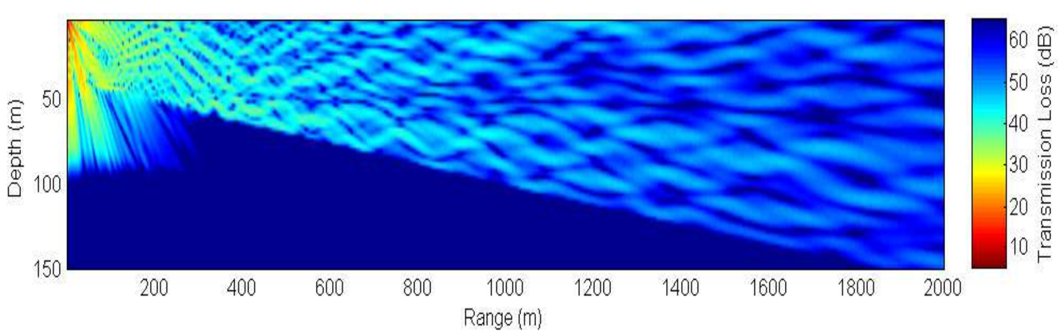
In general, where uncertainties in source levels and site specific propagation efficiencies existed, the analysis incorporated assumptions that would generate the higher expected noise levels. A number of conservative assumptions were incorporated into the hydroacoustic modeling analysis:

- Sound speed profiles from January were used because cooler winter temperatures near the sea-surface favored longer-range propagation;
- The vessels were simulated assuming a deeper source depth to account for the fact that the entire hull acts as a distributed area source and therefore a more efficient radiator of underwater sound; and
- The sea surface was assumed to be smooth, which results in maximum reflection of sound.

The received underwater sound level at any location within the region of interest was computed from the ⅓-octave band source levels by subtracting the numerically modelled transmission loss at each ⅓-octave band center frequency and summing across all frequencies to obtain a broadband value. For this study, transmission loss and received levels were modelled for ⅓-octave frequency bands between 10 and 8,000 Hz. Because the acoustic energy of the underwater noise sources in this study are predominantly in the low to moderate frequencies, this frequency range is sufficient to capture essentially all of the energy output.

An example of broadband underwater results for a single transect are presented in Figure 4 with distance given on the x-axis and depth on the y-axis for a transect originating from anchorage position G-3 and extending across the Strait of Georgia. The black line shows the sea bottom with sound energy extending into and below the seabed (i.e., some sound energy will radiate into the water column through seafloor). The broadband transmission loss values are given by color bin next to the plot, by depth and distance from the source.

Figure 4 –Transmission Loss at 500 Hz from Anchorage Site G-3



As shown in the plot, received sound levels may vary greatly vertically or horizontally from 2 to 5 dBL (or more) on the scale of a few meters. This implies that the precise location of fish or marine mammals is important, with the probability that a receiver just meters apart may receive quite different exposures.

The modeled acoustic fields for each of the scenarios are presented as radii tables of distances to the specific sound level values (Table 4) and maps of modeled un-weighted underwater sound fields (Figures 5 and 6) for vessels on standby at the anchorage and vessel transiting. It is important to note that the distances predicted to the threshold values are the maximum at any depth down to the seafloor, i.e. the distance to the farthest occurrence of the threshold value. While conservative, it may greatly overestimate the effective exposure zone. This occurs in cases where the volume ensonified to a specific level is discontinuous and small pockets of higher received levels occur far beyond the majority of the ensonified volume. By incorporating the maximum values observes inclusive of those ensonified pockets, worst case predictions are made.

The potential for anthropogenic noise to affect a marine animal depends on how well marine life can hear the noise. Noises at frequencies that animals cannot hear well are less likely to disturb or injure animals. The tabulated results are presented in terms of broadband and for the three functional hearing groups, for low-frequency cetaceans (LF), mid-frequency cetaceans (MF), high frequency cetaceans (HF). The values listed as N/A fall below a threshold value, i.e. does not occur at any distance.

Table 4 – Distances to Maximum-Over-Depth Sound Level (m) | Vessel at Anchorage and Transiting

Units: rms SPL, dB re 1 µPa
Broadband and For the Three Functional Hearing Groups

SPL rms	Unweighted		LF cetaceans		MF cetaceans		HF cetaceans	
	Stationary	Transiting	Stationary	Transiting	Stationary	Transiting	Stationary	Transiting
160	<5	<5	N/A	<5	N/A	N/A	N/A	N/A
150	<10	<15	< 5	<15	N/A	<5	N/A	< 5
140	< 15	135	< 10	135	< 5	< 5	N/A	<5
130	35	250	< 15	250	< 10	< 15	< 5	< 10
120	110	450-800	35	450-800	<15	50	< 10	35
110	275	1400-2000	80	1400-2000	35	150	< 15	100

Underwater sound is a result of pressure generated by waves of sound energy traveling through water as vibrations of fluid particles. In order to be detected, a sound must be above the “background” level. Additionally, results from some studies suggest that sound may need to be biologically relevant to an individual to elicit a behavioral response. The documentation of ambient underwater conditions is important because the differences between the underwater soundscapes in conjunction with the noise levels expected during operational periods would need to be evaluated to properly determine the potential for adverse impacts. The distances provided in Table 4, in conjunction with available data that describe existing conditions can be used by marine biologists and mammologists to assess potential environmental impact on the marine life in proximity to the anchorage areas.

Figure 5 – Maximum Over-Depth Underwater Sound Levels | Vessels at Anchorage

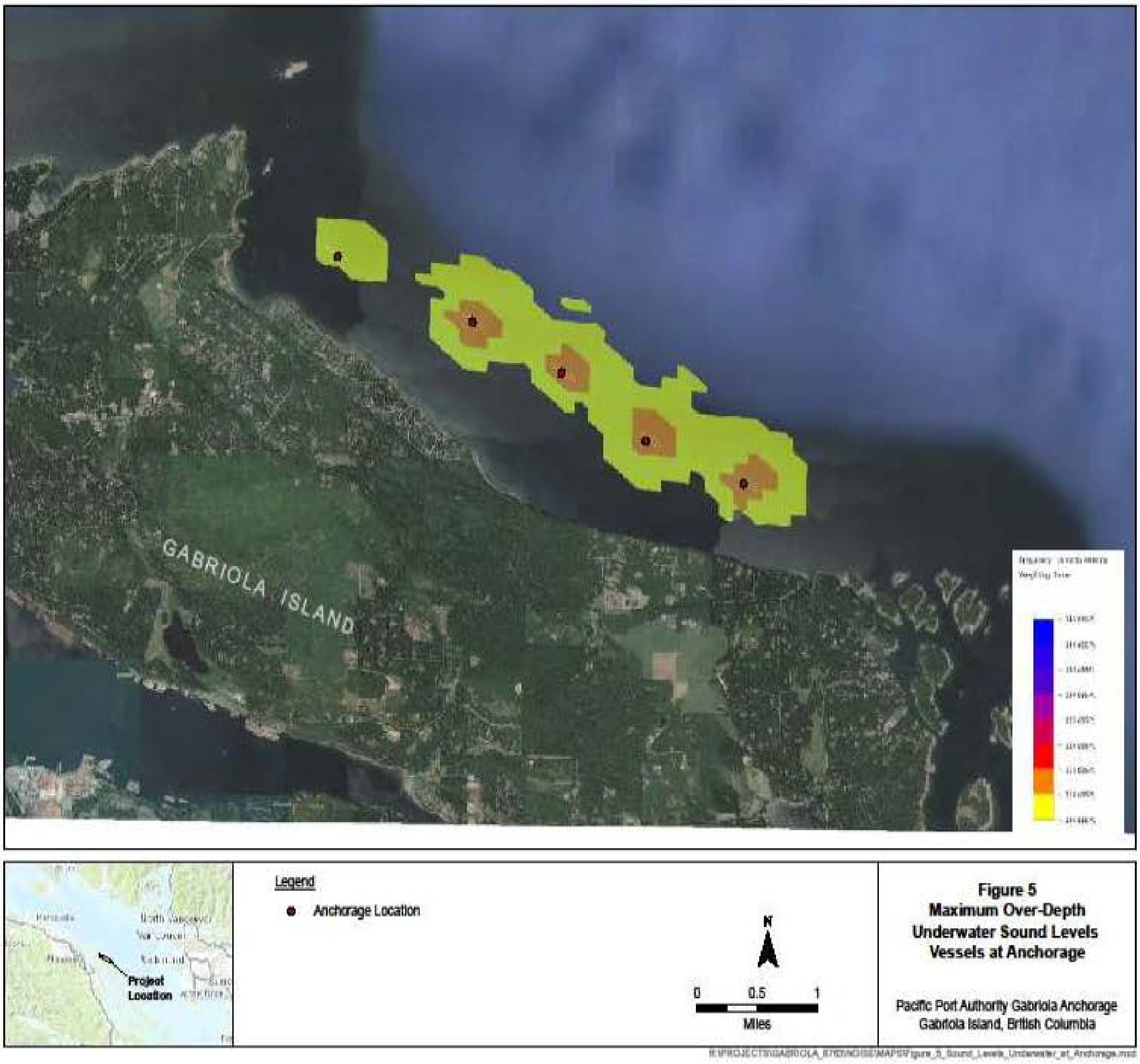
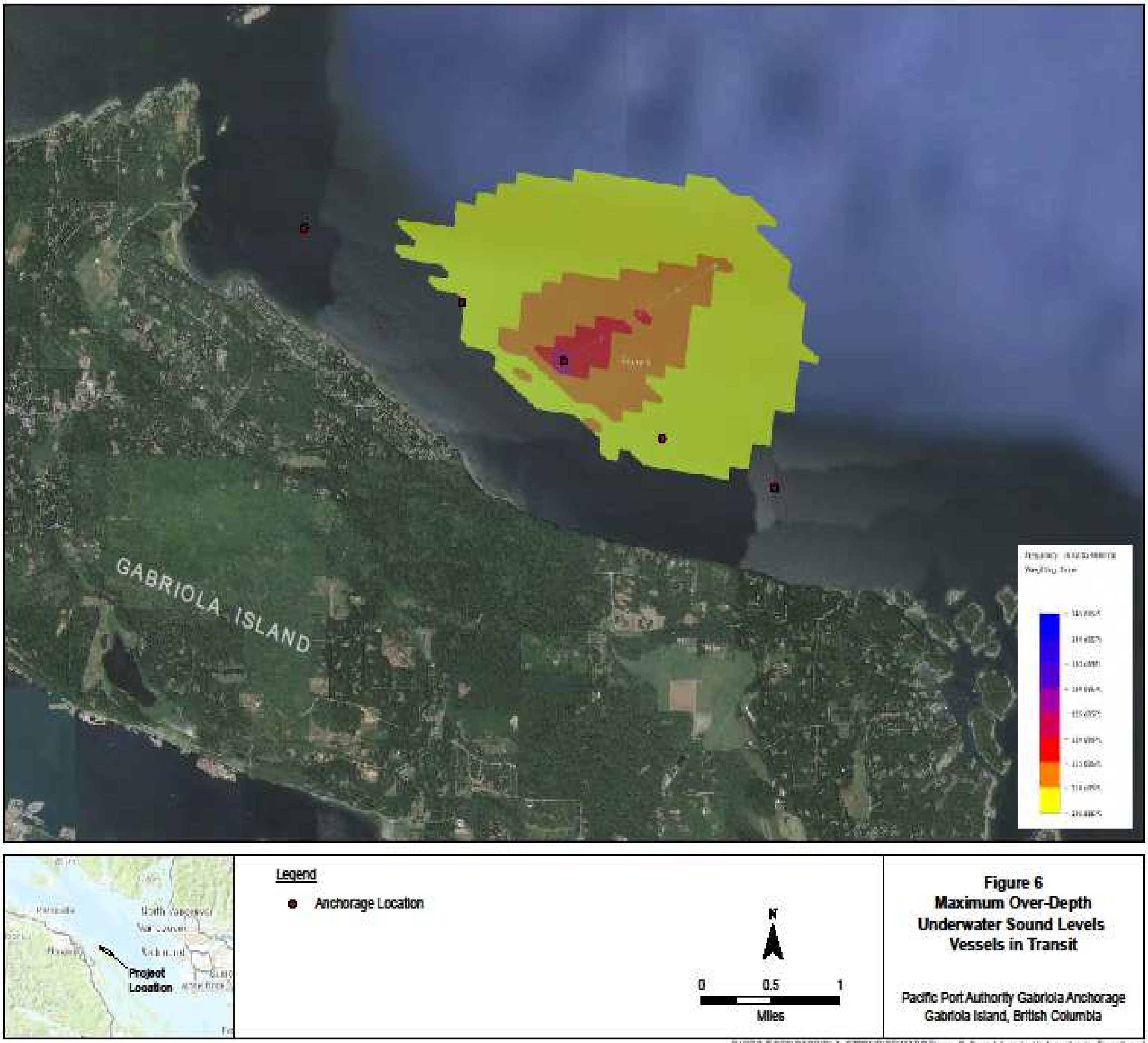


Figure 6 – Maximum Over-Depth Underwater Sound Levels | Vessel in Transit



6.0 IN-AIR NOISE ASSESSMENT

The main in-air noise sources for vessels at anchorage are the generator exhaust including the mechanical ventilation fans for the engine room and the main boiler and generator mechanical noise. During vessel standby, it is expected that only the main generators would be operating to produce the necessary electrical power onboard the vessel. The sound is transmitted into the air directly from mechanical equipment and vented through the stack exit. As a part of the study it has been established that a ship that complies with the noise limits as prescribed by the International Maritime Organization (IMO 1975 and 1981) can have a diesel generator exhaust with a sound power rating of up to 107 dBA to meet external limits on a typical vessel (Lloyd's Register ODS, 2010). There are no landside components associated with the proposed Project that would generate noise.

Acoustical modeling was conducted using Cadna/A computer software developed by DataKustik GmbH. The model incorporates the physical features of the sound source and the surrounding area topography. The propagation calculations were completed in accordance with ISO 9613, Part 1: Calculation of the absorption of sound by the atmosphere, 1993 and Part 2: General method of calculation (ISO 9613-2:1996). The method evaluates received sound levels from sources of a known sound emission under meteorological conditions favorable to propagation. Cadna/A assesses the sound propagation based on the Octave Band Center Frequency range from 31.5 Hz to 8000 Hz. Additional acoustic modeling setup parameters are shown in Table 5.

Table 5 – In-Air Noise Modeling Setup Parameters

Model Input	Parameter Value
Standards	ISO 9613-2, Acoustics – Attenuation of sound during propagation outdoors.
Engineering Design	Proposed anchorage positions provided by Pacific Pilotage Authority
Reflection Loss	2 dB – indicates reduction in acoustic energy due to Reflection
Grid Spacing	5 to 10 meters
Terrain Description	Digital elevation dataset to accurately represent Gabriola Island terrain in three dimensions
Ground Absorption	0.5 (semi-reflective) and 0.0 (reflective) for water bodies
Receiver Characteristics	4 meters (13 feet) above ground level
Meteorological Factors	Omnidirectional downwind propagation / mild to moderate atmospheric temperature inversion
Temperature	10°C
Relative Humidity	70%

At any location, both the magnitude and frequency of environmental noise may vary considerably over the course of the day and throughout the week. This variation is caused in part by changing weather conditions and other contributing factors. To account for the inherent level of uncertainty in the noise predictions over extended distances, a number of conservative assumptions regarding the Project have been made. These include the assumption that an omnidirectional downwind conditions exist 100% of the time and that all vessels will be operating at the maximum allowable sound output per IMO external noise guidelines. Worst case directivity was also incorporated in all modeling calculations. Further considerations were made for the specialized condition of sound propagation over water. As part of the analysis, a limited inventory of several key existing noise sensitive areas (NSAs) within a radius of 2 km of the five anchorage positions were identified. These NSAs are representative of the closest residential structures and other areas where noise may be of principle concern. Topographical information was imported into the acoustic model to accurately represent terrain in three dimensions.

Vessels at anchorages occasionally have occasionally caused issues with noise disturbance at nearby dwellings. The rules and regulations of noise from anchorages have not been as explicit as in other areas of industry and commerce. The British Columbia noise guiding limits for rural residential areas during the nighttime (10 p.m. to 7 a.m.) period is 40 dBA (BC OGC 2009). The guideline is a receptor-oriented regulation, which specifies allowable sound levels at designated receptor points, with the nighttime rural residential limit being the most stringent.

This preliminary analysis was performed based on the available knowledge at the commencement of the study. Two modeling scenarios were analyzed:

- **Scenario 1**: Vessel located at the closest anchorage position; and
- **Scenario 2**: Vessels simultaneously at all five anchorage positions (G1-G5).

Predicted noise level results are summarized below in Table 6. The applicable BC noise guideline limits are also presented. A sound contour plot displaying Project operational sound levels in color-coded sound isopleths is presented in Figure 6. The resultant sound contour plot and tabulated results are independent of the existing acoustic environment and represent Project-generated sound levels only. The results demonstrate compliance with the provincial and federal guidelines including the Health Canada sleep disturbance criteria of 30 dBA (indoor) which is defined at the exterior of a residential structure at 45 dBA (HC 2011). Therefore, the Project has demonstrated compliance with all applicable guidelines which have been shown to be adequately protective of the most sensitive sector of the population.

Table 6 – Received In-Air Noise Levels at Points of Interest

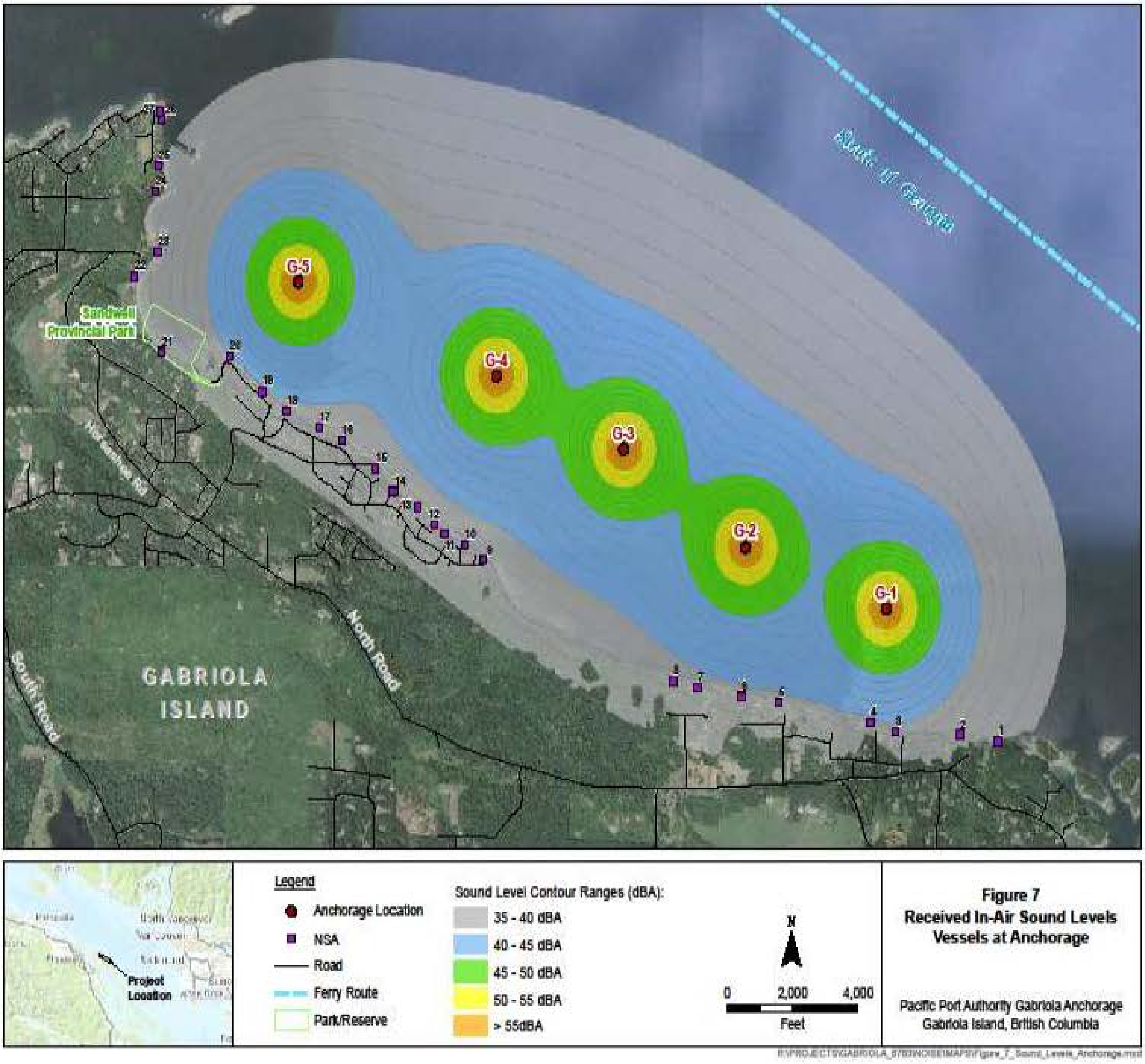
Points of Interest	Receptor Type	Geographic Coordinate System NAD83 UTM10N		BC Permissible Sound Level (dBA)	Calculated Sound Level (dBA)	
					Scenario 1: Vessel at Closest Anchorage Position	Scenario 2: Cumulative, Vessels at all 5 Anchorage Positions
NSA-1	Residence	448132	5445397	40	34	35
NSA-2	Residence	447776	5445453	40	36	37
NSA-3	Residence	447182	5445475	40	38	39
NSA-4	Residence	446946	5445547	40	38	39
NSA-5	Residence	446096	5445697	40	35	38
NSA-6	Residence	445744	5445748	40	33	39
NSA-7	Residence	445339	5445813	40	31	38
NSA-8	Residence	445112	5445864	40	31	38
NSA-9	Residence	443344	5446798	40	34	38
NSA-10	Residence	443171	5446911	40	35	38
NSA-11	Residence	442984	5446996	40	35	38
NSA-12	Residence	442883	5447069	40	35	38
NSA-13	Residence	442732	5447204	40	35	38
NSA-14	Residence	442517	5447327	40	35	38
NSA-15	Residence	442356	5447503	40	35	38
NSA-16	Residence	442041	5447721	40	35	38

Points of Interest	Receptor Type	Geographic Coordinate System NAD83 UTM10N		BC Permissible Sound Level (dBA)	Calculated Sound Level (dBA)	
					Scenario 1: Vessel at Closest Anchorage Position	Scenario 2: Cumulative, Vessels at all 5 Anchorage Positions
NSA-17	Residence	441830	5447815	40	36	38
NSA-18	Residence	441530	5447942	40	37	38
NSA-19	Residence	441301	5448095	40	38	39
NSA-20	Residence	440997	5448362	40	39	39
NSA-21	Provincial Park	440369	5448401	variable	35	36
NSA-22	Residence	440114	5448982	40	33	34
NSA-23	Residence	440329	5449171	40	35	36
NSA-24	Residence	440305	5449635	40	33	34
NSA-25	Residence	440334	5449834	40	33	34
NSA-26	Residence	440362	5450199	40	32	33
NSA-27	Residence	440352	5450253	40	31	33

Best management practices to minimize noise from vessels at anchorage that are presently endorsed by the British Columbia Chamber of Shipping (CSBC) include:

- Limiting the use of the ships whistle, except as required under the Collision Regulations.
- Limiting the use of deck side loud hailers.
- Keeping the use of power tools and chipping hammers to a minimum and never during the hours of darkness.
- Keeping the number of generators running to a necessary minimum.

Figure 7 – Received In-Air Sound Levels | Vessels at Anchorage



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APPENDIX D

EFFECTS OF ANCHORING ON BIOLOGICAL RESOURCES AT PROPOSED GABRIOLA ANCHORAGES (MIRE 2016A)

EFFECTS OF ANCHORING ON BIOLOGICAL RESOURCES AT PROPOSED GABRIOLA ANCHORAGES

Prepared for

Pacific Pilotage Authority

March 2016

June Mire, Ph.D.
Tetra Tech, Inc.

Contents

1.0 Introduction 1

2.0 Description of Vessels and Anchors 1

3.0 Baseline Condition of Substrate and Benthic Biological Resources in Proposed Anchorage Area... 2

3.1 Physical Environment 2

3.2 Marine Vegetation 4

3.3 Sponges 4

3.4 Infaunal invertebrates 4

3.5 Epibenthic invertebrates .... **Error! Bookmark not defined.**

3.6 Fish 8

3.7 Listed Species 10

4.0 Effects of Anchoring 11

4.1 Scour Area 11

4.2 Turbidity 13

5.0 Conclusions 14

6.0 Recommendations and Mitigation 15

7.0 References 17

Tables

Table 1. Southern Gulf Island Anchorages Usage 1
Table 2. Water Depth at Proposed Anchorages 2
Table 3. Invertebrates Observed or Expected during ROV Survey of Proposed Anchorage 7
Table 4. Species in the Strait of Georgia 11
Table 5. Recommended Sequence of Anchorage Use 16

Figures

Figure 1. ROV Transects (with Swing Circles) at Proposed Gabriola Anchorages 3

Figure 2. Important Subtidal Habitats in the Project Area 5

Figure 3. Sponge Reefs in the Vicinity of the Proposed Gabriola Anchorage 6

Figure 4. Sand Lance Habitat in the Southern Strait of Georgia 9

Figure 5. Rockfish Conservation Areas near the Proposed Gabriola Anchorage 10

1.0 Introduction

The Pacific Pilotage Authority is proposing to establish five anchorage locations for deep sea vessels along the east coast of Gabriola Island in the Strait of Georgia to provide a safe holding area for vessels awaiting berths at Port Metro Vancouver. A significant increase in deep sea vessels requiring anchorages on the coast of British Columbia since 2009 requires that additional anchorages be established. In 2014, 170 vessels sought anchorage in the southern Gulf Islands because Port Metro Vancouver was filled to capacity (Table 1).

Table 1. Southern Gulf Island Anchorages Usage

Total for Southern Gulf Island Anchorages by Year			
Year	**Number of Ships**	**Total Stay (Days)**	**Average Stay (Days)**
2009	23	154	6.7
2010	62	327	5.3
2011	135	1064	7.9
2012	92	649	7.1
2013	106	882	8.3
2014	170	1582	9.3

The number of vessels, timing of arrival, and duration of stay varies tremendously among locations and years. Vessel traffic is influenced by the size of the grain crop, demand for coal, labour fluctuations in neighboring countries, availability of trains and trucks, winter weather, and other factors. The anticipated use is predominantly coal ships bound for Westshore Terminals. Historical use of anchorages in the Southern Gulf Islands indicates that the length of stay has steadily increased since 2009 (Table 1).

2.0 Description of Vessels and Anchors

The proposed Gabriola anchorages would accommodate four 300-meter vessels and one 260-metre vessel along the 50-metre isobath. As no permanent mooring facility is available in the proposed anchorage area, vessels would use on-board anchors and chains to hold position. Capesize vessels range between 80,000 and 175,000 deadweight tonnes (dwt) and typically carry about 300 metres of chain.

3.0 Baseline Condition of Substrate and Benthic Biological Resources in Proposed Anchorage Area

Baseline conditions at the proposed anchorages were inferred from the published literature and a one-time limited survey using a remotely operated vehicle (ROV) outfitted with a recording device. The ROV equipment, boat and personnel were supplied and operated by the Nanaimo Port Authority (NPA). A 300T twisted pair 2/2 thruster ROV system from Seamor Marine was used to record subtidal conditions along transects run through each of the proposed anchorage areas on December 15, 2015. One 0.7-nautical-mile (1.3 km) transect was run perpendicular to shore through each of the five anchorage locations and one 0.25-nautical-mile (0.5 km) transect was run parallel to shore along the 20 metre contour interval (Figure 1). Water depths along the five anchorage transects ranged from 25 to 69 metres (Table 2).

Table 2. Water Depth at Proposed Anchorages

Proposed Anchorage	Minimum Depth (m)	Maximum Depth (m)	Depth at Centre (m)
G1	45	64	52
G2	29	60	42
G3	40	57	47
G4	30	69	45
G5	25	45	Not recorded

3.1 Physical Environment

The proposed anchorage area slopes upward from the 100-metre contour to the eastern shore of Gabriola Island at an incline of about 7 percent (Young 2015). Tidal movement is moderate, with flood and ebb currents of 0.5 knots and 1.0 knot respectively; currents run northwest- southeast (Young 2015). Waters in the proposed anchorage area are relatively calm, as the wind has limited fetch and waves are unable to grow to large heights. Texada and Lasqueti Islands block the wind so that waves cannot gather momentum or height along Gabriola Island (Young 2015).

The ROV survey provided a cursory view of a limited area approximately 1 square metre immediately in front of the camera along the transect lines. Based on the small area observed during the survey, benthic conditions appeared similar throughout the area. Areas G1 through G4 were predominantly mud, and Area G5 was sand; coarse substrates increased from west to east, with some gravel and large rocks present at G1. Nearshore portions of the transects contained coarser materials than deeper offshore areas, where mud was more common.

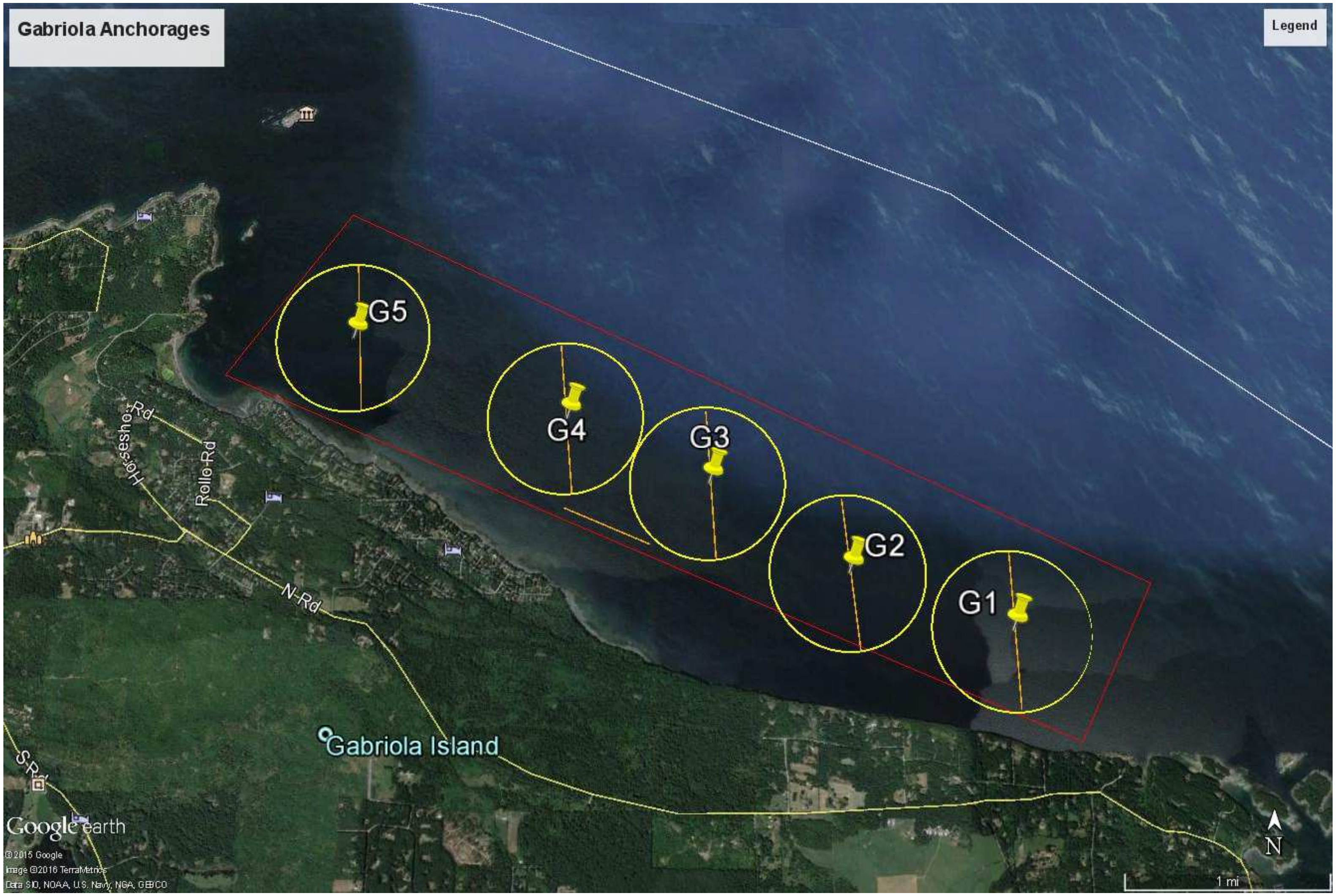

Figure 6. ROV Transects (with Swing Circles) at Proposed Gabriola Anchorages

3.2 Marine Vegetation

Seagrasses, kelp, and other macrophytic algae occur in the general vicinity of the proposed anchorage. However, no major seagrass beds are reported in the immediate area (Figure 2). Sparse eel grass (*Zostera marina*) and loose fronds were observed during the ROV survey in Area G3. A macrophytic red alga, Turkish towel (*Chonracanthus exasperates*), was observed in Areas G1, G2, and G3. Detached fragments of bull kelp (*Nereocystis luetkeana*) were observed in the shallower portion of Area G5. No kelp forests were observed within the proposed project area, which extends into deeper water than is typically inhabited by bull kelp. However, bull kelp was reported to occur in the nearshore area of the proposed anchorage (Figure 2) (Burd et al. 2008).

3.3 Sponges

Two species of glass sponge (*Aphrocallistes vastus* and *Heterochone calyx*) are known to build reefs in the Strait of Georgia, but *A. vastus* is dominant by a wide margin (Kahn et al. 2015). Glass sponge reefs are built on topographic bedrock features that rise above the soft sediment in areas where swift currents deliver food to the sponges (Chu and Leys 2010); the principal food item is bacteria (Kahn et al. 2015). The nearest glass sponge reef to the proposed anchorage is north of the proposed anchorage in water depths of 100 to 150 metres (Cook et al. 2008) (Reef #6 [Nanaimo] on Figure 3). The reef is heavily damaged, apparently by bottom trawls, but shows signs of recolonization by young sponges. An area of Gabriola sponge reef is called out as a crab harvest exclusion zone in DFO (2013):

- 49°13.664'N 123°48.115'W then to
- 49°13.676'N 123°47.475'W then to
- 49°13.176'N 123°47.520'W then to
- 49°13.163'N 123°48.160'W then to the beginning point.

3.4 Infaunal invertebrates

Infaunal invertebrates were not identifiable in the ROV footage because of the small size of the animals and the speed of the ROV. Common infaunal species such as polychaetes, amphipods, and isopods are assumed present in the proposed anchorages, but no site-specific information is available to characterize the infaunal community.

3.5 Epibenthic invertebrates

Epifaunal and larger infaunal invertebrates such as sea stars, feather stars and finger sponges were observed on all transects observed during ROV surveys in the proposed anchorage. Bivalves were observed in G3, G4, and G5 (Table 3). In addition to the species observed during the ROV survey, typical species captured by trawling over mud substrates between 20 and 100 metres in the Strait of Georgia may be present at the proposed site (Bernard 1978). The Dungeness crab (*Cancer magister*) occurs throughout the Strait of Georgia, and may be commercially harvested in the proposed Gabriola anchorage (DOF 2013). A trans-boundary bottom trawl survey in 2001 reported that 60 percent of the invertebrate biomass occurred in water between 10 and 37 metres deep (on the United States side of the boundary) (Palsson et al. 2003). The distribution of invertebrate biomass was reported to be similar on the British Columbia side of the boundary, where biomass declined with water depth (Burd et al. 2008).

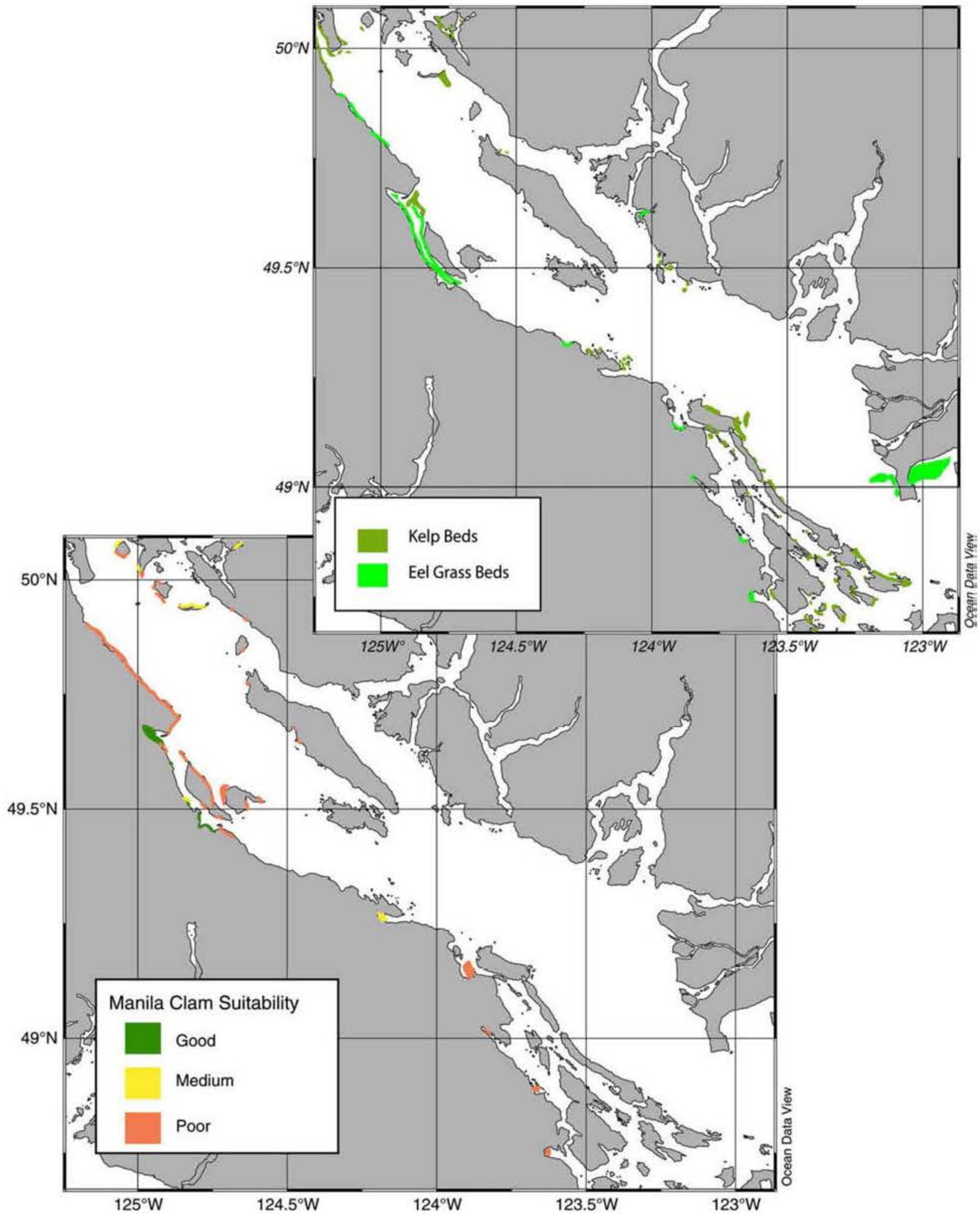

Figure 7. Important Subtidal Habitats in the Project Area

Source: Burd et al. (2008)

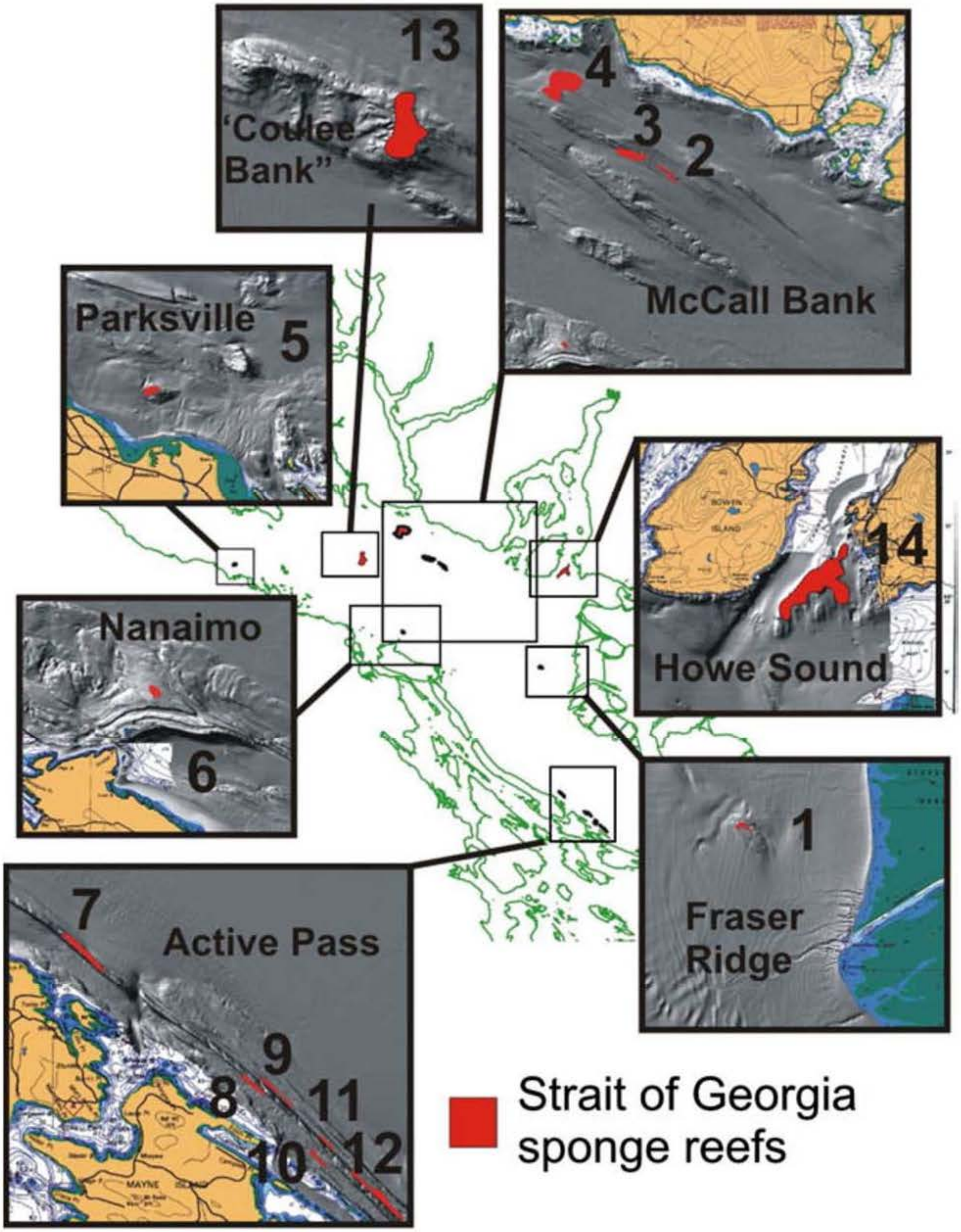

Figure 8. Sponge Reefs in the Vicinity of the Proposed Gabriola Anchorage

Source: Cook et al. (2008)

Table 3. Epibenthic Invertebrates Observed or Expected in the Proposed Gabriola Anchorages

Taxonomic Group	Common Name	Scientific Name	Proposed Anchorage Area					E
			G1	G2	G3	G4	G5	
Sponges	Bristly Vase Sponge	*Leucandra neathi*	O					
	Tube Sponge	*Niphatidae family*			O			
	Finger Sponge	*Neoesperiopsis spp.*	O	O	O			
Tube worm	Calcareous Tube Worm	*Serpula vermicularis*					O	
Polychaetes	Polychaete	*Aphrodita japonica*						E
	Polychaete	*Glycera capitata*						E
	Polychaete	*Maldane glebifex*						E
	Polychaete	*Sternaspis fossor*						E
Mollusks	Pink Scallop	*Chlamys rubida*				O	O	
	Pacific Blue Mussel	*Mytilus edulis*			O	O		
	Pacific Oyster	*Crassosterea gigas*			O			
	Nut clam	*Acila castrensis*						E
	Bivalve	*Compsomyax subdiaphana*						E
	Bivalve	*Pandora filosa*						E
	Gastropod	*Tachyrhynchus lacteolus*						E
Echinoderms	Sea Cucumber	*Chiridota spp.*				O	O	
	Feather Star	*Flometra serratissima*	O	O	O			
	Blood Stars	*Henricia spp.*	O		O		O	
	Ochre Star	*Piaster ochraceus*				O	O	
	Morning Sun Star	*Solaster dawsoni*					O	
	Gunpowder Star	*Gephyreaster swifti*					O	
	Vermillion Star	*Mediaster aequalis*			O		O	
	Wrinkled Star	*Pteraster militaris*					O	
	Sea star	*Luidia foliata*						E
	West Coast Sand Dollar	*Dendraster excentricus*					O	
	Sea urchin	*Brisaster latifrons*						E
Cnidarians	Sea Whip	*Balticina septentrionalis*					O	
	Short Plumose Anemone	*Metridium senile*	O		O		O	
	Tube-dwelling anemone	*Pachycerianthus fimbriatus*						E
	White Sea Pen	*Virgularia* spp.			O			
Crustacean	Crab	*Cancer* sp.		O				

O = Observed during ROV Survey of Proposed Anchorage (December 2015)

E = Expected based on Bernard (1978): mud substrate at depths of 20 to 100 metres

3.6 Fish

No site-specific fish surveys were conducted at the proposed Gabriola anchorages. Two small fish were observed during the ROV transect survey in December 2015: one English sole (*Parophrys vetulus*) and one juvenile ling cod (*Ophiodon elongates*).

The Strait of Georgia supports numerous fisheries, many of which are linked to the production of seasonal blooms of zooplankton. About 30 percent of the Pacific salmon (*Oncorhynchus* spp.) harvested in British Columbia spend some time as juveniles in the Strait of Georgia (Beamish et al. 2012). Processes within the water column are considered to directly influence the annual cycle of plankton masses, although benthic habitats certainly play a role (Beamish and MacFarlane 1999). The complex factors that affect the abundance of fisheries has recently been reviewed (Perry and Masson 2013) but is beyond the scope of this evaluation. However, it is fairly well established that a key component of sustainability for salmon and Pacific herring (*Clupea pallasi*) is the temporal link between plankton abundance and early life stages of fishes that depend on them for survival (Beamish et al. 2012; Schweigert et al. 2013). Regional factors such as nutrient loads and global climate change leading to a rise in sea temperature are suspected of disrupting the temporal co-occurrence of predator and prey, leading to declines in some fisheries (Hallowed et al. 2013). Decadal processes in the northern Pacific, such as the El Niño – Southern Oscillation (ENSO), may be affecting plankton supplies more than local stressors (Li et al. 2013).

Rising sea surface temperatures have also adversely affected some benthic fishes in the Strait of Georgia; some species also experience overharvest by bottom trawl and hook and line fisheries, degradation or loss of spawning and nursery areas, exposure to contaminants, and other stressors (Johannessen and McCarter 2010). One of the most important benthic fishes in the Strait of Georgia is the Pacific sand lance (*Ammodytes hexapterus*), which is a principal prey of seabirds in the area (Therriault et al. 2009). The sand lance forages for zooplankton in the water column by day and buries itself in coarse sand (0.25–2.0 millimetres grain diameter) at night and in winter. Preferred burying habitat is in water less than 80 metres deep with high bottom current speeds (25 to 63 centimetres per second). Most foraging occurs within 2 kilometres of burying habitat. The nearest suitable sand lance habitat based on these three parameters occurs to the south of the proposed Gabriola anchorage (Robinson et al. 2013) (Figure 4). The proposed anchorage does not contain the coarse sand this species requires, nor does it have the swift bottom currents the sand lance prefers.

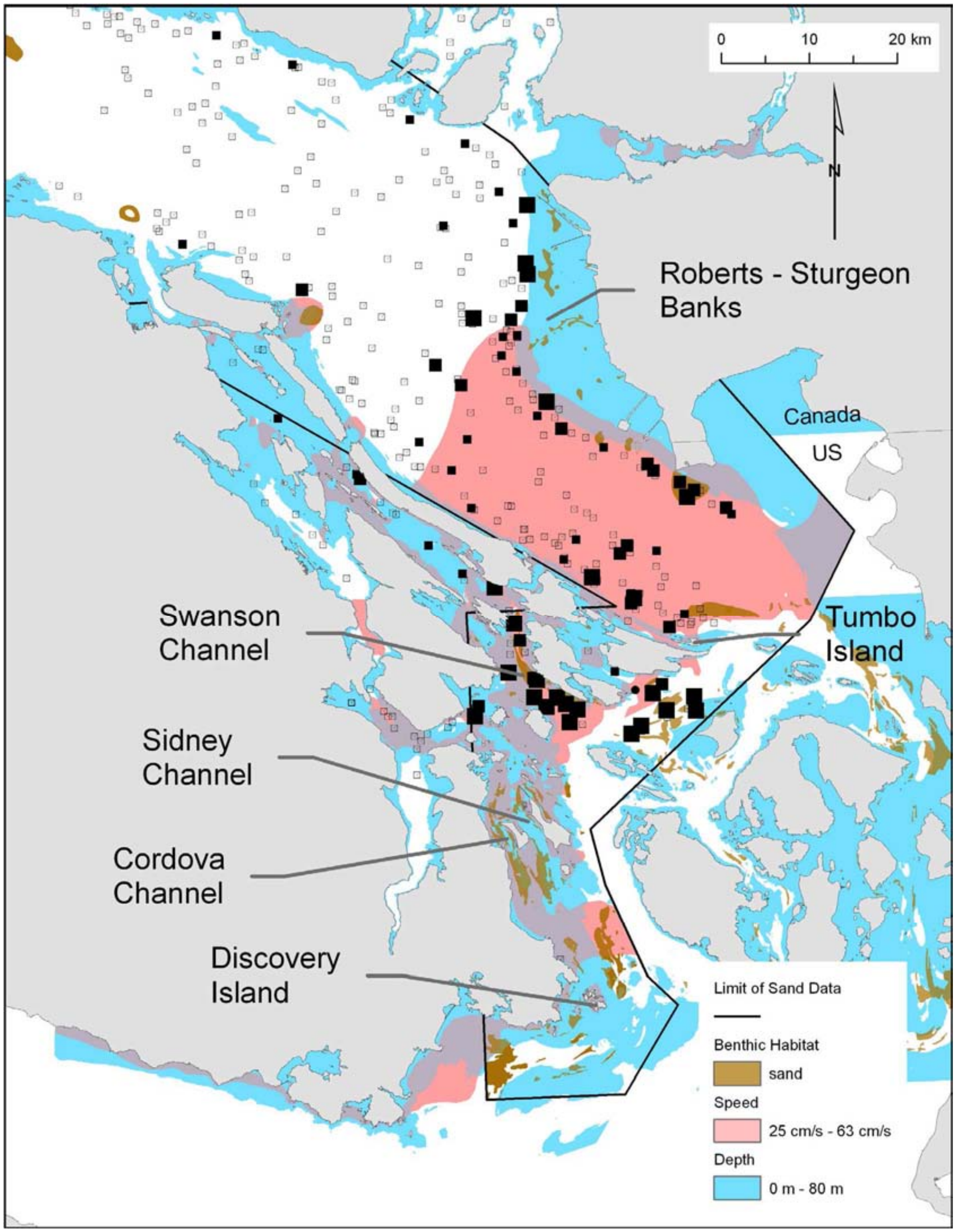

Figure 9. Sand Lance Habitat in the Southern Strait of Georgia

Source: Robinson et al. (2013)

Inshore rockfish (*Sebastes* spp.) are declining in abundance and protected from certain types of harvest within conservation areas in the Strait of Georgia. The yelloweye, quillback, copper, china, and tiger rockfish live on rocky reefs and do not swim far from their home reef (DFO 2006). No rockfish conservation areas are designated within the proposed Gabriola anchorages (DFO 2016) (Figure 5).

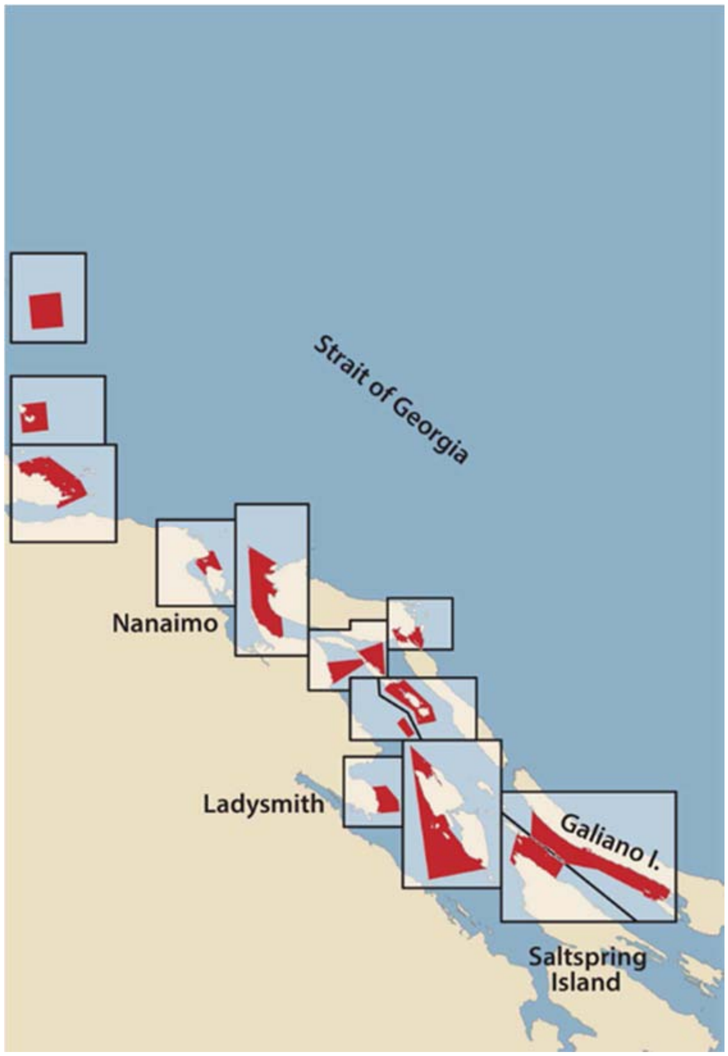

Figure 10. Rockfish Conservation Areas near the Proposed Gabriola Anchorage

Source: DFO (2016)

3.7 Listed Species

Two invertebrate and four fish species in the Georgia Basin have been listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or under Canada's Species at Risk Act (SARA) (Table 4). Risk is attributed primarily to habitat loss, pollution, and fishing (Johannessen and McCarter 2010).

Table 4. Species in the Strait of Georgia

Common Name	Scientific Name	SARA Listing	COSEWIC Listing
Northern abalone	*Haliotis kamtschatkana*	Yes	Endangered
Olympia oyster	*Ostrea conchaphila*	Yes	Special Concern
Bluntnose sixgill shark	*Hexanchus griseus*	No	Special Concern
Chinook salmon	*Oncorhynchus tshawytscha*	No	Threatened
Coho salmon	*Oncorhynchus kisutch*	No	Endangered
Green sturgeon	*Acipenser medirostris*	Yes	Special Concern

COSEWIC = Committee on the Status of Endangered Wildlife in Canada
SARA = Canada's Species at Risk Act

Neither of the listed invertebrates occurs in the proposed anchorage area. The pinto abalone is almost entirely absent from the southern Strait of Georgia (NMFS 2014). The Olympia oyster occurs in estuaries, salt-water lagoons, tidal flats, and attached to hard substrates. The Strait of Georgia population has been reduced to relicts attached beneath floating structures (Gillespie 1999, South Coast Conservation Program 2010).

The four listed fish species likely occur in the vicinity of the proposed anchorage. Existing threats to these fishes include warming water due to changes in the Fraser River and other rivers; decreased dissolved oxygen and pH, related to increase in water temperature; loss of riverine spawning habitat; sea level rise eliminating mudflat habitat; and reduced availability of prey (Beamish et al. 2010, 2012; Johannessen and McCarter 2010; Neville et al. 2015; Preikshot et al. 2013; Thomson et al. 2012).

4.0 Effects of Anchoring

Principal adverse effects of the proposed project include physical stressors associated with anchoring and anchor drag, including displacement of substrate material, direct injury to organisms in the area, and increased turbidity. Effects on marine vegetation, benthic organism, and fishes are discussed below. The anchor-chain assembly dropped from a vessel results in direct physical stress to any object it contacts, including benthic substrate and living organisms. In fine sediment, a secondary physical stress occurs when suspended particles become entrained in the water column, increasing the turbidity of the water. The vertical length of chain in the water column may be an obstacle to some large fish, especially sharks.

4.1 Scour Area

The chain that connects the anchor to the vessel must be long enough to allow the vessel to move up and down with tides, swells, and waves. The weight of the chain assists in anchoring the vessel. Excess chain is free to move about the bottom near the anchor, as the vessel moves around the anchor. Movement of the chain creates a "scour area," characterized by additional direct contact with substrate and organisms and increased turbidity. Direct effects on substrate include displacement of material and burying of small patches of hardbottom with fine sediment. Such disturbances of substrate cause subsequent displacement, injury, or death of organisms that were attached to, buried in, or otherwise associated with the substrate.

The typical scour area is a function of water depth and chain length, as shown in Figure 1. However, vessels can be displaced laterally across the substrate during storms or when struck by another vessel. In such cases, the anchor itself is displaced, and the scour area is extended to previously undisturbed areas.

Chain scour around the anchor creates mobile rubble and maintains unconsolidated sediments. Within the scour area, recruitment of invertebrates may be continuously depressed as planktonic larvae avoid certain habitat cues and select others. Such habitat selection and avoidance behavior is well-documented in coral recruits, and may also occur in lesser-known species with planktonic larvae (Baird 2001, Harrington et al. 2004, Ritson-Williams et al. 2010). Invertebrate larvae that do recruit to the scour area would likely be crushed by direct contact with the chain or buried by displaced sediment. Numerous studies have documented the deleterious and long-lasting effects of mobile rubble in reef habitats; as storms and currents move the rubble around, attached organisms in the immediate area can be injured or killed. (Allingham and Neil 1995; Chew 1999; Fox et al. 2003; Jaap 2000; McManus and McManus 2012; Riegl 2001; Risk et al. 2001). Although the effects of unstable rubble have been studied most in tropical coral reef habitats, the physical and ecological principals of rubble movement are universal; unstable substrates would adversely affect benthic invertebrates in the proposed anchorage area.

Direct physical effects on marine vegetation, benthic organisms, and fishes include displacement, direct injury, and mortality caused by the anchors and chains, as discussed below.

Marine Vegetation. Anchoring would adversely affect any seagrass, kelp, or other macrophytic algae by uprooting any plants within the scour area and preventing colonization of plants within or adjacent to the scour area. This effect would begin soon after the first anchor was dropped and would continue as long as a vessel remained anchored in that location. The anchor and chain are in direct contact with the seafloor. Any vegetation within the scour area around the anchor at the time it was dropped would likely be injured or buried as the chain circles around the anchor. The area of vegetation injury would be determined by the length of chain that contacted the seafloor where vegetation was growing.

Soft-bottom Benthic Habitat and Organisms. Soft-bottom habitat would be disturbed by the moving chain and dislodged rubble. The repeated disturbance of the substrate by the chain would make it impossible for most organisms to complete a normal life span. Individuals that recruited to the scour area would be unlikely to persist long enough to reproduce and so would be lost to the population. Therefore, soft-bottom infaunal and epifaunal invertebrates would be unable to recolonize the scour area as long as the chain was in place. In addition to the degradation of the physical habitat, the anchor and chain would directly displace, injure, or kill benthic organisms that were unable to move from the area before being crushed or buried by the anchor and chain.

Mobile Fishes and Invertebrates. Most mobile invertebrates and fishes would avoid the anchorage during active anchor dropping, and selectively relocate during periods of high-intensity chain movement. These animals are able to move in and out of the scour zone without harm, and are not expected to be adversely affected. Some slower-moving crustaceans and smaller fish may be caught beneath the chain and crushed. Animals that were injured or killed within the scour zone would likely be scavenged by mobile predators that enter the area during quiet periods then leave when the chain starts moving. Pelagic eggs and larvae would not be affected by scouring.

All of the listed fishes are mobile and capable of avoiding a dropped anchor and chain. None of the listed fish spawn in the proposed anchorage. The green sturgeon and bluntnose sixgill shark are benthic feeders, and may encounter the chain while foraging. The weight of the chain relative to the fish makes it unlikely that either sturgeon or shark would become entangled in the chain.

4.2 Turbidity

In addition to the physical disturbance of substrate, the anchors and chains would cause particles of fine sediment to become suspended in the water column. The increased turbidity would last as long as the chain was moving on the seafloor. Turbidity plumes would not necessarily remain in the anchorage area, but would likely be transported by currents and wind. In locations where high turbidity is the norm, such as shallow estuaries or sediment-laden rivers, organisms may be adapted to high concentrations of particulates and low light levels. However, when turbidity increases above the norm for a given habitat, organisms may be disadvantaged or even killed.

The increased turbidity caused by dropping anchors and subsequent chain movement could adversely affect benthic resources by physically clogging the filter-feeding mechanisms of some invertebrates and the gills of some fishes, burying or suffocating benthic organisms, scattering light, and reducing photosynthesis. Because the turbid waters would not necessarily remain within the scour area, but could move under the influence of wind and currents, turbidity effects may extend beyond the anchorage.

A second large sediment displacement event would occur when an anchor is lifted in preparation for the vessel to leave the anchorage. Depending on the operational circumstances, the vessel operator may find it necessary to manoeuver the vessel to weigh the anchor, dragging the anchor a bit before lifting it from the substrate (St. Eustatius National Parks Foundation. 2007). Anchor lifting would create a large turbidity plumes that would extend vertically from the seafloor to the surface of the water. The combination of weighing anchor and engaging the engines to get underway would cause local mater movements that would disperse the turbidity plume beyond the anchorage area.

Marine Vegetation. Highly turbid waters scatter light, reduce the depth of light penetration, and interfere with photosynthesis. Reduced light penetration affects both phytoplankton and submerged vegetation. In addition, suspended sediment that eventually resettles can cover submerged vegetation. Particulates on the surface of plants can block the light necessary for photosynthesis and interfere with respiratory gas exchange.

Soft-bottom Benthic Habitat and Organisms. The filter- feeding apparatus of bivalves and sponges can become physically clogged by high concentrations of suspended particulates, essentially causing the organism to starve. Alternatively, the animal may continue to feed, but become full of sediment rather than nutritious phytoplankton or zooplankton. Some bivalves simply close their valves when turbidity is above their tolerance threshold. As a short-term strategy, this behavior protects the animal from excess sediment intake; however, the animal cannot feed when its vales are closed, so continuous high turbidity can lead to starvation and death.

Turbidity can interfere with foraging by visual predators as well as by filter feeders. A larval fish that typically picks zooplankton from the water column may not be able to forage efficiently in the dim, hazy light of highly turbid water. Moreover, the larval fish may select large particulates mistakenly, much like the filter feeders described above, leading to loss of condition due to poor nutrition. The gills of small fishes are susceptible to injury by excess particulates, causing reduced respiratory fitness.

As described above, suspended sediment eventually settles from the water column, potentially burying or coating the surfaces of soft-bodied invertebrates. While some larger invertebrates, such as sea anemones and sea stars, are able to remove sediment from their body surfaces, such maintenance requires energy and can lead to reduced growth or reproductive success. Smaller organisms, such as hydroids, may be completely buried by settling particulates.

Mobile Fishes and Invertebrates. Mobile predators such as larger crabs and fish are capable of avoiding areas of unacceptably high turbidity. Visual predators may be disadvantaged while feeding in areas of low light, but many fishes and decapod crustaceans have secondary sensory abilities that allow them to forage using chemical (smells) and tactile (touch) signals. Turbidity caused by the movement of the chain on the seafloor would not be a stressor to the green sturgeon, which is a sensory feeder that is tolerant of murky waters (NMFS 2014). The bluntnose sixgill shark is a nocturnal feeder that eats both live prey and carrion (COSEWIC 2007); most sharks rely on chemical cues to locate food. The salmon are pelagic foragers that are unlikely to be disturbed by benthic turbidity plumes around the chain.

By reducing light penetration, turbidity may affect the distribution and abundance of phytoplankton, which can launch a cascade of adverse effects on the food web, leading to declines in zooplankton, larval fishes, and larger predators, including adult fish. Although such an effect would be considered significant in a closed pond or lake, it is of less concern in the open waters of the Strait of Georgia, where fish are free to relocate to more suitable foraging grounds.

4.3 Physical Obstruction

While a vessel is at rest, the anchor chain extends through the water column from the vessel to the seafloor along a vertical or diagonal line. The chain would create a vertical obstruction in the water column that pelagic organism would have to manoeuver around. Smaller invertebrates and fish would not likely be affected, but the large bluntnose sixgill shark may be affected by the obstruction, particularly if a vessel drops more than one anchor or if several vessels are anchored near one another. DFO refers to a cluster of anchor chains as a "forest" of obstructions that can adversely affect sharks that collide with the chains or alter their behavior to avoid the chains (DFO 2014). The potential effects of anchor chains in the water column are acknowledged but evaluation is limited because no published research on the incidence of such effects was available.

5.0 Conclusions

The proposed Gabriola Anchorages project would adversely affect marine vegetation, benthic invertebrates, and mobile fishes and invertebrates within and adjacent to the designated anchorages. Direct physical contact with the anchor and chain and subsequent increases in turbidity would displace, injure, or kill organisms and degrade benthic habitat. Effects on marine vegetation, benthic invertebrates, and mobile organisms are discussed below.

Marine Vegetation. Marine vegetation in the scour areas would be eliminated by chain scour during the initial vessel occupancy. Depending on the interval between vessel visits, some regrowth of vegetation may occur. The ability of the substrate to support regrowth of vegetation would depend on the interval between vessel visits and the extent of turbidity plumes from neighboring anchorages. The most likely scenario is that very little vegetation would remain within the project area after the first few vessel visits. The proposed anchorage would have direct and indirect adverse effects on marine vegetation, including eel grass, kelp, and macrophytic algae. Effects on local populations would be major and significant, resulting in complete loss of vegetation in the scour area. No species-level effects would be realized, however, because suitable habitat in other areas of the Strait of Georgia would continue to support eel grass, bull kelp, and macrophytic algae.

Benthic Invertebrates. Anchors and chains would have direct adverse effects on soft-bottom habitats and benthic invertebrates within the anchorage areas. Chain scour would displace, injure, or kill invertebrates during the period of vessel occupancy, and prevent recruitment of individuals from the water column or immigration of individuals from adjacent benthic habitats. Increased turbidity would interfere directly with feeding by some organisms, and reduce the penetration of light necessary for photosynthesis. The net effect would be to reduce availability of phytoplankton and zooplankton in the area, further stressing filter-feeding or planktivorous benthic invertebrates.

Effects on local populations of infaunal and small epifaunal invertebrates would be major and significant, resulting in severe reduction of invertebrate populations in the active anchorage areas. However, with the mitigation recommended in Section 7.0, some recovery of benthic invertebrates may be possible. If an anchorage site remains unused for a period of weeks, some recolonization could occur, depending on the season and availability of colonizers. No species-level effects are expected because suitable habitat for soft-bottom invertebrates in other areas of the Strait of Georgia would continue to support typical soft-bottom infaunal and epibenthic species.

Mobile Fishes and Invertebrates. Mobile fishes and invertebrates are generally capable of avoiding a dropped anchor and chain. The proposed anchorage is not within a known spawning area for any fish or invertebrate species. The green sturgeon and other benthic fishes may encounter the chain while foraging. However, the chain is too heavy to be moved by fish and does not pose an entanglement risk. The proposed anchorage does not contain the coarse sand required by the Pacific sand lance, nor does it have the swift bottom currents the sand lance prefers.

Turbidity caused by the movement of the chain on the seafloor is considered a stressor to some fishes, but not to all. Species that use non-visual mechanisms for foraging (such as chemical or physical detection methods) or nocturnal foragers are unlikely to be adversely affected by turbidity. The green sturgeon, like all sturgeon, is tolerant of highly turbid water, as it feeds on mud and other soft substrates; it is not particularly sensitive to slight water disturbances (NMFS 2014; COSEWIC 2004).

Most pelagic foragers would be able to avoid the chains and anchors while feeding. Some reduction in plankton abundance could occur in the immediate anchorage area. Disturbance of the soft-bottom benthic habitat in the proposed anchorage area would not contribute appreciably to the decline of resident species. The proposed project would not adversely affect burying habitat or foraging grounds of the Pacific sand lance. The proposed anchorage would have direct and indirect adverse effects on mobile fish and invertebrates, including listed fishes. However, the effects would be localized and minor, not rising to the level of significance.

6.0 Recommendations and Mitigation

The proposed anchorages will degrade or destroy a large area of soft-bottom substrate, making it uninhabitable for the operational duration of the anchorage. Without a permanent mooring system, anchors will be repeatedly dropped within the anchorage, and chains will continue to create scour areas and turbidity plumes. If all five anchorages are occupied continuously, the maximum area of impact will be realized. However, if occupancy is intermittent, a purposeful plan of use could reduce the overall area of impact. Tetra Tech recommends that the anchorages be used sequentially as shown in Table 5.

Table 5. Recommended Sequence of Anchorage Use

Number of Vessels Present Simultaneously	Vessel #1	Vessel #2	Vessel #3	Vessel #4	Vessel #5
1	G1				
2	G1	G3			
3	G1	G3	G2		
4	G1	G3	G2	G4	
5	G1	G3	G2	G4	G5

The recommended pattern of use would preserve the area where the most diverse benthic community was observed (G5) so that it would not be used unless all other anchorages were occupied. Under such a heavy use scenario, many benthic resources would already be stressed by turbidity effects and the habitat at G5 would then be subjected to direct physical impacts. Spacing the use of anchorages as indicated in Table 4 would allow for the possibility of recovery of fast-growing infauna in G2, which could then serve as source areas for the adjacent anchorages when they are not occupied. Although promoting benthic community growth in areas that are designated to be used as anchorages may seem pointless, it must be noted that mobile predators can move into anchorages to forage whether or not the anchorage is occupied. In fact, some mobile predators would likely take advantage of the occupation by preying on the displaced, injured, or dead organisms. Therefore, promoting recolonization and growth of benthic organisms in unoccupied anchorages is a reasonable mitigation for the total loss of undisturbed habitat in the proposed anchorage area.

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APPENDIX E

EFFECTS OF BALLAST WATER DISCHARGE ON THE ENVIRONMENT AT PROPOSED GABRIOLA ANCHORAGES (MIRE 2016B)

EFFECTS OF BALLAST WATER DISCHARGE ON THE ENVIRONMENT AT PROPOSED GABRIOLA ANCHORAGES

Prepared for

Pacific Pilotage Authority

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Contents

1.0 Introduction 2

2.0 Vessels Anticipated to Dock at Gabriola Anchorages 2

3.0 Ballast Water Treatment and Management 3

3.1 Ballast Water Discharge Regulations 3

3.2 Ballast Water Treatment Alternatives 5

3.3 Ballast Water Management on Trans-Pacific Bulkers 6

4.0 Effects of Treated Ballast Water Discharge 7

5.0 References 8

Tables

Table 1. Southern Gulf Island Anchorages Usage 2

1.0 Introduction

The Pacific Pilotage Authority is proposing to establish five anchorage locations for deep sea vessels along the east coast of Gabriola Island in the Strait of Georgia to provide a safe holding area for vessels awaiting berths at Port Metro Vancouver.

A significant increase in deep sea vessels requiring anchorages on the coast of British Columbia since 2009 requires that additional anchorages be established. In 2014, 170 vessels sought anchorage in the southern Gulf Islands because Port Metro Vancouver was filled to capacity (Table 1). Vessel traffic is influenced by the size of the grain crop, demand for coal, labour fluctuations in neighboring countries, availability of trains and trucks, winter weather, and other factors.

The number of vessels, timing of arrival, and duration of stay varies tremendously among locations and years. The anticipated use is predominantly coal ships bound for Westshore Terminals. Historical use of anchorages in the Southern Gulf Islands indicates that the length of stay has steadily increased since 2009 (Table 1).

Table 1. Southern Gulf Island Anchorages Usage

Total for Southern Gulf Island Anchorages by year			
Year	Number of Ships	Total Stay (Days)	Average Stay (Days)
2009	23	154	6.7
2010	62	327	5.3
2011	135	1064	7.9
2012	92	649	7.1
2013	106	882	8.3
2014	170	1582	9.3

Baseline environmental conditions at the proposed anchorages are described in the Gabriola Anchorage Environmental Assessment Appendix D (*Effects of Anchoring on Biological Resources at Proposed Gabriola Anchorages*) based on a one-time limited remotely operated vehicle (ROV) survey and numerous reports and peer-reviewed publications. This Technical Memorandum focuses on the potential environmental effects of ballast water discharged by vessels using the proposed anchorages.

2.0 Vessels Anticipated to Dock at Gabriola Anchorages

A recent review and adjustment of anchorages in the southern Gulf Islands resulted in the loss of anchorages for the larger Capesize vessels that serve the Westshore and Neptune coal terminals at Vancouver Metro Port. As a result, Pacific Pilotage authority must designate appropriate deep sea anchorages to accommodate Capesize vessels. Capesize ships are so named because they must travel around Cape Horn to move between the Atlantic and Pacific Oceans; they are too large to navigate through the Panama Canal. Most Capesize vessels are designed to carry iron ore and coal. The proposed Gabriola Anchorages would accommodate four 300-meter vessels and one 260-metre vessel along the 50-metre isobath. Most of the vessels would be waiting a turn to dock at the Westshore Terminals, Canada's busiest coal export terminal, which moves more than 33 million tonnes of coal each year (http://www.westshore.com/#/main). A Capesize vessel, or bulker, expected to use the proposed anchorages would rely heavily on ballast for safety and stability during its trans-Pacific voyage to Port Metro Vancouver. Most bulkers would arrive with empty cargo holds and full ballast tanks. In some cases a vessel operator may decide to take on additional ballast if rough seas are expected.

Ballast water typically would not be released until the vessel reached the port where it is to take on cargo. Operational discharges associated with shipping include ballast water, waste disposal, air emissions, sewage/grey water, cargo sweepings and bilge water (DFO 2014). Vessels may be observed discharging water while at the Gabriola Anchorage. However, the discharge is not likely to be from ballast tanks. Transoceanic vessels must take on seawater almost continuously to cool the engine and generators. The seawater flows through the pipes to cools the equipment, then is discharged. Cooling water does not enter the ballast tanks and does not carry nonindigenous species (Port Metro Vancouver 2016a).

Canada's principal buyers of coal are in Asia, South America, and Europe, and vessels may arrive from virtually anywhere to pick up coal. It is the nature of international shipping that vessels carrying goods from port to port form a complex network of trade under the multiple influences of global financial conditions, weather, and international relations. It is not possible to predict the last port of call of the vessels that would dock at the proposed Gabriola Anchorage. Much of the information about vessel operations is considered proprietary and not easily accessible by the public. Some recently published research using partial records provided by the Canadian Ballast Water Information System (BWIS) indicates that about 70 percent of the ballast discharge in Pacific Canadian ports on 2006-2007 came from Asia (47 percent from Japan, 12 percent from China, and 10 percent from South Korea). Of all vessel types, bulkers contribute the greatest volume of ballast water to west coast ports (82 percent) (Lo et al. 2012). Canadian Atlantic ports received far more ballast water than Pacific ports; of the Pacific ports, Port Metro Vancouver was among the top recipients of ballast water discharge.

3.0 Ballast Water Treatment and Management

The discharge of ballast water from vessels is a dominant vector of introduction of nonindigenous species (NIS) to marine and aquatic environments; organisms from viruses to crustaceans have been transported across the oceans in ballast water (Cohen and Dobbs 2015; DFO 2014). Adverse effects of many NIS are well-documented, but models predicting which NIS will become established or invasive in a given habitat are less reliable. Once an NIS becomes invasive, it may alter the host ecosystem in complex and unexpected way, including altering abundance and distribution of native species through direct predation or resource competition or indirect effects on habitat. Potential environmental effects of ballast water discharges by vessels holding at the proposed Gabriola anchorages were evaluated within the context of Canadian regulations governing ballast water discharge and patterns of regional shipping activity.

3.1 Ballast Water Discharge Regulations

Port Metro Vancouver has long prohibited vessels from discharging ballast water at the port unless mid-ocean exchange had occurred (Port Metro Vancouver 2016b). Recognizing the role of ballast water discharge as a vector for NIS, Transport Canada established regulations to control potentially harmful releases of NIS into Canadian waters (Transport Canada 2012).

Since 1997, vessels discharging ballast water to the Port of Vancouver (Port Metro Vancouver) have been required to perform mid-ocean ballast water exchange (BWE) to reduce the likelihood of introducing NIS in ballast water discharge (Scriven et al. 2015). BWE involves replacing ballast water taken into tanks in one location (usually freshwater or brackish water) with water from an open ocean environment (Albert et al. 2010). Flushing ballast holds with high salinity seawater far from any coast reduces the likelihood that invasive species in discharged ballast water will become established and also removes potentially harmful chemicals from water taken on at prior ports-of-call (Transport Canada 2012). Exchange can be effected through a sequential empty and refill process or by opening the ballast tanks and allowing seawater to flow through while the vessel is underway (Lo et al. 2012).

The role of ballast water in transport and introduction of NIS has been actively investigated by scientists and governments around the world. The International Maritime Organization (IMO), the organization responsible for improving maritime safety and preventing pollution from vessels, identified vessel transport of NIS as a major issue confronting the international maritime community. In 1997, the IMO adopted voluntary guidelines titled *International Guidelines for Preventing the Introduction of Unwanted Aquatic Organisms and Pathogens from Ships' Ballast Water and Sediment Discharges*. In February 2004, the IMO drafted the *International Convention for the Control and Management of Ships' Ballast Water and Sediments,* commonly referred to as the "BWM Convention." The BWM Convention outlined ballast water management procedures and established an international standard for ballast water discharges (IMO 2004).

The BWM Convention phases out ballast water exchange over time and requires on-board treatment of ballast water). The BWM Convention would become enforceable 1 year after ratification by 30 countries representing at least 35 percent of the gross tonnage of the world's merchant shipping. Canada ratified the Convention in 2010. By February 2016, 47 nations had signed the Convention, but fell short of the gross tonnage requirement (IMO 2016).

The IMO implements a process known as "Type Approval" whereby vendors can request evaluation and approval of shipboard ballast water treatment systems claimed to meet the standards of the Ballast Water Convention, known as the "D-2" standards. Transport Canada has a similar program, although it has not granted Type Approval to any systems. In addition to meeting the IMO standards, treated ballast water must be demonstrated not to contain chemicals that pose risk to human health or the environment (Scriven et al. 2015). Transport Canada allows vessels to use a treatment method rather than ballast water exchange if the ballast water, after treatment, meets the IMO D-2 standard (also in Section 9 of the TP 13617 E Regulations). Section 9 acknowledges that Transport Canada allows but does not require IMO treatment systems on vessels entering Canadian waters (Transport Canada 2012).

In accordance with the convention and Transport Canada regulations, vessel operators are required to manage ballast water in one of four ways:

- Option 1: Operate a ballast water management system approved by Transport Canada.
- Option 2: Retain ballast water on board while in Canadian waters.
- Option 3: Discharge ballast water to a shore-based reception and treatment facility.
- Option 4: Conduct open ocean exchange of ballast water at least 200 nautical miles from shore in waters at least 200 metres deep, unless precluded by safety concerns.

Only Option #4 (ballast water exchange) is used by bulkers calling at Port Metro Vancouver. The most recent published research of Canadian Pacific Coast ports was based on data from 2006-2007; at that time, most bulkers exchanged ballast water using a flow-through process (Lo et al. 2012).

3.2 Ballast Water Treatment Alternatives

The IMO, Canada, the United States, and Australia have called for an end of ballast water exchange as a means of controlling NIS, largely because it is not effective in meeting the IMO D-2 standards and poses safety risks to some vessels (Environment and Climate Change Canada. 2016). To meet the new IMO D-2 standards, new treatment systems are being developed and tested by the IMO, member nations, and numerous vendors.

The IMO has separate approval processes for BWMSs that include Active Substances (G9) or exclude Active Substances (G8). Most technologies that do not use Active Substances are believed to pose little to no risk to human health or the environment. Several of the more common non-chemical technologies are ultraviolet (UV) irradiation, cavitation and ultrasound, deoxygenation, heat, and electrochlorination (EC). The IMO grants two levels of approval for BWMSs using Active Substances: Basic and Final (Marine Environmental Protection Committee [MEPC] 57/21 2008). The approval process includes a review of the design and construction of the technology, environmental safety tests, and land-based tests in various salinities. Systems that use Active Substances must also undergo ship-based toxicity tests of the effluent under realistic operating conditions (American Bureau of Shipping [ABS] 2011). After a BWMS using Active Substances has obtained Final Approval under the G9 guidelines, it must then apply for Type Approval by a Flag Administration (IMO 62/BWM.2/Circular 28 2010). The IMO's Guidelines of the Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP) prohibit approval of BWMSs that release substances which are persistent, bioaccumulative, or toxic (PBT). Most applicants for approval under G9 guidelines offer systems that produce disinfection byproducts (DBP) either through direct chlorination or EC devices (Banerji et al. 2012). DBPs cause fewer acute impacts to human health or the environment than do PBT chemicals. Final Approval under G9 guidelines is granted to a system that has demonstrated acceptable levels of risk to human health and the environment, as judged by the GESAMP of the IMO.

The IMO has granted Final Approval to more than 50 ballast water treatment systems (Cohen and Dobbs 2015). Several that use Active Substances, however, have since been withdrawn from the market because they were shown to be unable to perform effectively and safely under real-world operating conditions (IMO BWM.2/Circ.34 2011, Wilhelmsen Technical Solutions 2012; Lloyd's Register 2012).

Flag Administration Type Approval may be granted by a country where the vendor has a business, legal, or other relationship. A BWMS that does not use Active Substances must first receive Basic Approval under IMO's Guidelines for Approval of Ballast Water Management Systems (G8 guidelines; MEPC 174/58 2008), which focus on whether the BWMS meets the D-2 standards. The G8 guidelines require both land-based and ship-based testing of efficacy in meeting the D-2 standards. If the treatment system is found to pose any risk to the environment or human health, the G8 guidelines call for additional testing of the ballast water discharge prior to Basic Approval. Once Basic Approval is granted, the vendor can seek Type Approval by a Flag Administration (MEPC 174/58 2008). The entire test sequence can take up to a year (Lloyds Register 2010a, b; ABS 2011).

In principle, an independent third party performs quality assurance and data validation, as outlined in the G8 guidelines (MEPC 174/58 2008). Shore-based tests of a system's ability to meet the IMO discharge standard are followed by shipboard tests of the operational efficacy under more realistic conditions. Flag Administration Type Approval is meant to confer independent approval of the system.

3.3 Ballast Water Management on Trans-Pacific Bulkers

The specific combination of components suitable for a given vessel depends in part on vessel size. For example, vessels that depend heavily on ballast water, such as bulk carriers and tankers, are best served by BWTSs that accommodate high flow rates and low per unit energy use. Highly ballast dependent vessels regularly sail in "ballast only" condition (that is, empty of cargo) and have very fast ballast water pumping rates). Ballast tanks on these vessels have high volume pumps designed to allow rapid discharge and port turnaround times under 24 hours. Representative ballast capacity of Capesize bulk carrier is 65,000 m^3 (ABS 2011).

Capesize vessels may be fitted with a variety of BWTSs, including chemical treatment, deoxygenation, and ozone generation. Chlorine generation and UV irradiation are suitable for all but the largest bulkers (ABS 2011). Electrochlorination devices may occasionally be used, but are generally not suitable for treatment of the large volume of ballast water in Capesize vessels.

The typical route, voyage duration, and water characteristics of ports are also important. For example, a vessel that frequently takes on ballast water from areas of high turbidity may have to incorporate special filtration to enhance the efficacy of disinfection treatments (ABS 2011, Lloyds Register 2010a, b). Some components are best suited to long voyages (deoxygenation) where treatment exposure times can be longer, while others perform optimally on shorter trips (UV radiation). No single technology has been shown superior in treating ballast water to meet the IMO D-2 standards. Current research is aimed at developing an effective combination of technologies that meets discharge standard for living organisms without violating water quality permits in the discharge (Wu et al. 2011a, b; Gavand et al. 2007).

About 80 percent of the commercially available shipboard BWMSs filter the incoming ballast water first to remove particulate matter and organisms (Lloyd's Register 2011a), followed by either chemical or mechanical disinfection. Physical separation is achieved with either filters or hydrocyclones. The D-2 standards are specific to size classes of living organisms, and so the mesh size of the filters must be appropriate. Mesh sizes between 40 and 50 micrometers (µm) are common, as these screen out certain groups of plankton but still allow adequate flow rates during ballasting (Lloyds Register 2010a, b).

Regardless of the other components in the BWMS, the filtration step imposes substantial energy requirements on the vessel because uptake pumps must work to draw water through the filter. Filtration also slows ballast water uptake by requiring intermittent backflushing to clear larger organisms, as well as debris. Disinfection methods include generation of oxidants from seawater (EC devices), direct addition of chlorine, or generation of chlorine dioxide from reagents carried on-board. Some systems follow treatment with additional steps to neutralize the ballast water prior to discharge.

BWMSs that rely heavily on filtration components may not be suitable for vessels that are highly ballast-dependent such as bulk carriers and tankers. Very large and ultra-large carriers take on too much ballast water too quickly to rely on filtration as a principal means of treating ballast water (ABS 2011). In recognition of the lack of approved BWMSs for very large vessels, the IMO agreed to re-establish a ballast water review group focused on vessels with ballast water capacity of at least 5,000 cubic meters and high flow rates (MEPC 62/24 2011).

"Disinfection" is a general term for destroying undesirable or harmful microbes such as bacteria and viruses; in the specific case of ballast water treatment, it includes destruction of other organisms as well, including unicellular algae and multicellular organisms. Both physical/mechanical disinfection and chemical disinfection processes are available in commercial BWMSs. Physical/mechanical disinfection methods include UV radiation, ultrasonic cavitation, and deoxygenation. Most of the systems include an optional process to reduce residual oxidants in the ballast water after the disinfection has been completed. Advanced oxidation systems generate hydroxyl radicals by various means, and the radicals act as disinfecting agents. Some systems also include ozonation as a disinfecting process.

Deoxygenation systems have not been demonstrated to meet the IMO D-2 standards, but development efforts are underway. The efficacy of deoxygenation systems is partially a function of duration. On trans-Pacific voyages between Asia and British Columbia, dissolved oxygen in untreated ballast water fell from about 4 mg/L to non-detectable levels after only 6 days at sea, and remained below detection limits until arrival 15 days later (Seiden et al. 2011). Existing commercial systems that use deoxygenation also lower the pH of the water because of the addition of carbon dioxide, which is converted to carbonic acid in the ballast water (ABS 2011). Low oxygen concentrations may induce some protists to enter a cyst stage that is difficult to kill or to determine of the viability of because it is in a resting or non-motile state (Casas-Monroy et al 2011). A promising treatment is Coldharbour Marine's Gas Lift Diffusion system, which combines deoxygenation using inert gas with micro-bubble cavitation and ultrasonic shockwaves to kill bacterial spores (IHS Maritime 2014).

4.0 Effects of Treated Ballast Water Discharge

No current ballast water management system meets both the IMO D-2 standard for living organisms and the water quality criteria considered safe for human and ecological health. Both treated and untreated ballast water discharge poses risk of NIS, including pathogenic viruses and bacteria. Chemically treated ballast water may contain residual harmful chemicals, as well as resistant populations of NIS (Werschkun et al. 2014).

Treatment of ballast water with an "approved" system does not ensure that NIS have been eliminated or that the discharge water is safe for humans or the environment. Despite the requirement that vendor applications to the IMO include human health and ecological risk assessment data, few of the approved systems provided adequate independent human health risk assessment documentation—and most of those documentations were inadequate for independent validation purposes (Banerji et al. 2012; Scriven et al. 2015). Likewise, the U.S. Coast Guard and U.S. EPA identified extensive deficiencies in the IMO approval documents (Albert et al. 2010). The rigor and independence of the approval process have been questioned, and many in the shipping industry have called for an increase in transparency, particularly in quality assurance and quality control (Cohen and Dobbs 2015). The Australian EPA cited several flaws in the IMO approval process, noting in particular that unrealistic test conditions limited the reliability and applicability of the results. Tests did not represent the realistic range of pH, temperature, salinity, or sediment load at ports around the world (de Souza 2010). For example, the Hamann SEDNA® BWMS was granted Basic and Final IMO Approval and Flag Administration Type Approval (Germany). Under commercial operating conditions, however, the discharge was discovered to be toxic to organisms under cold freshwater conditions (Albert et al. 2010, de Souza 2010).

Numerous independent data sets demonstrate that open-ocean BWE is not always feasible or completely effective in achieving the necessary reductions of NIS in ballast water (Zhang and Dickman 1999, Dickman and Zhang 1999, Cordell et al. 2009, Burkholder et al 2007, Villac and Kaczmarska 2011). Given that discharged ballast water is likely to contain NIS, and may contain chemical residuals, despite IMO and Transport Canada's efforts, what would be the potential effect of ballast water discharge from the vessels moored at the proposed Gabriola anchorages?

A vessel operator may discharge ballast water to balance the vessel when loading cargo, to navigate shallow waters, to maintain navigational control, or to respond to other circumstances (Boltovskoy et al. 2011, ABS 2011). However, under most circumstances, ballast water is not released until the vessel arrives at port and begins loading cargo. Risk associated with ballast water discharge would occur in Port Metro Vancouver, regardless of where the vessel was held while waiting for berthing space at the port. In fact, any delay caused by lack of space at the port could coincidentally decrease the risk of living NIS in the discharge because the abundance of viable propagules is inversely proportional to the age of the ballast water, measured as the time since it was taken onto the vessel (Sutherland and Levings 2013). For example, on trans-Pacific voyages between Asia and British Columbia, dissolved oxygen in ballast water fell from about 4 mg/L to non-detectable levels after only 6 days at sea, and remained below detection limits until arrival 15 days later (Seiden et al. 2011). Deoxygenation is one of the most effective and environmentally safest methods of killing NIS in ballast water.

The risk of NIS introduction in ballast water is indisputable. However, the trans-Pacific bulkers that would be moored at the proposed Gabriola anchorages are not the principal vectors of NIS in the Strait of Georgia. The long transit time from Asian ports and the required open ocean exchange reduce the density of viable propagules in bulkers relative to other classes of vessels, notably intracoastal ships that travel along the Pacific Coast of North America. Under Transport Canada regulations, vessels that do not venture outside the 200 nautical mile continental limit are exempt from ballast water exchange requirements. These vessels have been shown to contribute far greater NIS that trans-Pacific bulkers (DiBacco et al. 2012). In fact, propagule pressure was lower in ballast water of transoceanic bulkers that used open ocean exchange than in intracoastal vessels, regardless of whether the intracoastal vessels had voluntarily exchanged ballast water (DiBacco et al. 2012).

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APPENDIX F

MARINE MAMMAL AND SEA TURTLE TECH MEMO (ZOIDIS 2016)

MARINE MAMMAL AND SEA TURTLE TECH MEMO

FOR THE
PACIFIC PILOTAGE AUTHORITY
GABRIOLA ANCHORAGES PROJECT

STRAIT OF GEORGIA
GABRIOLA ISLAND, BRITISH COLUMBIA

March 2016

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1.0 INTRODUCTION

The Pacific Pilotage Authority (PPA) is proposing to establish five anchorage locations for deep sea vessels along the east coast of Gabriola Island in the Strait of Georgia to provide a safe holding area for vessels awaiting berths at Port Metro Vancouver. A significant increase in deep sea vessels requiring anchorages on the coast of British Columbia since 2009 requires that additional anchorages be established. The number of vessels, timing of arrival, and duration of stay varies tremendously among locations and years. The anticipated use is predominantly coal ships bound for Westshore Terminals. PPA proposes to allow large deep sea vessels, with lengths up to 300 meters (m), to anchor off Gabriola Island in the Strait of Georgia.

This section presents the marine wildlife species known to occur in the project area and presents the impact assessment for the EA on those species.

Marine Mammals

Introduction

Marine mammals are a diverse group of approximately 130 species. Approximately twenty-five of these species are known to occur in British Columbian waters (Williams and Thomas 2007; Ford and Nichol 2011). Most of these species occur and live predominantly in the marine habitat, though some species spend portions of time in terrestrial habitats (e.g. seals and sea lions). Marine mammals are generally categorized into four main types: cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees, dugongs, and sea cows; none of these are in the project area), and several species of marine carnivores (e.g. marine otters). The Order Cetacea is further divided into two suborders. The toothed whales, dolphins, and porpoises (Suborder Odontoceti) range in size from slightly longer than 1 meter (m) (3 feet [ft] to more than 18 m (60 ft) and have teeth, which they use to capture and consume individual prey. The baleen whales (Suborder Mysticeti) are universally large (more than 5 m [15 ft] as adults), and they are batch feeders that that use baleen instead of teeth to engulf, suck, or skim large numbers of small prey from the water or ocean floor sediments.

Species conservation status in British Columbia (BC) is established by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Species in Canada designated with a status may or may not be protected under the Species at Risk Act (SARA). SARA protects certain listed mammals, reptiles, amphibians, invertebrates, and plants on federal lands and certain listed birds and fish on all lands in Canada.

Marine mammal populations can be influenced by a number natural factors and human activities. These factors impact marine mammal populations directly (e.g. injuring, killing, or hunting individuals outright), or indirectly (e.g. through reduced survival or lowered reproductive success of selected individuals). Climate change can affect marine mammal species directly through habitat loss (especially for species that depend on ice) and indirectly via impacts on prey, changing prey distributions and locations, and changes in water temperature. Changes in prey can impact marine mammal foraging success, which in turn affects reproductive success, and survival. Climate change also may influence marine mammals through resulting changes in human activities, such as increased shipping or more oil and gas extraction resulting from sea ice loss. The most common sources of impacts on marine mammals include hunting (both commercial and native practices), fisheries interactions (such as gear entanglement), bycatch (accidental or indirect catch), ship strikes, noise pollution, chemical pollution, and general habitat deterioration or destruction. Ship strikes and noise are both growing issues for most marine mammals and may significantly affect the population of a species. Disturbance (harassment) of marine mammals is prohibited by both Canadian and US federal legislation.

Following is a short description for each species expected to occur in the project area. Sightings documented in the Project Footprint provided from the database held by the BC Cetacean Sightings Network at Vancouver Aquarium (BC Cetacean Sightings Network 2013) are shown in Figure X and include killer whales, pacific white-sided dolphins, gray whales, humpback whales and unidentified porpoise/dolphin. It is important to note that marine mammals and sea turtles are mobile species and can occur even if they have not been sighted previously and that the reason for lack of documentation is not correlated to presence or absence but rather to the degree of systematic sighting surveys. For COSEWIC Criteria definitions, please see Appendix A.

<u>Cetaceans:</u>

North Pacific Right Whale
Status: Endangered
Last Examination and Change: May 2015 (no change)
COSEWIC Criteria: A2abd; D1
SARA: Schedule 1, Endangered

The North Pacific right whale (*Eubalaena japonica*) is one of the world's most endangered large whale species. It is estimated that the historical population was over 11,000 animals, but research indicates that their numbers are now much lower. The numbers in the eastern North Pacific are extremely low, with estimates of fewer than 50 individuals in the southeastern Bering Sea, the only known area of regular occurrence of this population. It is most unlikely that the number of mature animals exceeds 250 individuals over its entire range (COSEWIC 2016a). Not much is known of the behavior of this species, largely because of its rarity. In the North Pacific, few individuals are observed, and they are usually alone (Brownell et al. 2001). They feed primarily on copepods, a type of zooplankton (SARA 2016a). Verified sightings of this species in Canadian waters were absent for over 60 years, however two separate individuals were seen in 2013 confirming that the current range includes Canadian waters (COSEWIC 2016a). The North Pacific right whale is protected under SARA. Threats to right whales including noise disturbance, habitat degradation, entanglement in fishing gear or debris, and ship strikes (O and Ford 2003; SARA 2007).

Humpback Whale.
Status: Special Concern
Last Examination and Change: May 2011 (In a lower risk category)
COSEWIC Criteria: Not Applicable (NA)
SARA: Schedule 1, Threatened

Humpback whales (*Megaptera novaeangliae*) have migrations that are complex and cover long distances. In Canada, Humpbacks are found on both coasts and are distinct separate populations. The range of the Western North Atlantic population of humpback whales extends north to Labrador. The North Pacific population extends along the full length of the west coast of BC to northwestern Alaska, US. The most recent population estimate was 18,302 individuals (COSEWIC 2016b). This represents a great increase from previous estimates of 6,000 individuals and suggests the population is recovering from whaling. Current numbers are still small compared to pre-whaling population estimates which is the reason for status of Special Concern. Humpbacks were commercially depleted in Canada but since legally protected from whaling in 1966, they are recovering. The North Pacific estimated rate of increase is between 4.9% to 6.8% per year (COSEWIC 2016b). Humpbacks are present seasonally and come to BC to feed in the summer, including groups with mothers and first-year calves. A report from 2009 (Nichol et al.) on the occurrence and distribution of humpback whales in BC waters found that in particular there are four areas of the coast (the waters surrounding Langara Island; coastal waters along the south eastern side of Moresby Island and Kunghit Island; the mainland channels around Gil Island and Gribbel Island and waters off southwest Vancouver Island including Barkley Sound, La Perouse Bank, Swiftsure Banks and Barkley

Canyon) that have an annual seasonal occurrence of humpback whales that is disproportionately larger compared to other coastal areas and may support that a Critical Habitat designation is warranted (Nichol et al. 2009). BC supports a local population of this species that faces several existing stressors including from noise disturbance casing impacts or displacements, habitat degradation, entanglement in fishing gear or debris, and ship strikes. Vessel strikes are considered the most significant threat for this species. In B.C. waters, humpback whales are the most commonly reported whale species involved in incidents with vessels. These interactions can cause injuries ranging from scarring to the mortality of individuals. Many shipping lanes cross migration and feeding areas, making the risk of collision more likely. Reductions in the density and availability of prey species are also a potential threat to the species (SARA 2016b).

Minke Whale
Status: Not at Risk
Last Examination and Change: April 2006 (New)
COSEWIC Criteria: NA
SARA: No Schedule, No Status

The minke whale (*Balaenoptera acutorostrata scammonii*) is a species that is not considered at risk in BC; there is no identifiable threat to the subspecies in the eastern North Pacific. There is no whaling and the number of deaths from entanglement in fishing gear and ship strikes is not as high as for other species and to date has not warranted concern). There is a possibility that individuals occurring in shore waters in Canada could constitute a local subset of the population (COSEWIC 2016c).

Grey Whale
Status: Special Concern
Last Examination and Change: May 2004 (In a higher risk category)
COSEWIC Criteria: Not Applicable (NA)
SARA: Schedule 1, Special Concern

Grey whales (*Eschrichtius robustus*) migrate each year from their southern latitude winter calving grounds to their summer feeding areas including in Canada. Most of the population passes along the BC coastline, and some individuals (about 80) may be locally resident and are seen repeatedly during the entire summer actively feeding in BC (COSEWIC 2016d). The population increased by 2.5% per year following the cessation of whaling, and peaked at about 27,000 animals in 1998 COSEWIC 2016d. The extent of recovery of the local BC summer resident group is unknown. However, over one-third of the population died from 1998 to 2002 (possibly due to a lack of food in other portions of their range). Birth rates, survival rates and other indicators suggest that the decline has ceased and that the population is stable or increasing since 2002(COSEWIC 2016d). Human activities are a source of disturbance affecting grey whales. Industrial activities such as salt extraction, oil exploration, and offshore mining cause noise and habitat distortion, and create a potential for ship strikes. Toxic spills and industrial noise in shallow marine areas are known to cause loss or deterioration of habitat quality which in turn affects breeding and feeding success. Disturbance including underwater noise associated with proposed oil development can potentially affect migration routes. Ship strikes and entanglement in fishing gear also are sources of injury and mortality. Subsistence whaling in the USA is also a potential source of existing stress for grey whales. (COSEWIC 2016d; SARA 2016c).

Fin Whale
Status: Threatened
Last Examination and Change: May 2005 (Reassigned)
COSEWIC Criteria: A1d
SARA: Schedule 1, Threatened

Fin whales (*Balaenoptera physalus*) can be found in coastal waters off BC. It's considered likely that some individuals including juveniles may be residential in the summer. Estimates of whale populations have not been made since whaling stopped; it is believed that the populations of fin whales in both the Pacific and the Atlantic are recovering. Currently sighted only infrequently on former whaling grounds off British Columbia. Coastal whaling took at least 7,600 animals from the population between 1905 and 1967, and thousands of additional animals were taken by pelagic whalers through the 1970s (SARA 2016d). Catch rates from coastal whaling stations declined precipitously off British Columbia in the 1960s. Based on the severe depletion and lack of sufficient time for recovery, it is inferred that present population is below 50% of its level, 60-90 years ago. Individuals continue to be at risk from ship strikes and entanglement in fishing gear. (COSEWIC 2016e; SARA 2007; SARA 2016d). As with the other large whales in the area, increasing noise levels from shipping, sonar, military operations, and oil and gas exploration are a growing threat affecting habitat quality, as is exposure to pollution. Any activities that degrade or displace fin whales from critical foraging habitat also pose a threat to the species.

Sei Whale
Status: Endangered
Last Examination and Change: May 2013 (No Change)
COSEWIC Criteria: A2ad, D1
SARA: Schedule 1, Endangered

The sei whale (*Balaenoptera borealis*) is a rorqual whale and belongs to the same family as the blue whale. Its back and sides are dark grey or bluish-grey in colour, while the ventral surface and throat grooves are greyish-white. Sei whales are generally 14 to 15 m long, and females are generally about 0.5 m longer than males. Sei whales can be confused with fin and minke whales, potentially resulting in an underestimation of population sizes. It is necessary to get a look at the right jaw or the ventral portion of the tail to be sure of the identification. The sei whale is a cosmopolitan species, with a patchy distribution in all of the oceans of the world. It is found off both the Atlantic and Pacific coasts of Canada. The sei whale Pacific population is found in the waters off BC where its northern limit is suggested to be about 55˚N. There have been no sightings of sei whales off Canada's Pacific coast since commercial whaling was halted in 1976. There has, however, been limited survey effort and sei whales are easily mistaken for fin or minke whales. Population estimates of 7,000 to 13,000 individuals, published in 1977 for the whole North Pacific, are still cited today (SARA 2016e). It favors temperate, deep offshore habitat more than other species of large whales. Records kept during commercial whaling off BC indicate that less than 0.5% of the sei whales were caught on the continental shelf. In summer, sei whales do not move as far toward the polar waters as the other baleen large whales. Individuals off the coast of BC are considered to be likely part of a northeastern Pacific population that was depleted by whaling. The low sighting numbers (visual and acoustic; Ford et al. 2010) suggests that numbers in Canada are currently very low (well below 250 mature individuals; COSEWIC 2016f) and reports of this species are similarly rare in adjacent US waters to the north (Alaska) and south (Washington, Oregon, California). Threats to this species along the coast of BC are poorly known, but likely are similar to those for the other large baleen whales including ship strikes, anthropogenic (human caused) noise, and long-term changes in climate (which could affect the abundance of their zooplankton prey). (COSEWIC 2016f; Gregr et al. 2006; SARA 2007; SARA 2016e).

Sperm Whale
Status: Not at Risk
Last Examination and Change: April 1996 (New)
COSEWIC Criteria: Not Applicable
SARA: Schedule 1, No Status

Sperm whales (*Physeter microcephalus*) range widely through the world's oceans and males are found off both coasts of Canada. The worldwide population is reasonably large despite historical large reductions by commercial whaling. Whaling for this species ended in 1972 in Canada. (COSEWIC 2016g; SARA 2016f).

Blue Whale
Status: Endangered
Last Examination and Change: May 2012 (No Change)
COSEWIC Criteria: A2abd, D1
SARA: Schedule 1, Endangered

Three subspecies of blue whales (*Balaenoptera musculus*) have been identified. The Blue whale that occurs in Canada is commonly known as the Northern Hemisphere subspecies. Two geographically separated populations exist in Canadian waters: one in the North Atlantic and the other in the North Pacific. The individuals off the coast of BC are considered to be part of a northeastern Pacific population that was depleted by whaling. The low sighting numbers (visual and acoustic; Ford et al. 2010) suggests their numbers are currently very low (significantly less than 250 mature individuals; COSEWIC 2016h). Past commercial whaling is the main factor responsible for this species population decline in Canadian waters. At least 11,000 were harvested in the North Atlantic before 1960. Approximately 1,500 of these were harvested in eastern Canadian waters from 1898 to 1951 (SARA 2016g). Threats to this species along the coast of BC are poorly known, but likely are similar to those for the other large whales including from ship strikes, anthropogenic noise, entanglement in fishing gear, and long-term changes in climate (which could affect the abundance of their zooplankton prey). (COSEWIC 2016h; Gregr et al. 2006; SARA 2011; SARA 2016g).

Harbour Porpoise
Status: Special Concern
Last Examination and Change: November 2003 (Changed)
COSEWIC Criteria: Not applicable
SARA: Schedule 1, Special Concern

Harbour porpoises (*Phocoena phocoena***)** are difficult to sight, and appear to be more sensitive than other species to human presence and activities. Harbour porpoises are among the smallest cetaceans and in western Canada, individuals occasionally reach lengths of 2 m. They are a short lived and are considered a “shy” species. In some highly developed areas such as Victoria and Haro Strait, they are now rarely seen. Harbour porpoises are widely distributed over continental shelves of the temperate northern hemisphere and there are two populations in Canada through they sometimes occur in bays and harbours, particularly during the summer; in BC an individual was sighted 55 km up the Fraser River (COSEWIC 2016i). The west coast Pacific Ocean population occurs throughout the coastal waters of BC. There is little data on the abundance of the Pacific Ocean population. The only survey data is from the southern inshore portion of BC were surveys have been conducted since 1996. That year 3000 individuals were documented. More recent surveys (2002) have not yet been analyzed (COSEWIC 2016i). Threats to this species include natural predators such as the great white shark, orca, and in some parts of their range bottlenose dolphin. Development and human presence in its habitat as well as underwater noise, pollutants (e.g. environmental contamination such as organochlorines, dioxins, furans, and heavy metals), and contaminants in their food chain are stressors (COSEWIC 2016i). They are highly prone to becoming entangled and are killed in fishing nets. Their presence in the same habitat as fishing grounds is an important recent threat to the Pacific Ocean population where they are bycatch, particularly in bottom-set gill nets used to capture groundfish. Other potential threats include: habitat degradation including loss of habitat due to use of acoustic harassment devices (particularly around aquaculture sites

(SARA 2016h). Because of their year round presence in the Strait of Georgia and restrictions to shallow habitat, this species is exposed to greater risk than many other marine mammal species (Baird and Guenther 1994); they are the most common species found in strandings in BC.

Dall Porpoise
Status: Not at Risk
Last Examination and Change: April 1989 (New)
COSEWIC Criteria: Not Applicable
SARA: Schedule 1, No Status

Dall's porpoise (*Phocoenoides dalli*) is not considered at risk in BC waters. Dall's porpoises are very abundant, probably one of the most abundant small cetaceans in the cooler waters of the North Pacific Ocean. It is common both offshore and in deep inshore waters (COSEWIC 2016j). Dall's porpoises can often be found in association with other small cetacean species such as Pacific white-sided dolphins. Dall's are typically found in groups of 1–20 (Jefferson 1991). They are generally found in slope, offshore, and nearshore deep waters. There is a paucity of data on population trends in BC waters (Baird and Guenther 1994) but they are known to be preyed on by killer whales and large sharks.

Pacific White-sided Dolphin
Status: Not at Risk
Last Examination and Change: April 1990 (New)
COSEWIC Criteria: Not Applicable
SARA: Schedule 1, No Status

The pacific white-sided dolphin (*Lagenorhynchus obliquidens*) is an abundant and year-round, permanent resident species found in the pelagic waters off the west coast of Canada. It occurs regularly in nearshore and inshore coastal waters (COSEWIC 2016k.). Four global populations have been suggested and one of these is from the waters of British Columbia and Alaska. This is a social species, often observed in large herds ranging from several animals, to tens of animals up to thousands of animals at certain times. It is common in temperate waters over the outer continental shelf and slope and primary habitat includes the cold temperate waters of the North Pacific Ocean as well as deep ocean regions.

Killer Whale

There are several killer whale (*Orcinus orca*) ecotypes that could occur in project waters. The status of these will be covered below after this general killer whale species description:

Killer whales are very easily spotted and well known due to their main identifying coloration characteristic i.e. the distinctive black and white pattern, blunt head, and tall dorsal fin in the middle of the back. Adult males are larger than females, with a maximum recorded length for a male at 9.0 m vs. 7.7 m for a female. However, the average length of adult individuals in BC waters is much smaller than these maximum lengths. The tall dorsal fin of adult males is triangular in shape and may reach up to 1.8 m in height, while in juveniles and adult females it reaches 0.9 m or less and is generally more falcate (hooked like a sickle). Furthermore, the pectoral fins and tail flukes are larger in adult males, and the tail fluke bends downwards (SARA 2016i).

Killer Whales are cosmopolitan and are observed in all oceans of the world and in all water temperatures, though generally they are found in colder regions or in areas of high prey productivity. They have been recorded in water ranging from shallow (several metres) to open ocean depths. They are found in all three of Canada's oceans, as well as occasionally in Hudson Bay and in the Gulf of St. Lawrence, but they appear to be uncommon in the Atlantic and Arctic (SARA 2016i). They occur in BC in almost all salt-water and some fresh-water areas, including inlets, narrow channels, and deep embayments. Both "resident" and "transient" Killer Whales have been recorded year-round off the Pacific coast. Killer Whales do not appear to be limited by such habitat considerations as depth, water temperature, or salinity. They will occasionally spend considerable time in brackish water and will even enter rivers (SARA 2016i).

Three distinct groups, or ecotypes, of Killer Whale inhabit the waters off British Columbia, each exhibiting different prey preferences, call dialects, and social organization. The resident (of which there are a Northern and Southern group), Bigg's (also called Transient), and Offshore killer whale ecotypes are considered socially and genetically isolated, despite sharing the same waters. It has been shown that individual populations or ecotypes specialize on different prey types (Ford and Ellis 2006) and vary in their calls and vocalizations (Ford 1988; Ford et al., 1998). Resident Killer Whales feed exclusively on fish (primarily salmon) and cephalopods, and their distribution is closely tied with peak abundance of various species of salmon prey. Bigg's killer whales or "Transients" feed primarily on marine mammals. Offshore Killer Whales are the least understood of the three ecotypes, but are believed to primarily consume fish, with shark species comprising a significant part of their diet.

There are two populations of "resident" Killer Whales: northern residents, and southern residents. Both populations are small, and have low potential rates of increase. The southern resident population has been growing only sporadically, and is smaller now than it was in the 1960s. The population began to increase after live-capture ended in 1973. Only 89 individuals were counted in 1998, 83 in 1999, 82 in 2000 and 78 in 2001. This population has declined by 20% over the last six years. Biggs (transient) killer whales usually travel in smaller groups than resident whales. Unlike residents, they do not stay with their mothers all their lives but may leave them upon reaching maturity, this is especially true of females with young calves of their own. However, sometimes these dispersing individuals rejoin their matrilineage groups after years of separation (Vancouver Aquarium Cetacean Research Program 2016). A long-term database of information collected during field encounters with transient killer whales, and a registry of photographically-identified transient whales, are maintained at Pacific Biological Station (PBS), Department of Fisheries and Oceans Canada (DFO).

They are existing direct stressors in the killer whale habitat already, from various anthropogenic sources including disturbance from whale watching vessels and other vessels, effects of persistent toxic chemicals, and high levels of noise which has been shown to cause displacement (Morton and Symonds 2002; Hoyt 2000), or affect foraging (since killer whales use acoustics to detect prey). Their ocean habitat should ideally not mask transmission or receiving of their echolocation clicks and vocalizations which are essential for navigation and foraging, and for their strong cultural and social set of behaviours. They may also be indirectly affected from reduction in prey availability from fishing or other causes. Overall, given the low population sizes, low potential rates of growth, high levels of disturbance, and that killer whales eat high up on the trophic chain, they have existing baseline levels of risk. Fishing boat/human interactions include direct takes (whaling, culling), live-capture fisheries, entanglement in fishing gear, collisions with vessels, and exposure to oil spills. Although the largest fisheries of whales were discontinued in the early 1980s and 1990s, small numbers are probably still taken (SARA 2016i). In particular, Bigg's killer whales are long-lived upper trophic level predators that are considered to be at risk due to small population size (521 individuals were identified between 1990 and 2011), very low reproductive rate (one calf approximately every five years), and high levels of chemical contaminants that are persistent, bioaccumulative and toxic. Bigg's killer whales are at risk of habitat degradation through acoustic disturbance from underwater noise. Other threats that may impede recovery are biological pollutants, trace metals, physical disturbance, toxic spills, collisions with vessels, and decreased prey availability (SARA 2016i; COSEWIC 2016l).

Ecotype Specifics

Killer Whale- Northeast Pacific offshore population
Status: Threatened
Last Examination and Change: November 2008 (In a higher risk category)
COSEWIC Criteria: D1
SARA: Schedule 1, Endangered

Specific Information and threats
Offshore Killer Whales appear to be the widest-ranging Killer Whale ecotype in the northeast Pacific Ocean; those identified in British Columbia have also been seen from the Bering Sea to southern California. The population is known as 'Offshore' due to its range relative to the coast; they are infrequently encountered in inshore waters, and predominantly inhabit continental shelf-edge and outer Canadian Pacific waters. This population has a very small number of mature individuals (~120). However, the population is monitored and appears to be stable.

A threat to this ecotype is habitat quality and abundance and availability of prey. Also, noise. (SARA 2016j). It is subject to threats from high level of contaminants, acoustic, and physical disturbance, and from the potential oil spills (COSEWIC 2016m).

Killer Whale- Northeast Pacific southern resident population
Status: Endangered
Last Examination and Change: November 2008 (No Change)
COSEWIC Criteria: C2a(I,ii); D1
SARA: Threatened

Specific Information and threats
The Northeast Pacific southern resident population is small and declining and this trend is expected to continue. Southern residents are limited by the availability of their principal prey, chinook salmon, and currently the forecast for this prey species is continued low abundance (COSEWIC 2016n). Southern residents are threatened by increasing physical and acoustical disturbance, oil spills and contaminants (COSEWIC 2016n). Other recent studies have found that southern-resident killer whales are contaminated with high levels of toxic chemicals such as organochlorine, making them susceptible to disease and reproductive difficulties. Water pollution also affects species on which the whales feed, leading to reduced food supply. The southern resident population is more subject to anthropogenic influences than the other populations and studies have shown they have levels of toxic chemicals. They are three times higher than levels known to cause immunotoxicity in Harbour Seals (Phoca vitulina). Organochlorine concentrations are four times higher than reported for the northern resident population. The southern residents are also subject to significantly higher levels of vessel interactions due to the proximity of their summer range to large urban centers (Seattle, Victoria, and Vancouver) (COSEWIC 2016n; SARA 2016j).

Killer Whale- Northeast Pacific northern resident population
Status: Threatened
Last Examination and Change: November 2008 (No Change)
COSEWIC Criteria: Met criterion for Endangered, D1, but designated Threatened, D1, because of the recent and apparently ongoing increase in mature individuals.
SARA: Schedule 1, Threatened

Specific Information and threats
The Northeast Pacific northern resident population of killer whale population is small, and like the Southern Population, is limited by the availability of its principal prey, Chinook Salmon. It is also at risk from physical and acoustic disturbance, oil spills and contaminants. However, this population has been increasing since monitoring began in 1975 (COSEWIC. 2016o). Northern resident killer whales are

potentially at risk from threats such as organochlorine and toxic-chemical contamination. Increasing levels of water pollution make the whales more susceptible to disease and reproductive difficulties. Sport, recreational (whale-watching industry) cause disturbance and commercial fisheries have depleted abundance of the various species of salmon on which the whales feed, leading to reduced food supply which in turn affects reproductive success. The proximity of their habitat to urban centers has led to more frequent collisions with boats and exposure to significantly higher numbers of oil spills (SARA 2016l).

Killer Whale- Northeast Pacific transient population
Status: Threatened
Last Examination and Change: November 2008 (No Change)
COSEWIC Criteria: Met criterion for Endangered, D1, but designated Threatened, D1, because total abundance has increased since the 1970's.
SARA: Schedule 1, Threatened

Specific Information and threats
This population has a very small number of mature individuals (~122). It is subject to threats from high-levels of contaminants, acoustical and physical disturbance, and potential oil spills. However, the population has been increasing since the mid-1970s when monitoring began, and its prey base of pinnipeds and cetaceans is likely stable or increasing (COSEWIC 2016p). While a variety of threats may directly or indirectly impact offshore killer whales as with all the ecotypes, they are particularly vulnerable to harmful oceanic events (e.g. oil spills) as they are typically found in large groups so therefore at least one third of the population may be present in a given time and place. The greatest threats to offshores include a reduction in prey availability, exposure to contaminants from prey, toxic spills, and acute acoustic disturbance (e.g. mid-frequency active sonar, seismic surveying, marine construction). Chronic acoustic disturbance, physical disturbance, interactions with commercial fisheries and aquaculture, direct mortality and climate change are other human-related threats that have potential to jeopardize this population (SARA 2016m).

Pinnipeds

Northern Elephant Seal
Status: Not at Risk
Last Examination and Change: April 1986 (New)
COSEWIC Criteria: Not Applicable
SARA: Schedule 1, No Status

Northern Elephant Seals (*Mirounga angustirostris*) have recovered despite virtual extermination in the 1800s due to protections of this species as well as their breeding sites in both the United States and Mexico. They are now common enough to not be considered at risk (COSEWIC 2016q).

Northern Fur Seal
Status: Threatened
Last Examination and Change: November 2010 (No Change)
COSEWIC Criteria: A2b
SARA: Schedule 1, Threatened

The northern fur seal (*Callorhinus ursinus*) is the most widely distributed and abundant pinniped (flipper-footed mammal) in the North Pacific Ocean. Northern fur seals are members of the otariid (eared seal) family and exhibit their characteristic external ears (pinnae), long muscular foreflippers, and the ability to turn their rear limbs forward and move on all four limbs (SARA 2016n). Most of the fur seals that winter in Canadian waters breed at four islands in the US. At present, the species does not have an established rookery in Canada. The four- to five-month breeding season is followed by a seven- to eight-month pelagic foraging phase, where the animals spend their time feeding mainly in offshore waters. The waters of BC are considered an important foraging area, especially for pregnant females on their return journey to the Alaskan rookeries. The largest numbers occur in waters off British Columbia from January through to June, approximately 20-150 km offshore (SARA 2016n). Pup production is used as an index of population size and pup production at the two largest breeding colonies, both in the Pribilof Islands, presently account for 90% of all fur seals in the eastern Pacific. This population has been declining for the last 45 years and pup numbers at these colonies have declined by 38% over the last 30 years (3 generations). Numbers of pups have been increasing in the much smaller colony at Bogoslof Island. These trends in pup production indicate that numbers of mature individuals will likely continue to decline. In 2008 there were approximately 650,000 fur seals in the eastern Pacific compared with more than 2 million in the 1950s. The causes of the declines are unknown, but continuing and potential threats include entanglement, oil spills, and the effects of contaminants (COSEWIC 2016r). The availability of suitable prey, principally small-schooling forage fish and pelagic squid, may also be a factor. Changes in prey availability could be caused by natural or human-related factors, including ocean climate, commercial fishing, or natural population cycles. Competition between other predators such as sea lions could also impact prey availability to the Northern fur seal population (SARA 2016n).

California Sea Lion
Status: Not at Risk
Last Examination and Change: April 1987 (New)
COSEWIC Criteria: Not Applicable
SARA: Schedule 1, No Status

Only males of the California Sea lion (*Zalophus californianus*) species migrate to BC from California. The breeding population in California is known to be expanding (COSEWIC 2016s).

Harbor Seal
Status: Not at Risk
Last Examination and Change: April 1999 (New)
COSEWIC Criteria: Not Applicable
SARA: Schedule 1, No Status

The west coast population of harbor seals (*Phoca vitulina richardsii*) is at or above historical levels and is not currently at risk (COSEWIC 2016t). Harbor seals in the Strait of Georgia have been found to have very high levels of PCDD and PCDFs. (Ross et al. 2004).

Steller Sea Lion
Status: Special Concern
Last Examination and Change: November 2013 (No Change)
COSEWIC Criteria: Not applicable
SARA: Schedule 1, Special Concern

The Steller sea lion (*Eumetopias jubatus*) can be found along the coasts of California up to the Bering Strait, and along the coasts of Asia and Japan. The world population is divided into two groups; the Eastern and the Western. The Stellars in Canadian waters are part of the Eastern population. The BC coastal islands are home to three main breeding areas for the Steller, located in the Scott Islands, at Cape St. James, and offshore from Banks Islands. These rookeries occupy less than 10 km^2. Approximately 70% of pups are born at a single location, on the Scott Islands (COSEWIC 2016u). The population is increasing, but is sensitive to human disturbance while on land and is vulnerable to catastrophic events at sea such as major oil spills due to its highly concentrated breeding aggregations. The species is near to qualifying for Threatened, but has recovered from historical culling and deliberate persecution (COSEWIC 2016u).

Sea Otter:

Status: Special Concern
Last Examination and Change: April 2007 (In a lower risk category)
COSEWIC Criteria: Not applicable
SARA: Schedule 1, Special Concern

Sea otters (*Enhydra lutris*) had been extirpated in British Columbia by the fur trade by the early 1900s, and it successfully reintroduced in 1969-72 to a remote portion of the west coast of Vancouver Island by federal, provincial, and state governments of Canada and the United States (SARA 2016n). It has since repopulated 25-33% of its historic range in BC but is not a stable population yet. Numbers are small (<3,500) and require careful monitoring. This species is very susceptible to death from oil spills, and the proximity to major oil tanker routes make them particularly vulnerable to oil spills (COSEWIC 2016v). They are also a prey for killer whales, especially offshores and transients.

Sea Turtles:

Three species of sea turtles are found in Canadian Waters, these are the Green (*Chelonia mydas*), Loggerhead (*Caretta caretta*), and Leatherback (*Dermochelys coriacea*) (SARA 2016o; Marine Mammal and Sea Turtle Reference Manual. 2006.). Most threats to the turtles in the ocean come from anthropogenic sources. Threats to turtles in the offshore environment include bycatch in commercial fisheries that kills almost 500,000 turtles every year. Turtles may become entangled in different types of fishing gear and entanglement in fishing gear at any time can result in serious injuries to the turtles, including severe cuts and necrosis (death) of the tissue, which could lead to the loss of a flipper. Entanglement also causes death by drowning. Sea turtles can mistake plastic bags for jellyfish, which are eaten by many turtle species in early life phases, and exclusively by leatherback turtles throughout their lives. Climate change, with predictions of increased ocean and air temperatures and sea level rise, may adversely impact turtles in all life stages, from egg to adult.

Green Sea Turtle
Status: NA
Last Examination and Change: NA
COSEWIC Criteria: NA
SARA: NA

Leatherback Sea Turtle
Status: Endangered
Last Examination and Change: May 2012 (Reassigned)
COSEWIC Criteria: A2abd
SARA: Schedule 1, Endangered

The pacific population of leatherback sea turtles has collapsed by over 90% in the last generation. Continuing threats include fisheries bycatch, marine debris, coastal and offshore resource development, illegal harvest of eggs and turtles, and climate change (COSEWIC 2016w).There are numerous threats to the leatherback which combined have contributed to its endangered status. The mortality rate of hatchlings due to predation is high, though once they reach adult size leatherbacks have few natural predators. Large sharks or killer whales may attack the turtles at sea and leatherbacks have been seen with partially amputated flippers as a result of these attacks. The greatest predator of the leatherback is from human consumption (Sara 2016p, q). In some countries, humans kill nesting female turtles and harvest leatherback eggs to eat. Because leatherbacks move very slowly on land, they are not able to defend themselves from humans on the nesting beaches. Also since they leave a trail to their nests when they make their way back to the water, the nests are easy for egg poachers to locate. Unlike other smaller species of sea turtles, leatherbacks are sometimes strong enough to drag large amounts of fishing line and gear to the surface of the water, where they are discovered and released. Leatherbacks as with all sea turtles are at risk from marine pollution. There are many recorded cases of leatherbacks dying as a result of eating or becoming entangled in marine debris, such as plastic sheeting, plastic bags, discarded fishing line, and tar balls.

Loggerhead Sea Turtle
Status: Endangered*
Last Examination and Change: April 2010 (New)*
COSEWIC Criteria: A2b+4b*
SARA: Under consideration
(*) In Atlantic Ocean

The Loggerhead Sea Turtle is widely distributed in the Atlantic, Pacific, and Indian Oceans. Although Atlantic and Pacific populations of the turtle are genetically distinct, there are no recognized subspecies. Loggerheads found in Canadian waters likely originate from the same nesting populations as turtles found in northeastern U.S. waters. While there are no confirmed reports of Loggerheads in the Pacific Ocean off British Columbia, sightings off the coasts of Washington and Alaska suggest they may occur in British Columbia occasionally (SARA 2016r; Lei, et al. 2010). At sea, loggerhead sea turtles prefer water temperatures of 18°C and warmer. Smaller individuals are vulnerable to predation and often shelter in floating mats of seaweed in the open ocean beyond the continental shelf. Larger juvenile loggerheads occupy shelf waters along the southeastern United States through to New England, and offshore waters of the North Atlantic. Mature Loggerheads mainly inhabit relatively shallow continental shelf waters from New York south through the Gulf of Mexico. Loggerhead Sea Turtle populations worldwide are in decline and have the potential to decline in the future. Threats to Loggerheads include fishery interactions (by catch), poaching of adult females and their eggs, loss and/or alteration of nesting habitat (through human development, beach erosion and nourishment, etc.), predation, pollution, and other factors such as climate change (SARA 2016r; Lei, et al. 2010). Fisheries and Oceans Canada is working to reduce bycatch by collecting information on turtle-fishery interactions, promoting fishing practices, and the use of gear types that reduce turtle bycatch.

Environmental Consequences of the Proposed Action

Effects of Anchoring

This section of the Environmental Assessment addresses potential impacts on marine mammals and sea turtles. Impacts are categorized to be either long-term or short-term; negligible, minor, moderate, or major; adverse or beneficial; direct or indirect; or significant. For the proposed project, long-term, moderate, adverse, direct and indirect impacts would result from operation of the proposed project which will bring a significant increase in deep sea vessels and will create anchorages on the coast Gabriola Island as shown in Figure 1.

Principal adverse effects of the proposed project include physical stressors such as vessel presence which in turn will create more noise (add noise into the marine habitat utilized by numerous marine mammals and sea turtles) and a greater likelihood of ship strike, both of which are adverse impacts (particularly strikes, which would be significant if they occur) for marine mammals. Impacts would be less in intensity for sea turtles that are less susceptible both to noise impacts and strikes. An indirect secondary physical stressor will be as a result of potentially reduced prey sources from an increase in the turbidity of the water. The changes in water quality from turbidity are not expected to cause adverse impacts in the short or long term since there is so much available habitat elsewhere near to the project site where these animals can forage therefore it is eliminated from further discussion.

Both marine mammals and sea turtles are already affected by numerous stressors as delineated previously. The addition of new stressors from this proposed project at Gabriola Island will add to the ongoing impacts these wildlife species are already undergoing. Species that are sensitive to human disturbance would be expected to leave the area from the addition of the five anchorages and the ones that are more tolerant may remain, however, their habitat will be of lesser quality.

The interplay of the factors related to the proposed action will increase the stress on the marine mammals and sea turtles in the project area. The longer then length of stay per vessel, the more noise will be produced and introduced into the marine habitat. Most ships are expected to stay between 5 to 10 days. The more ships present at one time, and the more frequently they are present (the shorter interval between empty anchorages), and other similar factors will all create variability which will either maximize or minimize the additive stress, such that marine mammals and sea turtles that may be present would be exposed to higher noise levels, for longer periods, more often, at certain times of the years vs. others or during certain high occupancy periods vs. lower occupancy periods. The calculus of the number of ships that may occur at one time, the occupancy rate (e.g. how many of the five sites will be occupied at one time), and length of stay (e.g. minimum or maximum number of days), with the shortest length of time between vessel visits, is not predictable yet will factor into the intensity of the stressors (noise, and related human disturbances). Also, the seasonal variability of ship presence and anchorage use is a factor that will affect different marine species differently. Some species are only present in the summer, and some are year round residents. The year round species will have more adverse, longer term impacts than the summer seasonal species.

Many of the species listed in the previous section may not expected to occur with regularity. For example, the highly endangered right whale or other whale species addressed are considered only potentially occurring in project area waters vs. the species known to occur regularly (see previous section for details on occurrences).

The number of vessels, timing of arrival, and duration of stay in Canada historically varies tremendously among locations and years but records indicate that the length of stay has steadily increased since 2009 (Table 1) and can exceed hundreds of days as shown below.

Table 1. Southern Gulf Island Anchorages Usage

Total for Southern Gulf Island Anchorages by Year			
Year	Number of Ships	Total Stay (Days)	Average Stay (Days)
2009	23	154	6.7
2010	62	327	5.3
2011	135	1064	7.9
2012	92	649	7.1
2013	106	882	8.3
2014	170	1582	9.3

Assessing impacts on endangered or sensitive species often involves evaluating the relative impacts of multiple anthropogenic and ecological pressures they are facing, both baseline, and those presented by the proposed action. This is especially difficult with free ranging wild animals which spend the majority of their time moving from location to location.

Noise

Harassment responses to anthropogenic sound in marine mammals are greatly influenced by the context of the exposure, and the individual animal's level of habituation or exposure experience, condition, natural history status (if the animal is foraging, migrating, reproducing, resting, etc.) as well as the level of the sound, frequency, duration, amplitude, and sound characteristics. While this leads to great variance in potential responses to a given sound, measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal behaviorally or physiologically. Marine mammals may react to man-made sounds in a variety of ways. Reactions can vary by species, by sound source, by number of sound sources in the same area, and/or based on the activity the animals are engaged in (feeding, mating, travelling) at the time. Response to an anthropogenic sound also depend on the frequency, duration, temporal pattern, and amplitude of the sound. The distance from the sound source and whether it is perceived as approaching or moving away can also affect the way an animal responds to a sound (Wartzok et al. 2003). For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson and others (1995). A more recent review (Nowacek et al. 2007) addresses studies conducted since 1995 and focuses on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Sound is a critical component in the natural history of marine mammals. Each species makes use of sound in different ways to forage, orient, socially interact with other conspecifics (including for reproduction), to detect or respond to predators, and in other behaviors. The analysis in this section deals with potential consequences resulting from exposure to underwater sound associated with ships and the anchorages.

Ship noise is an underwater noise source known to cause impacts; this has been documented in a majority of studies. Many studies have documented short-term responses to vessel sound and vessel traffic (Watkins et al. 1981; Baker et al. 1983; Magalhães et al. 2002) especially in whales. Unfortunately, it is not always possible to determine whether a marine mammal exhibiting a behavioral change is responding to the physical presence of the vessel itself, to the noise generated by the vessel, or to some unknown unrelated but synchronous factor. This is also true of other noise sources. Most observations of behavioral responses of marine mammals to human generated sounds have been limited to short-term behavioral responses, which include generally short term disturbances to feeding, resting, or social interactions. Responses such as rapid diving, change in swim speed, or change in respiration rate can add stress on young animals, though overall these are considered minor short term, not biological significant impacts. If noise causes an animal to leave an area especially on a permanent basis that is a more adverse impact.

Responses to noise also include changes in the type or timing of marine mammal vocalizations relative to the source of the sound, and/or masking of sounds from other individuals of the same species. Some species have been shown to respond negatively by retreating or by engaging in antagonistic responses (Watkins 1986; Terhune and Verboom 1999).

Marine mammals have been observed to decrease their vocalizations in response to noise (Aguilar Soto et al 2006; International Whaling Commission 2007) which has implications on breeding, feeding, and social interactions. Marine mammals communicate with underwater calls and vocalizations. Sound is important to whales since it is used for navigation and for odontocetes, is has importance in finding prey. Dolphins, for example, echolocate to find fish. They produce short ultrasonic clicks which result in echoes that form an acoustic image to help them detect food, obstacles, etc.). Mysticete whales such as the humpback tend to react to anthropogenic sound below 1 kHz, suggesting that they are more sensitive to low- or mid-frequency sound (Richardson et al. 1995).

Except for some vocalization changes in response to auditory masking, behavioral reactions in the presence of a noise source could occur due to a preceding or unrelated but coincident stress. Stress responses are difficult to tie to a single cue. Also, responses can overlap; for example, an increased respiration rate could be coupled to a flight response. Differential responses between and within species are expected in any underwater noise scenario since hearing ranges vary across species and the behavioral ecology of individual species is unlikely to completely overlap.

The presence of the additional ships will increase the area of insonified waters found in the project area waters and underwater noise levels would be expected to increase. Vessel noise transmitted through air (for seals and otters) and water (for marine mammals and sea turtles) would be created by any propulsion machinery, any thrusters, and ubiquitous ship generators sourced from the project vessels. Hull vibrations emitted from project ships would vary in duration and intensity with type of ship, engine size, age of the vessel, and other parameters known to alter noise signature but regardless, machinery noise from ships would be transmitted through water and would enter the marine habitat.

Underwater noise can affect marine mammals by causing temporary threshold shifts (TTS) or permanent threshold shifts (PTS). TTS is a temporary reduction in hearing sensitivity caused by exposure to intense sound, as a function of duration and intensity of the sound. At very high decibel levels or after prolonged exposure to noise, permanent hearing damage or PTS may occur. Noise can affect behavior as discussed above, cause physiological shifts (TTS or PTS), or mask other sounds important to the animal such as conspecific calls. Masking can render certain frequency bandwidths inaudible and make it impossible for the animal to detect low intensity sounds. Dredges produce underwater noise that is continuous and of high enough intensity to affect marine life adversely in some scenarios.

It is important to note that the project area waters already contain multiple other sources of continuous sounds including from ships (recreational and commercial vessels), aircraft, and every day common use of ship depth sonar systems (depth sounders).

In sum, effects on marine mammals exposed to underwater or in-air noise vary with the frequency, intensity, and duration of the sound source and the hearing characteristics of the exposed animal. The effects of underwater anthropogenic noise on marine mammals varies considerably among species, depending on the hearing thresholds, reproductive or age class, ambient conditions, and many other factors. Canada utilizes the NOAA Fisheries standards for acoustic impacts which rely on generic sound exposure thresholds to determine when an activity produces sound that might result in effects that constitute a take by harassment. NOAA Fisheries is in the process of developing new science-based thresholds to improve and replace the current generic exposure level thresholds (Southall et al. 2007, Ellison et al. 2012, NOAA Fisheries 2013). NOAA Fisheries defines Level A Harassment zone of injury to marine mammals as occurring at a sound exposure limit threshold of received sound pressure levels (SPL) of 180 decibels (dB) referenced to 1 microPascal (μPa) root mean square (RMS), for both mysticetes and odontocetes, and 190 dB RMS re 1μPa for pinnipeds. This threshold considers instantaneous sound pressure levels (SPLs) at a given receiver location. The NMFS 180 dB RMS re 1 μPa guideline and 190 dB RMS re 1 μPa respectively are designed to protect all marine species from high sound pressure levels at any discrete frequency across the entire frequency spectrum. These are very conservative criteria as they do not consider species-specific hearing capabilities. Level B harassment (defined under the Marine Mammal Protection Act in the US [MMPA] as any act of pursuit, torment, or annoyance that has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering) has been defined at 120 dB RMS re 1 μPa for continuous noise and 160 dB RMS re 1 μPa for impulse noise. In zones where received sound levels exceed these thresholds, project sound may approach or exceed ambient sound levels (i.e., threshold of perception or zone of audibility); however, actual perceptibility will be dependent on the hearing thresholds of the species under consideration and the inherent masking effects of ambient sound levels. For a detailed discussion on sound, noise, and relevant units, please see the Underwater and In-Air Noise Modeling Tech Memo produced for this project.

As documented in the Underwater and In-Air Noise Modeling Tech Memo, The primary sources of in-air noise on a vessel at anchorage that give rise to noise onshore where seals may occur or in the nearshore where otters may occur were divided into three categories:

- Diesel generator and engine exhaust
- Ventilation inlets/outlets
- Secondary noise sources, e.g. pumps, and refrigerated equipped containers

The diesel generator is used to generate power on board the vessel. During anchorage stay, it will most often be the predominant continuous source of noise radiating from the ship to the surroundings.

The underwater acoustic modeling methodology considered scenarios based on descriptions of the expected operations activities. The following scenarios were developed:

- Scenario 1: Vessels at anchorage all five anchorage positions (G1-G5) concurrently; and
- Scenario 2: One vessel transiting within the anchorage area.

These are minimum and maximum scenarios and as such, only represent each end of the spectrum of potential noise sources. The major source of noise from vessels is propulsion. Other sources include other rotating machinery (engines, gearboxes, generators, fans, etc.). These components produce structure-borne vibrations, which are transmitted through the hull of the vessel.

In-air noise

Predicted noise level results are summarized in Table 6 of the Underwater and In-Air Noise Modeling Tech Memo (Gabriola Anchorage Environmental Assessment, Appendix C). The results indicate project-generated sound levels only will be in the 30 dBA to 45 dBA range. While dBA thresholds for land dwelling/ in-air hearing marine mammals have not been set, these findings are below the levels considered to cause disturbance or injury. Seals, sea lions or otters that may forage, transit, pup or rest in the area are not expected to have the potential for MMPA Level B harassment, indicating the proposed activities would not result in any population level effects, injury, or death to land dwelling/ in-air hearing marine mammals.

Underwater noise

The potential for project-sourced noise to affect a marine animal depends on how well marine life can hear the noise. Noises at frequencies that animals cannot hear well are less likely to disturb or injure animals. The tabulated results shown below from the Underwater and In-Air Noise Modeling Tech Memo are delineated by the three functional hearing groups of marine mammals as set by NOAA in the US: by low-frequency cetaceans (LF), mid-frequency cetaceans (MF), and high frequency cetaceans (HF). It shows the distances at which sounds of a certain sound pressure level (SPL) will be received (N /A indicates below a threshold value and does not occur at any distance). LF cetaceans are generally the larger baleen whales; MF are generally dolphins, toothed whales, and beaked whales (of which none are known to occur in the project area); HF (porpoises); and for pinnipeds: phocid or earless seals which can hear roughly between 75 Hertz to 100 kilohertz and otariids or eared sea lions which can hear roughly from 100 Hertz to 48 kilohertz, placing them between the LF and MF cetaceans.

Table 2 – Distances to Maximum-Over-Depth Sound Level (m) | Vessel at Anchorage and Transiting

Units: rms SPL, dB re 1 µPa
Broadband and For the Three Functional Hearing Groups

SPL rms	Unweighted		LF cetaceans		MF cetaceans		HF cetaceans	
	Stationary	Transiting	Stationary	Transiting	Stationary	Transiting	Stationary	Transiting
160	<5	<5	N/A	<5	N/A	N/A	N/A	N/A
150	<10	<15	< 5	<15	N/A	<5	N/A	< 5
140	< 15	135	< 10	135	< 5	< 5	N/A	<5
130	35	250	< 15	250	< 10	< 15	< 5	< 10
120	110	450-800	35	450-800	<15	50	< 10	35
110	275	1400-2000	80	1400-2000	35	150	< 15	100

Without documentation of the current existing ambient underwater conditions at Gabriola Island we cannot properly determine the potential for adverse impacts since it is not known if the proposed action noise sources will be louder than, or masked by existing sound levels. It is known that marine mammals in BC are already impacted by sound and noise, particularly killer whales (Morton and Symonds 2002). Likely the baseline or ambient noise levels in project area waters is already loud from other existing vessel traffic though there are no measured baseline noise levels yet that are available

Level A harassment (PTS), defined as 180 dB re 1 µPa-1m rms for cetaceans (whales, dolphins, and porpoises), and 190 dB re 1 µPa-1m rms for pinnipeds (seals and sea lions) is not expected. The project would not produce any levels in this range. Should marine mammals be within 5 or 10 m of the vessels when they are stationary, impacts from noise on marine mammals would be expected to be adverse and are within Level B harassment thresholds (120 dB RMS re 1 µPa for continuous noise such as from ships) especially for by the LF cetaceans which will occur during portions of the year, especially in the summer (e.g. grey whales, humpback whales). During transit, Level B harassment thresholds will be met especially for by the LF cetaceans but also for the MF (e.g. killer whales) and HF animals (e.g harbor or Dall's porpose), albeit at greater distances from the source.

Marine mammals should they be collocated with the project actions may be exposed to be affected by noise. If they are immediately adjacent to the noise sources they could experience temporary, mild behavioral effects, however would be able to swim beyond this range or to the surface within a few seconds to minimize the potential for further disturbance. Noise may cause an individual marine mammal to avoid the action and swim away, thereby reducing the risk of this threat, and the marine mammal can find higher quality habitat elsewhere. However, the effect of this displacement may have other, secondary consequences on animals that are already stressed such as reduced foraging success and reproductive success. Killer whales are likely to experience more adverse impacts than the other marine mammal species as they have shown to displaced when noise levels are high (Morton and Symonds 2002), have ongoing population level effects that impact their successful reproduction, and are the target of whale watching vessels and other existing disturbances.

Sea turtles are not likely to be affected by underwater noise as the physiology of sea turtles makes them less at risk to adverse impacts from noise than for example, marine mammals. In the US NOAA has set the exposure threshold for disturbance at 160 dB and for injury and hearing loss at 180 dB for marine wildlife. These noise ranges and levels would be likely masked by general existing noise and noise production from project actions is expected to never reach the injury level of 180 dB. Therefore, sea turtles are expected to have a less than significant effect and vessel noise could cause any unseen turtle (on or near the sea bottom) in close proximity to swim away, reducing the risk of this threat.

Without baseline noise levels being documented, we cannot fully evaluate the impacts of this additional project noise. The potential impact on marine life in proximity to the anchorage areas is expected to be adverse in that noise is being added to the environment and it will affect their habitat in the long term. Noise is not expected to cause PTS but could cause TTS. Noise impacts are likely not significant since most marine mammals are highly mobile species and there is other available habitat in proximity to the project area. However, it should be noted that killer whales have small populations, are generally limited by the availability of its prey and are already at risk from both physical and acoustic disturbances so this species would be expected to experience moderate adverse long term impacts from the additional noise. This would be mitigation with the actions listed below to minor adverse.

Noise Mitigations:

In air mitigations:

- Limiting the use of the ships whistle, except as required under the Collision Regulations.
- Limiting the use of deck side loud hailers.
- Keeping the use of power tools and chipping hammers to a minimum and never during the hours of darkness.

Underwater mitigations:

- Keeping the number of generators running to a necessary minimum.
- Seasonal restrictions should be in place such that in the summer only allowing a maximum of 3 vessels anchored at a time and keeping 1 or 2 anchorages empty at all times in the summer.
- Reducing the number of days ships are at anchor and allowing no more than 5 days in a row.
- Conduction a specific study that evaluates baseline existing underwater noise levels in order to conduct a secondary more specific analysis of noise impacts on marine wildlife in the project area.
- Developing a specific Marine Mammal Monitoring and Mitigation Plan that would address specifically the resources in the area, and develop a discreet and species set of mitigations that the vessels would follow to minimize noise impacts including but not limited to, seasonal restrictions, staggering departures, arrivals, and occupancy, etc.

- Continuing and expanding existing scientific studies i.e. the vessels would set up a fund wherein a portion of the monies they raise go to furthering studies on the marine mammals and the impacts in area.
- Expanding education and outreach; and
- Incorporating ongoing adaptive management approaches.

These mitigations would contribute to a reduction in the noise and in turn, reduce the severity of the impacts which are expected to be minor on marine mammals should they be collocated with the ships. With the implementation of mitigation and conservation measures included, the Project Action would not result in adverse effects to any listed species.

Ship Strike

Virtually all of the larger whale species have been documented to have been hit by vessels. This includes blue whales, fin whales, sei whales, Bryde's whales, minke whales, right whales, sperm whales and humpback whales. Hydrofoils have also struck and killed whales in California and Venezuela (Richardson et al. 1995). Areas where important feeding grounds for whales or other marine mammal species overlap with major shipping lanes tend to be highly problematic for strikes and marine mammals. Strikes are generally not an issue for sea turtles and will not be analyzed further.

Vessel movements have the potential to affect marine mammals by directly striking or disturbing individual animals. The probability of vessel and marine mammal interactions occurring in the Study Area is dependent upon several factors including numbers, types, and speeds of vessels; the regularity, duration, and spatial extent of activities; the presence/absence and density of marine mammals; and protective measures implemented by ships. It is also difficult to differentiate between responses to vessel sound versus visual cues associated with the actual physical presence of a vessel; thus, it is assumed that both play a role in prompting reactions from animals.

Nearly every species of dolphin and small whale in the family Delphinidae is known to have at least occasionally suffered from collisions with vessels, including killer whales and dolphins (Van Waerebeek et al, 2007). Smaller species, especially those that regularly ride bow waves of vessels, may be more vulnerable, as they spend more time in close proximity to ships and boats, although alternately, they are the most highly mobile. The more coastal species are also those that are thought to suffer disproportionally more from strikes due to their much higher probability of encountering ships and other motorized vessels, which generally concentrate their activities within the coastal zone. Several species of porpoises have also been documented to suffer from ship collisions (Parsons and Jefferson 2000, Van Waerebeek et al, 2007). Ship collisions do not appear to be particularly common for porpoise and dolphins, or killer whales as they are for the larger whales. Additive impacts from the proposed project vessel traffic are difficult to determine since there is currently no method of correlating existing vessel traffic with potential for ship strikes on marine mammals.

Mitigations:

- Speed restrictions: vessels must enter and depart at no greater than 10 knots.
- A bridge monitor will be onboard to watch for marine mammals during approaches and departures and during initial transit. This will consist of a continuous lookout from the bridge, scanning with binoculars for cetaceans and pinnipeds. (though during night operations, lights are not as part of the monitoring effort, due to issues relating to light for marine wildlife and birds).
- The incoming and outgoing vessels will communicate with an existing harbor master or Port Control as well as with other vessels operating within the area to relay or receive the location and other relevant information for any listed species entering or occurring during approaches and

departures, and will abide by instructions, including the possibility of reducing vessel speed or halting vessel movement until the animal leaves the vicinity.

- Approaches and departures shall be postponed or halted when marine mammals and sea turtles are within 100 yards of the vessel.
- No one associated with the vessels shall attempt to feed, touch, pursue or otherwise intentionally interact with any listed marine species.
- To the extent possible, when piloting vessels, vessel operators shall adjust speed and/or alter course to remain at least 100 yards from whales, and at least 50 yards from other marine mammals and sea turtles, and will not pilot the vessel as to cause another vessel or object to approach within 100 yards.
- If despite efforts to maintain the distances and speeds described above, a marine mammal or turtle approaches the vessel, and only if the safety of the vessel, crew, and adjacent habitat is assured, put the engine in neutral until they animal moves away and then slowly (under 5 knots) move away to the prescribed distance.
- Marine mammals and sea turtles shall not be encircled or trapped between multiple vessels or between vessels and the shore.
- Seasonal restrictions should be in place such that in the summer only allowing a maximum of 3 vessels anchored at a time and keeping 1 or 2 anchorages empty at all times in the summer.
- Reducing the number of days ships are at anchor and allowing no more than 5 days in a row.
- Conduction a specific study that evaluates baseline existing underwater noise levels in order to conduct a secondary more specific analysis of noise impacts on marine wildlife in the project area.
- Developing a specific Marine Mammal Monitoring and Mitigation Plan that would address specifically the resources in the area, and develop a discreet and species set of mitigations that the vessels would follow to minimize ship strike impacts including but not limited to, seasonal restrictions, staggering departures, arrivals, and occupancy, etc.
- Continuing and expanding existing scientific studies i.e. the vessels would set up a fund wherein a portion of the monies they raise go to furthering studies on the marine mammals and the impacts in area.
- Re-evaluating shipping patterns and lanes after one year to asses if any changes are needed to reduce impacts.
- Expanding education and outreach; and
- Incorporating ongoing adaptive management approaches.

These mitigations would contribute to a reduction in the likelihood of ship strikes and in turn, reduce the severity of the impacts which are expected to be minor on marine mammals should they be collocated with the ships. With the implementation of mitigation and conservation measures included, the Project Action would not result in adverse effects to any listed species.

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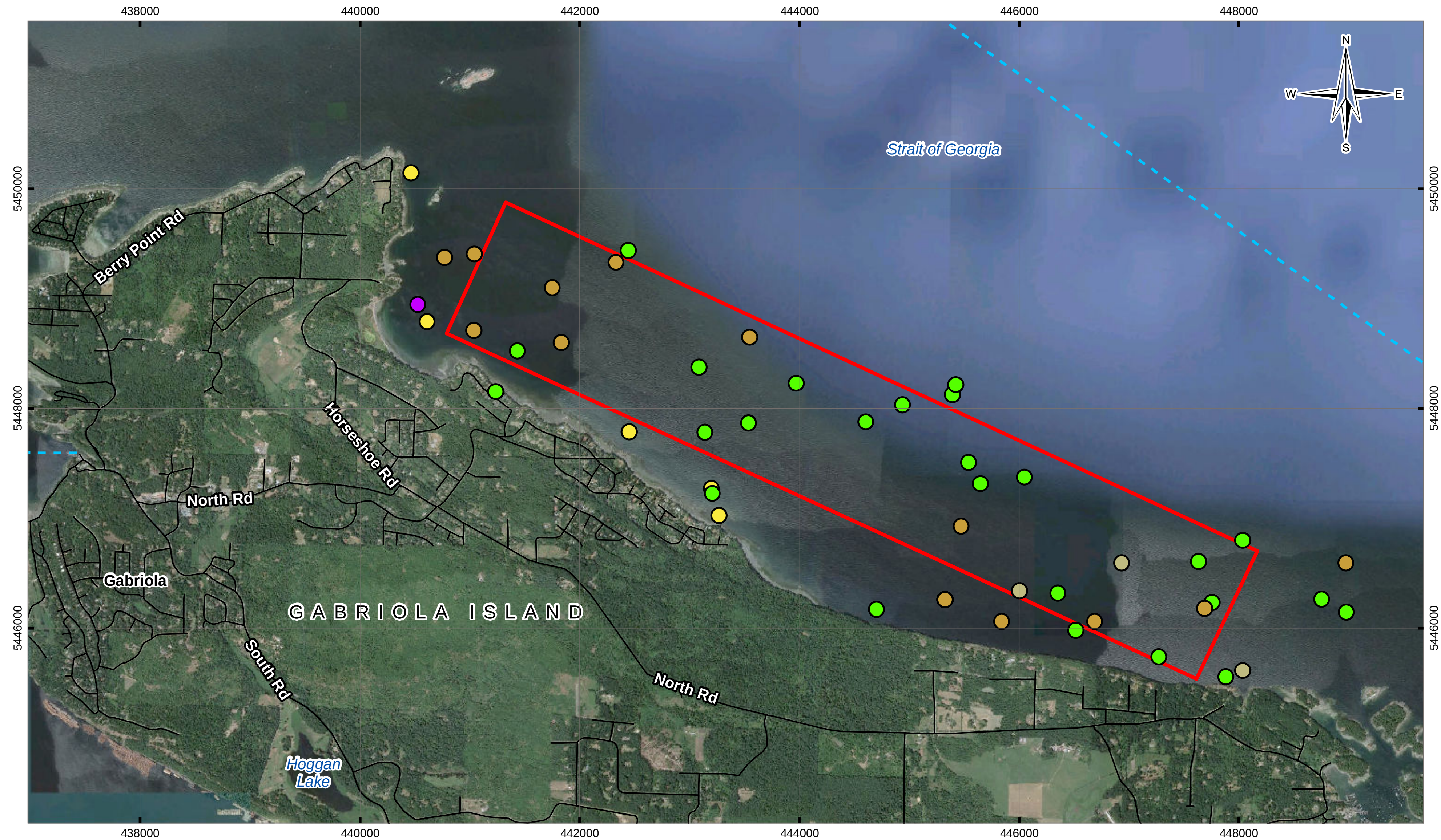
FIGURES

V:\Misc_GIS\CANADA\GIS\LAYOUTS\Marine Mammal Sightings.mxd modified 2/22/2016 by yashekia.evans



LEGEND

Species

- Pacific white-sided dolphin
- gray whale
- humpback whale
- killer whale
- unidentified porpoise/dolphin

- Project Area
- Road
- Ferry Route

NOTES
Base data source:
Imagery from Google; Nanaimo (2016);
Sightings data from the B.C. Cetacean
Sightings Network.
2013.

STATUS
ISSUED FOR REVIEW

Scale: 1:50,000
1 0.5 0 1
Kilometres

PROJECTION	DATUM
UTM Zone 10	NAD83

FILE NO.
Marine Mammal Sightings.mxd

CLIENT
Pacific Pilotage Authority

TETRA TECH EBA

ENVIRONMENTAL ASSESSMENT NEW ANCHORAGES GABRIOLA ISLAND, BC

Marine Mammal Sightings

PROJECT NO.	DWN	CKD	APVD	REV
ENV.VENV03029-01	MEZ	SL	SW	0

OFFICE	DATE
Tt EMI-OAK	February 22, 2016

Figure X

APPENDIX A: COSEWIC CRITERIA DEFINITIONS

COSEWIC's revised criteria to guide the status assessment of wildlife species. These were in use by COSEWIC by November 2001, and are based on the revised IUCN Red List categories (IUCN 2001). Some minor changes to definitions were made in 2011 and 2014 to make COSEWIC criteria more consistent with IUCN criteria. An earlier version of the quantitative criteria was used by COSEWIC from October 1999 to May 2001. (http://www.cosewic.gc.ca/eng/sct0/original_criteria_e.cfm) For definitions of terms, see COSEWIC's Glossary of Definitions and Abbreviations. This table is a short-hand reminder, for more fulsome guidance on applying these criteria see the latest IUCN Redlist guidelines.

Indicator	Endangered	Threatened
A. Decline in Total Number of Mature Individuals		
A1. An observed, estimated, inferred or suspected reduction in total number of mature individuals over the last 10 years or 3 generations, whichever is the longer, where the causes of the reduction are: clearly reversible **and** understood **and** ceased, based on (and specifying) any of the following: (a) direct observation (b) an index of abundance appropriate to the taxon (c) a decline in index of area of occupancy, extent of occurrence and/or quality of habitat (d) actual or potential levels of exploitation (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.	Reduction of ≥ 70%	Reduction of ≥ 50%
A2. An observed, estimated, inferred or suspected reduction in total number of mature individuals over the last 10 years or 3 generations, whichever is the longer, where the reduction or its causes may not have ceased **or** may not be understood **or** may not be reversible, based on (and specifying) any of (a) to (e) under A1.	Reduction of ≥ 50%	Reduction of ≥ 30%
A3. A reduction in total number of mature individuals, projected or suspected to be met within the next 10 years or 3 generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.	Reduction of ≥ 50%	Reduction of ≥ 30%
A4. An observed, estimated, inferred, projected or suspected reduction in total number of mature individuals over any 10 year or 3 generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased **or** may not be understood **or** may not be reversible, based on (and specifying) any of (a) to (e) under A1.	Reduction of ≥ 50%	Reduction of ≥ 30%
B. Small Distribution Range and Decline or Fluctuation		
B1. Extent of occurrence estimated to be	< 5,000 km²	< 20,000 km²
or		
B2. Index of area of occupancy estimated to be	< 500 km²	< 2,000 km²
and (for either B1 or B2) estimates indicating at least two of a – c:		
a. Severely fragmented **or** known to exist at: b. Continuing decline, observed, inferred or projected, in any of (i) extent of occurrence, (ii) index of area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or subpopulations, (v) number of mature individuals.	≤ 5 locations	≤ 10 locations

c. Extreme fluctuations in any of (i) extent of occurrence, (ii) index of area of occupancy, (iii) number of locations or subpopulations, (iv) number of mature individuals.		
C. Small and Declining Number of Mature Individuals		
C. Total number of mature individuals estimated to be:	<2,500	<10,000
and one of either C1 or C2:		
C1. An estimated continuing decline in total number of mature individuals of at least:	20% within 5 years or two generations, whichever is longer, up to a maximum of 100 years in the future	10% within 10 years or three generations, whichever is longer, up to a maximum of 100 years in the future
or		
C2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals **and at least one of the following:** a.(i) No subpopulation estimated to contain **or** a.(ii) one subpopulation has **or** b. There are extreme fluctuations in number of mature individuals.	> 250 mature individuals ≥ 95% of all mature individuals	> 1000 mature individuals 100% of all mature individuals
D. Very Small or Restricted Total Canadian Population		
D. Total number of mature individuals very small or restricted in the form of either of the following:		
D1. Population estimated to have	< 250 mature individuals	< 1000 mature individuals
or		
D2. **For threatened only**: Canadian population with a very restricted index of area of occupancy (typically < 20 km^2) or number of locations (typically ≤ 5) such that it is prone to the effects of human activities or stochastic events within a very short time period (1-2 generations) in an uncertain future, and is thus capable of becoming extinct, extirpated or critically* endangered in a very short period of time.	Does not apply	Index of area of occupancy typically < 20 km^2 **or** Number of locations typically ≤ 5
E. Quantitative Analysis		
E. Quantitative analysis (population projections) showing the probability of extinction or extirpation in the wild is at least	20% within 20 years or 5 generations, whichever is longer, up to a maximum of 100 years	10% within 100 years

***critically endangered (used only to inform application of D2)**

COSEWIC procedures do not allow for a possible status of Critically Endangered; however, these criteria are useful in understanding whether or not a taxon is facing the extremely high risk of extinction in the wild required by D2. Criteria thresholds for Critically Endangered are defined in IUCN (2014). Threshold changes from Endangered are as follows:

A Criterion:
- A1, $\geq$ 90% population reduction.
- A2,A3 or A4, $\geq$ 80% population reduction

B Criterion:
- B1, EOO<100 km^2
- B2, IAO<10 km
  - a) Severely fragmented or Number of locations is changed to = 1

C Criterion: Number of mature individuals < 250
- C1, an estimated continuing decline in total number of mature individuals of at least 25% in 3 years or 1 generation whichever is longer
- C2, a continuing decline, observed, projected, or inferred, in numbers of mature individuals and at least one of the following:
  - a(i) No subpopulation estimated to contain <50 mature individuals
  - a(ii) one subpopulation has 90-100% of mature individuals

D1 Criterion: Population estimated to have < 50 mature individuals

E Criterion: Quantitative analysis (population projections) showing the probability of extinction or extirpation in the wild is at least 50% within 10 years or 3 generations, whichever is longer, up to a maximum of 100 years

Special Concern:

Those wildlife species that are particularly sensitive to human activities or natural events but are not endangered or threatened wildlife species.

Wildlife species may be classified as being of Special Concern if:

(a) the wildlife species has declined to a level of abundance at which its persistence is increasingly threatened by genetic, demographic or environmental stochasticity, but the decline is not sufficient to qualify the wildlife species as Threatened; or

(b) the wildlife species may become Threatened if factors suspected of negatively influencing the persistence of the wildlife species are neither reversed nor managed with demonstrable effectiveness; or

(c) the wildlife species is near to qualifying, under any criterion, for Threatened status; or

(d) the wildlife species qualifies for Threatened status but there is clear indication of rescue effect from extra-limital subpopulations.

Examples of reasons why a wildlife species may qualify for "Special Concern":

- a wildlife species that is particularly susceptible to a catastrophic event (e.g., a seabird population near an oil tanker route); or
- a wildlife species with very restricted habitat or food requirements for which a threat to that habitat or food supply has been identified (e.g., a bird that forages primarily in old-growth forest, a plant that grows primarily on undisturbed sand dunes, a fish that spawns primarily in estuaries, a snake that feeds primarily on a crayfish whose habitat is threatened by siltation; or
- a recovering wildlife species no longer considered to be Threatened or Endangered but not yet clearly secure.

Examples of reasons why a wildlife species may not qualify for "Special Concern":

- a wildlife species existing at low density in the absence of recognized threat (e.g., a large predatory animal defending a large home range or territory); or
- a wildlife species existing at low density that does not qualify for Threatened status for which there is a clear indication of rescue effect.

Guidelines for use of Extinct or Extirpated

A wildlife species may be assessed as extinct or extirpated from Canada if:

- there exists no remaining habitat for the wildlife species and there have been no records of the wildlife species despite recent surveys; or
- 50 years have passed since the last credible record of the wildlife species, despite surveys in the interim; or
- there is sufficient information to document that no individuals of the wildlife species remain alive.

Guidelines for use of Data Deficient

Data Deficient should be used for cases where the status report has fully investigated all best available information yet that information is insufficient to: a) satisfy any criteria or assign any status, or b) resolve the wildlife species' eligibility for assessment.

Examples:

- Records of occurrence are too infrequent or too widespread to make any conclusions about extent of occurrence, population size, threats, or trends.
- Surveys to verify occurrences, when undertaken, have not been sufficiently intensive or extensive or have not been conducted at the appropriate time of the year or under suitable conditions to ensure the reliability of the conclusions drawn from the data gathered.
- The wildlife species' occurrence in Canada cannot be confirmed or denied with assurance.

Data Deficient should **not** be used if: a) the choice between two status designations is difficult to resolve by COSEWIC, or b) the status report is inadequate and has not fully investigated all best available information (in which case the report should be rejected), or c) the information available is minimally sufficient to assign status but inadequate for recovery planning or other such use.

APPENDIX G
SPECIES AT RISK

Table 1: Plant Species at Risk with Potential to Occur in Anchorage Area

Scientific Name	English Name	Global Status	Prov Status	COSEWIC	SARA	BC List
CDC Species and Ecosystem Explorer						
Allium amplectens	slimleaf onion	G4	S3			Blue
Allium crenulatum	Olympic onion	G4	S3			Blue
Allium geyeri var. tenerum	Geyer's onion	G4G5T3T5	S3			Blue
Anagallis minima	chaffweed	G5	S3			Blue
Carex feta	green-sheathed sedge	G5	S3			Blue
Carex tumulicola	foothill sedge	G4	S2	E (Mar 2008)	1-E (Feb 2010)	Red
Dryopteris arguta	coastal wood fern	G5	S3	SC (Nov 2001)	1-SC (Jun 2003)	Blue
Githopsis specularioides	common bluecup	G5	S2			Red
Heterocodon rariflorum	heterocodon	G5	S3			Blue
Hosackia pinnata	bog bird's-foot lotus	G4G5	S1	E (May 2004)	1-E (Jul 2005)	Red
Isoetes nuttallii	Nuttall's quillwort	G4?	S3			Blue
Juncus oxymeris	pointed rush	G5	S3?			Blue
Juniperus maritima	seaside juniper	G3G4	S3			Blue
Limnanthes macounii	Macoun's meadow-foam	G2	S2	T (Nov 2004)	1-T (Aug 2006)	Red
Malaxis brachypoda	white adder's-mouth orchid	G4Q	S2S3			Blue
Meconella oregana	white meconella	G2G3	S1	E (May 2005)	1-E (Aug 2006)	Red
Microseris bigelovii	coast microseris	G4	S1	E (Apr 2006)	1-E (Dec 2007)	Red
Packera macounii	Macoun's groundsel	G5	S3			Blue
Rubus nivalis	snow bramble	G4?	S3?			Blue
Rupertia physodes	California-tea	G4	S3			Blue
Sericocarpus rigidus	white-top aster	G3	S2	SC (Apr 2009)	1-SC (Jun 2003)	Red
Toxicodendron diversilobum	poison oak	G5	S3?			Blue
Trifolium dichotomum	Macrae's clover	G4?	S2S3			Blue
Triglochin concinna	graceful arrow-grass	G5	S3			Blue
Uropappus lindleyi	Lindley's microseris	G5	S1	E (Mar 2008)	1-E (Feb 2010)	Red
Viola howellii	Howell's violet	G4	S2			Red
Zeltnera muehlenbergii	Muhlenberg's centaury	G5?	S1	E (Mar 2008)	1-E (Feb 2010)	Red
Stewardship Centre for BC - Species at Risk						
Bidens amplissima	Vancouver Island beggarticks	G3	S3	SC	SC-1	Blue
CDC Non-Sensitive Species Occurrence						
Allium amplectens	Slimleaf onion	G4	S3?			Blue
Entosthodon fascicularis	Banded cord moss	G4G5	S2S3	SC (May 2015)	SC-1	Blue
Hosackia pinnata	Bog bird's foot lotus	G4G5	S1	E (May 2004)	E-1	Red
Isoetes nuttallii	Nuttall's quillwort	G4?	S3?			Blue
Limnanthes macounii	Macoun's meadowfoam	G2	S2	T	T-1	Red
Sericocarpus rigidus	White top aster	G3	S2	SC (April 2009)	SC-1	Red
Toixcodendron diversilobum	Poison oak	G5	S3?			Blue
CDC Non-Sensitive Ecosystem Occurrence						
Populus tremuloides / Malus fusca / Carex obnupta	trembling aspen / Pacific crab apple / slough sedge	G2	S1S2			Red
Pseudotsuga menziesii / Mahonia nervosa (x3)	Douglas-fir / dull Oregon-grape	G2	S2			Red
Notes:						
		G- Global	**1**- Critically Imperiled	**E** - Endangered	**E** - Endangered	**Red** - species legally designated as Threatened or Endangered under the Wildlife Act, extirpated or candidates for such.
		GNA - Not applicable	**2** - Imperiled	**NAR** - Not at Risk	**SC** - Special Concern	
		GNR - Not ranked	**3**- Vulnerable	**SC** - Special Concern	**T** - Threatened	
		Q - Questionable taxonomy	**4** - Apparently Secure	**T** - Threatened		**Blue** - species not immediately threatened but are of concern because of chacteristics that make them sensitive to human activities
		T - Infraspecific taxon (subspecies)	**5** - Secure			
		U - unrankable due to lack of information	**?** - Unranked			
		1 - Critically Imperiled	**B**- breeding pop.			**Yellow** -includes uncommon, common, declining and increasing species (all species not included on Red or Blue list).
		2 - Imperiled	**H** - Historical			
		3- Vulnerable	**M** - migrant pop.			
		4 - Apparently Secure	**N** - non breeding pop.			
		5 - Secure	**S** - Sub National			

Table 2: Wildlife Species at Risk with Potential to Occur in Anchorage Area

Scientific Name	English Name	Global Status	Prov Status	COSEWIC	SARA	BC List	Identified Wildlife [1]	MBCA [2]
CDC Species and Ecosystems Explorer								
Accipiter gentilis laingi	Northern Goshawk, laingi subspecies	G5T2	S2B	T (Apr 2013)	1-T (Jun 2003)	Red	Y (May 2004)	
Anaxyrus boreas	Western Toad	G4	S3S4	SC (Nov 2012)	1-SC (Jan 2005)	Blue		
Aneides vagrans	Wandering Salamander	G4	S3S4	SC (May 2014)		Blue		
Ardea herodias fannini	Great Blue Heron, fannini subspecies	G5T4	S2S3B,S4N	SC (Mar 2008)	1-SC (Feb 2010)	Blue	Y (May 2004)	
Asio flammeus	Short-eared Owl	G5	S3B,S2N	SC (Mar 2008)	1-SC (Jul 2012)	Blue	Y (May 2004)	
Botaurus lentiginosus	American Bittern	G4	S3B			Blue		Y
Brachyramphus marmoratus	Marbled Murrelet	G3	S3B,S3N	T (May 2012)	1-T (Jun 2003)	Blue	Y (May 2004)	Y
Branta bernicla	Brant	G5	S3M			Blue		Y
Butorides virescens	Green Heron	G5	S3S4B			Blue		Y
Callophrys mossii mossii	Moss' Elfin, mossii subspecies	G4T4	S2S3			Blue		
Carychium occidentale	Western Thorn	G3G4	S2S3			Blue		
Cercyonis pegala incana	Common Wood-nymph, incana subspecies	G5T4T5	S2			Red		
Chordeiles minor	Common Nighthawk	G5	S4B	T (Apr 2007)	1-T (Feb 2010)	Yellow		Y
Chrysemys picta	Painted Turtle	G5	S3	E/SC (Apr 2006)	1-E/SC (Dec 2007)	No Status		
Chrysemys picta pop. 1	Painted Turtle - Pacific Coast Population	G5T2	S2	E (Apr 2006)	1-E (Dec 2007)	Red		
Coenonympha tullia insulana	Common Ringlet, insulana subspecies	G5T3T4	S1			Red		
Contopus cooperi	Olive-sided Flycatcher	G4	S3S4B	T (Nov 2007)	1-T (Feb 2010)	Blue		Y
Corynorhinus townsendii	Townsend's Big-eared Bat	G3G4	S3S4			Blue		
Cypseloides niger	Black Swift	G4	S2S3B	E (May 2015)		Blue		Y
Danaus plexippus	Monarch	G5	S3B	SC (Apr 2010)	1-SC (Jun 2003)	Blue		
Erynnis propertius	Propertius Duskywing	G5	S2			Red		
Euchloe ausonides insulanus	Large Marble, insulanus subspecies	G5T1	SX	XT (Apr 2010)	1-XX (Jun 2003)	Red		
Eumetopias jubatus	Steller Sea Lion	G3	S3B,S4N	SC (Nov 2013)	1-SC (Jul 2005)	Blue		
Falco peregrinus pealei	Peregrine Falcon, pealei subspecies	G4T3	S3B	SC (Apr 2007)	1-SC (Jun 2003)	Blue		
Glaucidium gnoma swarthi	Northern Pygmy-Owl, swarthi subspecies	G4G5T3Q	S3			Blue	Y (Jun 2006)	
Haliotis kamtschatkana	Northern Abalone	G3G4	S2	T (May 2000)	1-T (Jun 2003)	Red		
Hemphillia dromedarius	Dromedary Jumping-slug	G3G4	S2	T (May 2014)	1-T (Jan 2005)	Red		
Hemphillia glandulosa	Warty Jumping-slug	G3G4	S2S3	SC (Apr 2013)	1-SC (Jan 2005)	Blue		
Hesperia colorado oregonia	Western Branded Skipper, oregonia subspecies	G5T3T4	S1	E (Nov 2013)		Red		
Hirundo rustica	Barn Swallow	G5	S3S4B	T (May 2011)		Blue		Y
Megascops kennicottii kennicottii	Western Screech-Owl, kennicottii subspecies	G5T4	S3	T (May 2012)	1-SC (Jan 2005)	Blue		
Monadenia fidelis	Pacific Sideband	G4G5	S3S4			Blue		
Mustela erminea anguinae	Ermine, anguinae subspecies	G5T3	S3			Blue		
Myotis keenii	Keen's Myotis	G2G3	S3?	DD (Nov 2003)	3 (Mar 2005)	Blue	Y (May 2004)	
Nearctula sp. 1	Threaded Vertigo	G3G5	S2	SC (Apr 2010)	1-SC (Jul 2012)	Red		
Patagioenas fasciata	Band-tailed Pigeon	G4	S3S4B	SC (Nov 2008)	1-SC (Feb 2011)	Blue		Y
Phalacrocorax auritus	Double-crested Cormorant	G5	S3S4B	NAR (May 1978)		Blue		
Plebejus saepiolus insulanus	Greenish Blue, insulanus subspecies	G5TH	SH	E (May 2012)	1-E (Jun 2003)	Red		
Pooecetes gramineus affinis	Vesper Sparrow, affinis subspecies	G5T3?	S1B	E (Apr 2006)	1-E (Dec 2007)	Red		
Pristiloma johnsoni	Broadwhorl Tightcoil	G3	S2S3			Blue		
Progne subis	Purple Martin	G5	S3B			Blue		Y
Prophysaon vanattae	Scarletback Taildropper	G4	S3S4			Blue		
Rana aurora	Northern Red-legged Frog	G4	S3S4	SC (May 2015)	1-SC (Jan 2005)	Blue	Y (May 2004)	
Sorex palustris brooksi	American Water Shrew, brooksi subspecies	G5T2	S2			Red	Y (Jun 2006)	
Speyeria zerene bremnerii	Zerene Fritillary, bremnerii subspecies	G5T3T4	S2			Red		
Sympetrum vicinum	Autumn Meadowhawk	G5	S3S4			Blue		
Tyto alba	Barn Owl	G5	S2?	T (Nov 2010)	1-SC (Jun 2003)	Red		
Uria aalge	Common Murre	G5	S2B,S3S4N			Red		Y
Zonitoides nitidus	Black Gloss	G5	S3S4			Blue		
Stewardship Centre for BC - Species at Risk								
Acipenser medirostris	Green Sturgeon	G3	S1N	SC (2013)	1-SC (2006)	Red		
Ardea herodias fannini	Great Blue Heron, fannini	G5T4	S2S3B,S4N	SC (2008)	1-SC (2010)	Blue		
Brachyramphus marmoratus	Marbeled Murrelet	G3	S3B,S3N	T (May 2012)	1-T (Jun 2003)	Blue	Y (May 2004)	Y
Butorides virescens	Green Heron	G5	S3S4B			Blue		
Callorhinus ursinus	Northern Fur Seal	G3	S2M	T (2010)		Red		
Cetorhinus maximus	Basking Shark	GNR	SNR	E (2007)	1-E (2010)			
Dermochelys coriacea	Leatherback Turtle	G2	S1S2N	E (2012)	1-E (2003)	Red		
Eumetopias jubatus	Steller Sea Lion	G3	S3B,S4N	SC (Nov 2013)	1-SC (Jul 2005)	Blue		
Falco peregrinus anatum	Peregrine Falcon, anatum	G4T4	S2?B	SC (2007)	1-SC (2012)	Blue		
Falco peregrinus pealei	Peregrine Falcon, pealei	G4T3	S3B	SC (Apr 2007)	1-SC (Jun 2003)	Blue		
Haliotis kamtschatkana	Northern Abalone	G3G4	S2	T (2000)	1-T (2003)	Red		
Oncorhynchus clarkii clarkii	Coastal Cutthroat Trout	G4T4	S3S4			Blue		
Oncorhynchus kisutch	Coho (interior Fraser population)	G4	S4	E (2002)		Yellow		
Orcinus orca pop. 5	Killer Whale (southern resident population)	G4G5T1	S1	E (2008)	1-E (2003)	Red		
Ostrea conchaphila	Olympia Oyster	G5	S3	SC (2011)	1-SC (2003)	Blue		
Phalacrocorax auritus	Double Crested Cormorant	G5	S3S4B	NAR (May 1978)		Blue		
Phocoena phocoena	Harbour Porpoise	G4G5	S3	SC (Nov 2003)	SC-1 (2003)	Blue		
Phoebastria albatrus	Short Tailed Albatross	G1	S1N	T (2013)	1-T (2005)	Red		
Puffinus creatopus	Pink-footed Shearwater	G23	S3N	T (2004)	1-T (2005)	Blue		
Salvelinus malma	Dolly Varden	G5	S4			Yellow		
Sebastes aleutianus	Rougheye Rockfish	GNR	SNR	SC (2007)	1-SC (2009)			
Sebastes paucispinis	Bocaccio	G4	SNR	E (2013)				
Sebastes pinniger	Canary Rockfish	GNR	SNR	T (2007)				
Sebastes ruberrimus	Yelloweye Rockfish	GNR	SNR	SC (2008)				
Sialia mexicana pop. 1	Western Bluebird (Georgia Depression population)	G5TNRQ	SHB			Red		
CDC Non-Senstivie Species Occurrences								
Erynnis propertius	Propertius Duskywing	G5	S2			Red		

Notes:

[1] As per the BC MOE Identified Wildlife Management Strategy, available: http://www.env.gov.bc.ca/wld/frpa/iwms/

[2] Migratory Birds Convention Act, available: http://laws-lois.justice.gc.ca/eng/acts/M-7.01/

Global Status	Prov Status	COSEWIC	SARA	BC List
G- Global	**1**- Critically Imperiled	**E** - Endangered	**E** - Endangered	**Red** - species legally designated as Threatened or Endangered under the Wildlife Act, extirpated or
GNA - Not applicable	**2** - Imperiled	**NAR** - Not at Risk	**SC** - Special Concern	
GNR - Not ranked	**3**- Vulnerable	**SC** - Special Concern	**T** - Threatened	
Q - Questionable taxonomy	**4** - Apparently Secure	**T** - Threatened		**Blue** - species not immediately threatened but are of concern because of chacteristics that make them sensitive to human activities or natural
T - Infraspecific taxon (subspecies)	**5** - Secure			
U - unrankable due to lack of information	**?** - Unranked			
1 - Critically Imperiled	**B**- breeding pop.			**Yellow** -includes uncommon, common, declining and increasing
2 - Imperiled	**H** - Historical			
3- Vulnerable	**M** - migrant pop.			

Table 3: Marine Mammals at Risk with Potential to Occur in Anchorage Area

Scientific Name	English Name	Global Status	Prov Status	COSEWIC	SARA	BC List
Cetaceans						
Balaenoptera borealis	Sei Whale	G3 (1996)	SHN (2006)	E (2013)	1-E (2005)	Red
Balaenoptera musculus	Blue Whale	G3G4 (1999)	S1N (2006)	E (2012)	1-E (2005)	Red
Balaenoptera physalus	Fin Whale	G3G4 (1997)	S2N (2006)	T 92005)	1-T (2006)	Red
Eschrichtius robustus	Grey Whale	G4 (2002)	S3 (2006)	SC (2004)	1-SC (2005)	Blue
Eubalaena japonica	North Pacific Right Whale	G1 (2008)	SH (2006)	E (2015)	1-E (2006)	Red
Megaptera novaeangliae	Humpback Whale	G4 (2008)	S3 (2006)	SC (2011)	1-T (2005)	Blue
Phocoena phocoena	Harbour Porpoise	G4 (2003)	S3 (2006)	SC (2003)	1-SC (2005)	Blue
Physeter macrocephalus	Sperm Whale	G3G4 (2008)	S3S4 (2006)	NAR (1996)		Blue
Orincus orca	Killer Whale					
pop. 2	Northeast Pacific Offshore pop.	G4G5TUQ (1998)	S2 (2011)	T (2008)	1-SC (2003)	Red
pop. 5	Northeast Pacific Southern Resident pop.	G4G5T1 (20050	S1 (2011)	E (2008)	1-E (2003)	Red
pop. 6	Northeast Pacific Northern Resident pop.	G4G5T2 (2006)	S2 (2011)	T (2008)	1-T (2008)	Red
pop. 3	Northeast Pacific Transient pop.	G4G5T3Q (1998)	S2 (2011)	T (2008)	1-T (2003)	Red
Pinnipeds						
Callorhinus ursinus	Northern Fur Seal	G3 (2008)	S2M (2006)	T (2010)		Red
Eumetopias jubatus	Steller Sea Lion	G3 (2011)	S3B, S4N 92013)	SC (2013)	1-SC (2005)	Blue
Mustelids						
Enhydra lutris	Sea Otter	G4 (2005)	S3 (2015)	SC (2007)	1-SC (2003)	Blue
Notes:						
		G- Global	**1**- Critically Imperiled	**E** - Endangered	**E** - Endangered	**Red** - species legally designated as Threatened or Endangered under the Wildlife Act, extirpated or
		GNA - Not applicable	**2** - Imperiled	**NAR** - Not at Risk	**SC** - Special Concern	
		GNR - Not ranked	**3**- Vulnerable	**SC** - Special Concern	**T** - Threatened	
		Q - Questionable taxonomy	**4** - Apparently Secure	**T** - Threatened		**Blue** - species not immediately threatened but are of concern because of chacteristics that make them sensitive to human activities or natural
		T - Infraspecific taxon (subspecies)	**5** - Secure			
		U - unrankable due to lack of information	**?** - Unranked			
		1 - Critically Imperiled	**B**- breeding pop.			**Yellow** -includes uncommon, common, declining and increasing
		2 - Imperiled	**H** - Historical			
		3- Vulnerable	**M** - migrant pop.			
		4 - Apparently Secure	**N** - non breeding pop.			
		5 - Secure	**S** - Sub National			

APPENDIX H

ABORIGINAL OVERVIEW ASSESSMENT (TETRA TECH EBA 2016)

TETRA TECH EBA

TECHNICAL MEMO

ISSUED FOR REVIEW

To:	Pacific Pilotage Authority	**Date:**	April 20, 2016
c:		**Memo No.:**	1
From:	Gordon Mohs	**File:**	ENV.VENV03029-01
Subject:	Aboriginal Overview Assessment Proposed Gabriola Anchorages		

This 'Issued for Review' document is provided solely for the purpose of client review and presents our interim findings and recommendations to date. Our usable findings and recommendations are provided only through an 'Issued for Use' document, which will be issued subsequent to this review. Final design should not be undertaken based on the interim recommendations made herein. Once our report is issued for use, the 'Issued for Review' document should be either returned to Tetra Tech EBA or destroyed.

1.0 OVERVIEW ASSESSMENT

Eight First Nation organizations were identified through the Province of British Columbia's Consultative Area Database (CAD) system, Geo-BC, including:

1. Stz'uminus First Nation;
2. Cowichan Tribes;
3. Halalt First Nation;
4. Lake Cowichan First Nation;
5. Lyackson First Nation;
6. Penelakut Tribe;
7. Hul'qumi'num Treaty Group; and
8. Snuneymuxw First Nation.

With the exception of the Snuneymuxw, all of the First Nations/Tribes listed are members of the Hul'qumi'num Treaty Group. In addition, the Stz'uminus, Snuneymuxw, and Halalt are members of the Naut'sa Mawt Tribal Council, based in Tsawwassen. Neither the Hul'qumi'num Treaty Group nor the Naut'sa Mawt Tribal Council have a 'Referrals Department' or 'Referrals Mandate'. Both organizations stated that each Band/Nation manages its own referrals.

British Columbia's Consultative Area Database system provides information on First Nations to be consulted with respect to a proposed development Project, based on the Project location (Attachment). The information provided for each query includes:

- Contact Title (who to contact);
- Contact Organization;

Tetra Tech EBA Inc.
Suite 1000 – 10th Floor, 885 Dunsmuir Street
Vancouver, BC V6C 1N5 CANADA
Tel 604.685.0275 Fax 604.684.6241

- Contact Address;
- Contact City;
- Contact Province;
- Contact Postal Code;
- Contact Phone;
- Contact Fax; and
- Contact Email.

This information is helpful, but is somewhat incomplete, as it does not identify the individuals or departments responsible for managing Project referrals or the relevant contact information. Moreover, some of the information provided was incorrect (e.g., telephone number for Hul'qumi'num Treaty Group – since corrected in Appendix) or incomplete (e.g. contact email).

All of the First Nation organizations were called on February 29, 2016 and queried regarding their Project Referrals' Process and if they had a designated person(s) who managed Project Referrals for their organization. In summary, all of the First Nations organizations identified have a Referrals' Coordinator, or someone who acts in that capacity.

Below is an up-to-date and complete list of contact information for all First Nation organizations identified, as per the proposed Project Geo-BC CAD query. The order in which First Nation organizations are listed below is the same as provided in the government's CAD database.

---

1. Contact Organization: **Stz'uminus First Nation**

- Contact Title: Chief & Council: Attention Referrals
- Contact Address: <contact information removed>
- Nation/Tribe Contact Phone: <contact information removed>
- Contact Fax: <contact information removed>
- Referrals Department: Coast Salish Development Corporation
- Referrals Manager(s): Chenoa Akey and Ray Gotier
- Referrals Manager(s) Contact Email: <email address removed>
- Referrals Manager direct phone: <contact information removed>
- Does FN have formal Referral Process: No formal process
- Comment: *Nation may not respond immediately to referrals. They often wait for Government Engagement Process before responding. May respond to Development Notification Letter.*

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2. Contact Organization: **Cowichan Tribes**

- Contact Title: Chief & Council: Attention Referrals
- Contact Address: <contact information removed>
- Nation/Tribe Contact Phone: <contact information removed>
- Contact Fax: <contact information removed>
- Referrals Department: Yes
- Referrals Manager(s): Natalie Anderson
- Referrals Manager(s) Contact Email: <email address removed> also <email address removed>
- Referrals Manager direct phone: Use Tribal Phone
- Does FN have formal Referral Process: YES
- Comment: *Nation has well developed Referrals Management System. Helen Reid is Referrals Manager until March 18, 2016, at which time Natalie Anderson is to be primary contact. Another Referrals Manager's name was also given: Candace Charlie.*

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3. Contact Organization: **Halalt First Nation**

- Contact Title: Chief & Council: Attention Referrals
- Contact Address: <contact information removed>
- Nation/Tribe Contact Phone: <contact information removed>
- Contact Fax: <contact information removed>
- Referrals Department: Referrals
- Referrals Manager(s): Raven August
- Referrals Manager(s) Contact Email: <email address removed>
- Referrals Manager direct phone: n/a contact through Tribal phone number
- Does FN have formal Referral Process: NO
- Comment: *for larger Projects, cc Jack Smith:*<email address removed>

4. Contact Organization: **Lake Cowichan First Nation**

- Contact Title: Chief & Council: Attention Referrals
- Contact Address: <contact information removed>
- Nation/Tribe Contact Phone: <contact information removed>
- Contact Fax: <contact information removed>
- Referrals Department: n/a
- Referrals Manager(s): Carole Livingstone
- Referrals Manager(s) Contact Email: <email address removed>
- Referrals Manager direct phone: n/a
- Does FN have formal Referral Process: YES
- Comment: *None*

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5. Contact Organization: **Lyackson First Nation**

- Contact Title: Chief & Council: Attention Referrals
- Contact Address: <contact information removed>
- Nation/Tribe Contact Phone: <contact information removed>
- Contact Fax: <contact information removed>
- Referrals Department: Lands and Resources
- Referrals Manager(s): Cory Thomas, Lands and Resources Clerk
- Referrals Manager(s) Contact Email: <email address removed>
- Referrals Manager direct phone: n/a
- Does FN have formal Referral Process: unknown
- Comment: *Cory's boss is Patricia McKinnon, Director of Operations:* <email address removed>

6. Contact Organization: **Penelakut Tribe**

- • Contact Title: Chief & Council: Attention Referrals
- Contact Address: <contact information removed>
- Nation/Tribe Contact Phone: <contact information removed>
- Contact Fax: <contact information removed>
- Referrals Department: n/a
- Referrals Manager(s): Denise James
- Referrals Manager(s) Contact Email: <email address removed>
- Referrals Manager direct phone: n/a use Tribal number
- Does FN have formal Referral Process: NO
- Comment: *None*

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7. Contact Organization: **Hul'qumi'num Treaty Group**

- Contact Title: n/a
- Contact Address: <contact information removed>
- Nation/Tribe Contact Phone: <contact information removed>
- Contact Fax; and n/a
- Referrals Department: n/a
- Referrals Manager(s): n/a
- Referrals Manager(s) Contact Email: n/a
- Referrals Manager direct phone: n/a
- Does FN have formal Referral Process: NO
- Comment: *HTG responded that each Band has its own Referrals Coordinator, that the HTG does not handle referrals at all.*

8. Contact Organization: **Snuneymuxw First Nation**

- Contact Title: Chief & Council
- Contact Address: <contact information removed>
- Nation/Tribe Contact Phone: <contact information removed>
- Contact Fax: <contact information removed>
- Referrals Department: Lands & Resources: Referrals
- Referrals Manager(s): Chris Good
- Referrals Manager(s) Contact Email: <email address removed>
- Referrals Manager direct phone: <contact information removed>
- Does FN have formal Referral Process: YES
- Comment: *The SFN Website makes the following comment on Referrals Process:*

The Referrals Office is to protect and advocate for the recognition of the Aboriginal rights of the Snuneymuxw First Nation by:

- Ensuring that SFN is aware of all resource development activities proposed or ongoing within their traditional territories.
- Facilitating the timely development of effective responses to BC province resource development referrals that set of out the views of SFN regarding the contemplated resource development.
- Facilitating the resolution of issues or concerns raised by SFN regarding ongoing or proposed resource development.
- The directive of the Referrals Office is to protect the hunting and fishing rights through the Douglas Treaty Implementation set up with the BC Government.

2.0 SUMMARY

In summary, there are three Nations in relative proximity to the proposed development Project and who are likely to have the most interest/engagement in the consultative process. Snuneymuxw are the nearest Nation to the proposed development Project and have clearly indicated that Gabriola Island is within their core territory. In addition, both the Cowichan Tribes and Lyackson are in proximity to Gabriola Island and have asserted territorial claims through the Hul'qumi'num Treaty Group. In the Hul'qumi'num Treaty Group's formal submission to the BC Treaty Commission, part of Gabriola Island is included within the Hul'qumi'num Treaty Group's 'Traditional Territory: Core Aboriginal Title Lands', described as follows: "the southeast portion of Gabriola Island, following the height of land between False Narrows and the small bay on the northeast corner of Gabriola Island, including the adjacent Flat Top Islands."

3.0 ARCHAEOLOGICAL OVERVIEW

A brief archaeological query of the north side of Gabriola Island was conducted through RAAD (Remote Access to Archaeological Data). Evidence of traditional land use and occupancy along the north side of the island is affirmed by the presence of several archaeological sites. Notably, there are 6 registered arch sites along the shoreline adjacent the proposed development zone, with an additional 26 registered sites in the Flat Top Islands archipelago to the east/southeast, and another 9 to the west/northwest. The presence of these sites indicates significant antiquity and use in proximity to the development.

4.0 POTENTIAL IMPACTS

Potential impacts likely to be asserted by local First Nations organizations, based on evidence of occupancy and general statements about lands, resources and traditional harvesting rights on their websites, include:

- Potential impact to traditional harvesting and fishing activities;
- Potential impacts to kelp beds and seaweed from ballast water;
- Potential impacts to kelp beds, seaweed, shellfish, fish and archaeological sites from potential fuel leakages;
- Potential impact of diesel fumes, noise and light pollution upon aquatic resources;
- Potential impacts to sub-surface archaeological sites; and
- Quality of life impacts from diesel fumes, noise and light pollution.

5.0 CLOSURE

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech EBA Inc.

ISSUED FOR REVIEW

Prepared by:
Gordon W Mohs, M.A.
Sx̱wōx̱wiyam, El:óliye, Pop'qo'les
Sr. Advisor, First Peoples' Community/Business Relations
Direct Line: <contact information removed>
<email address removed>

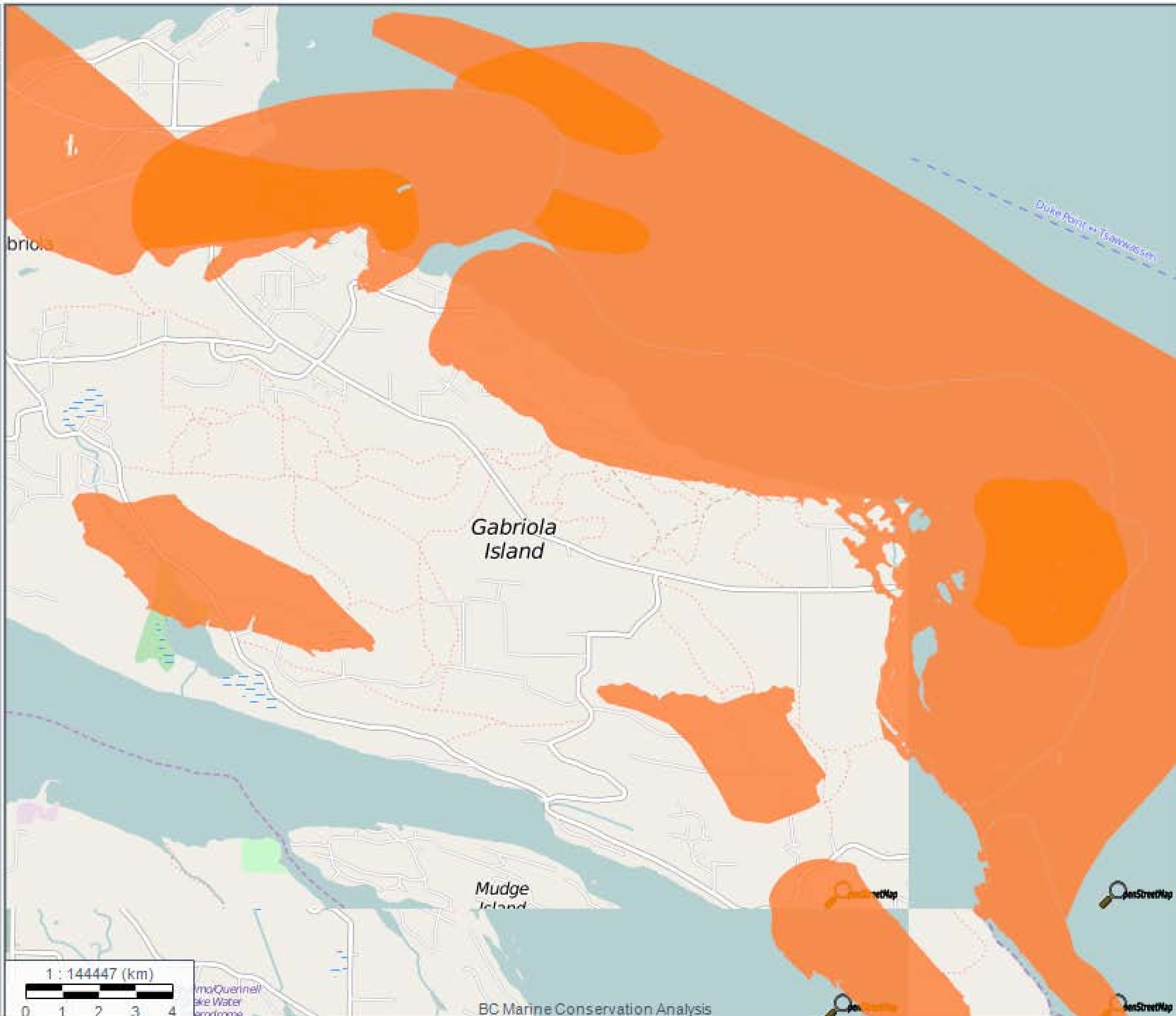
/dr

APPENDIX I
MARINE ATLAS OF PACIFIC CANADA MAPS

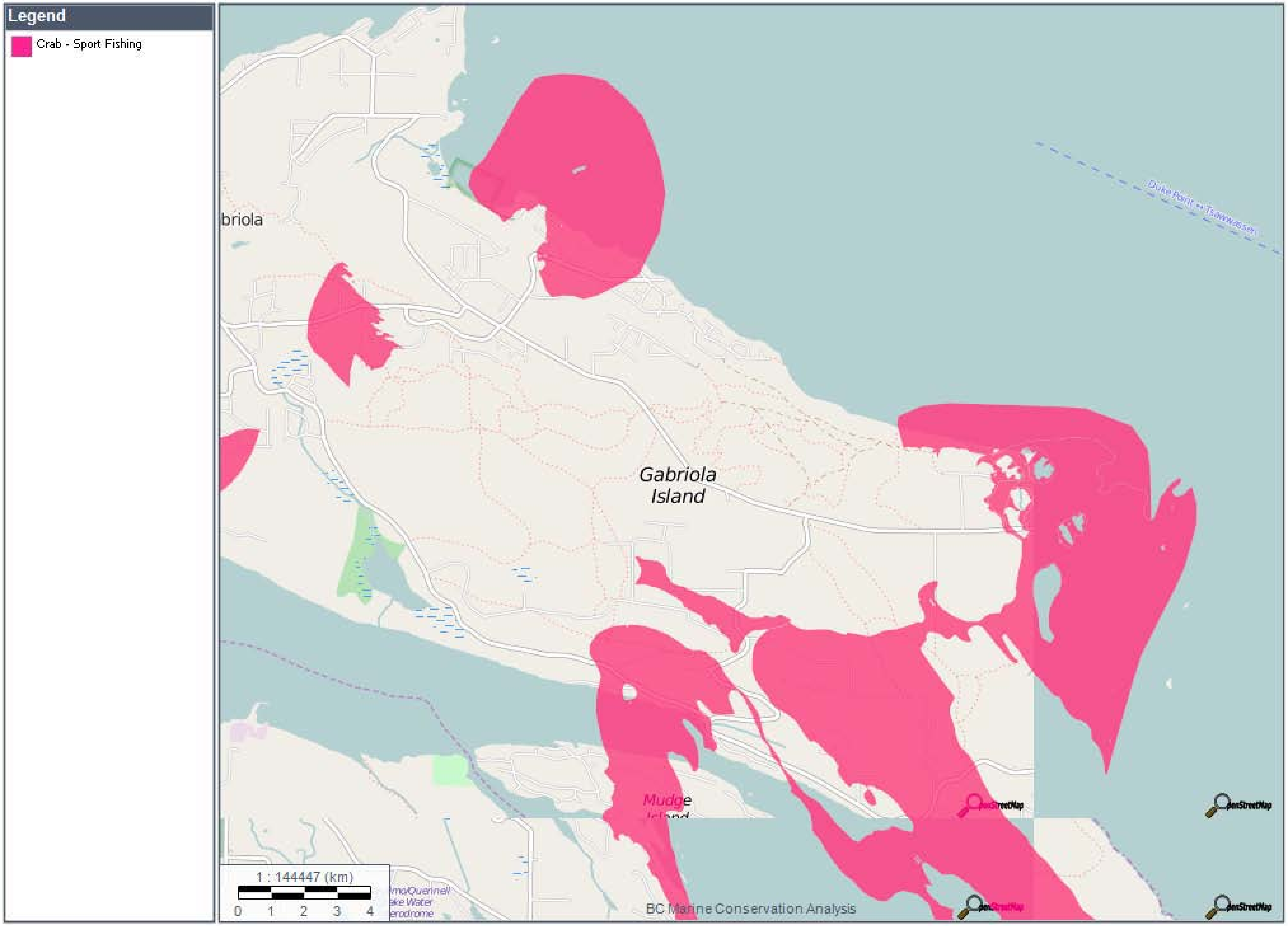
Anadromous sport fishing area

Legend

Anadromous Fish - Sport Fishing



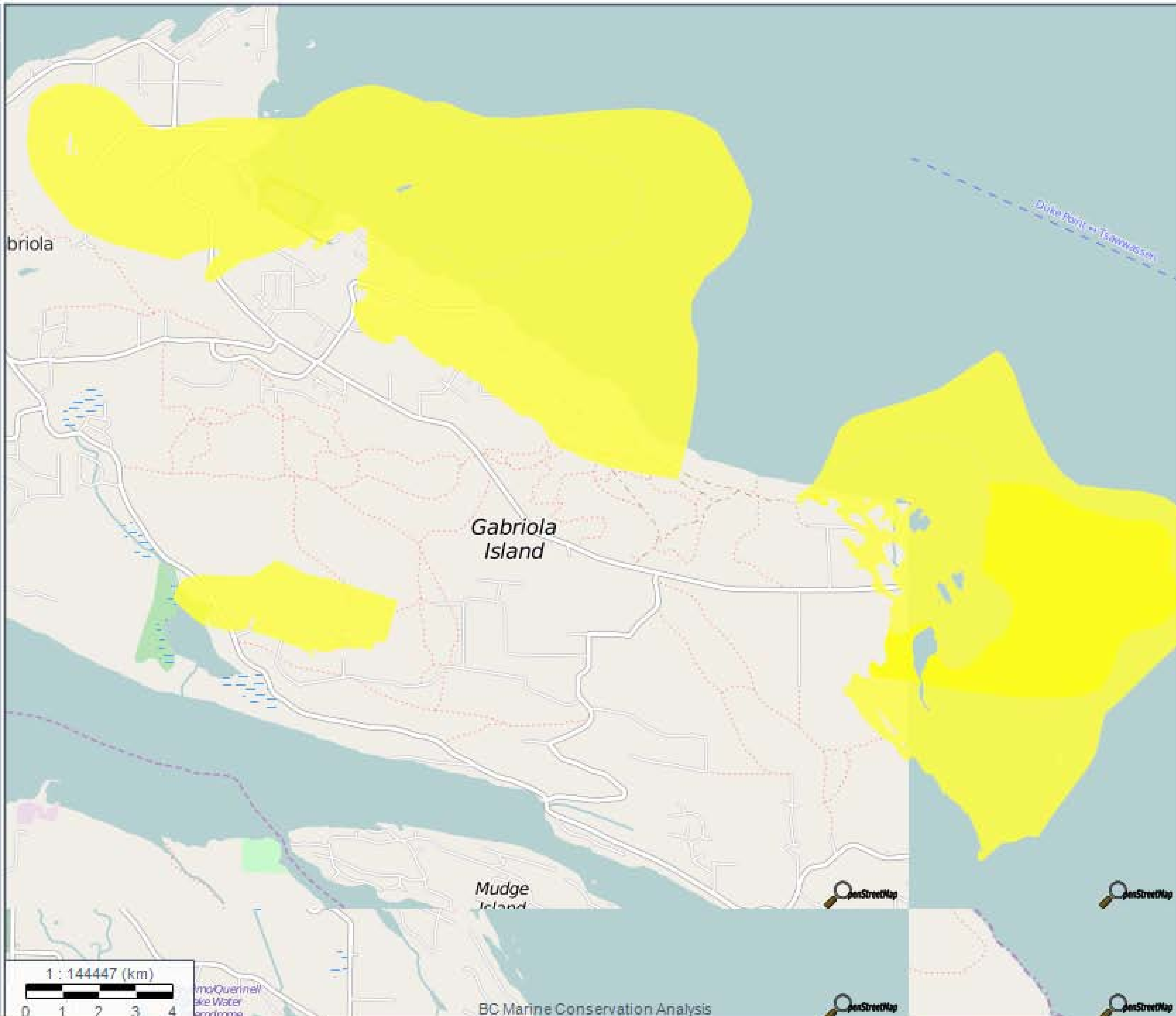
Crab sport fishing area



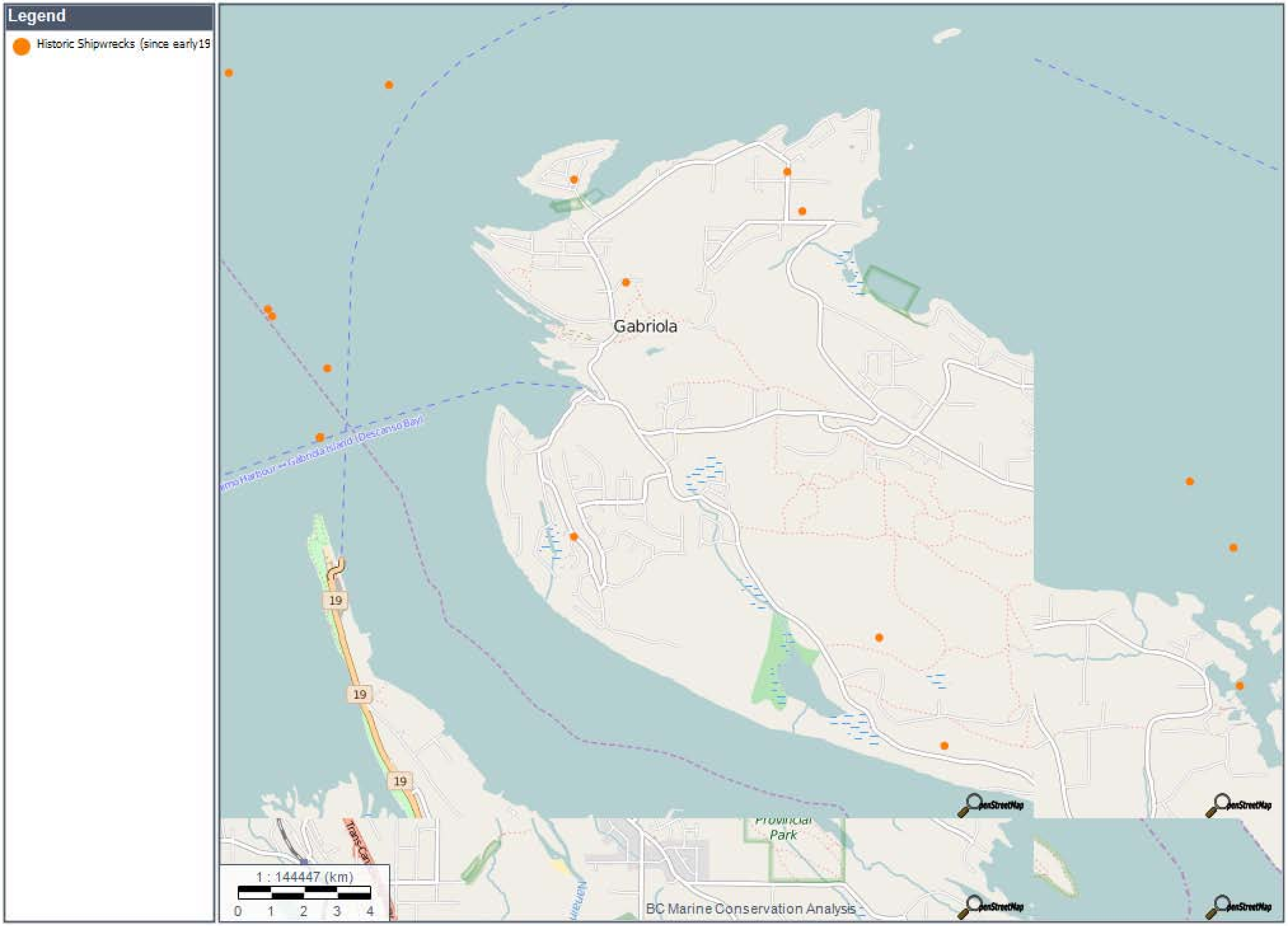
Groundfish sport fishing area

Legend

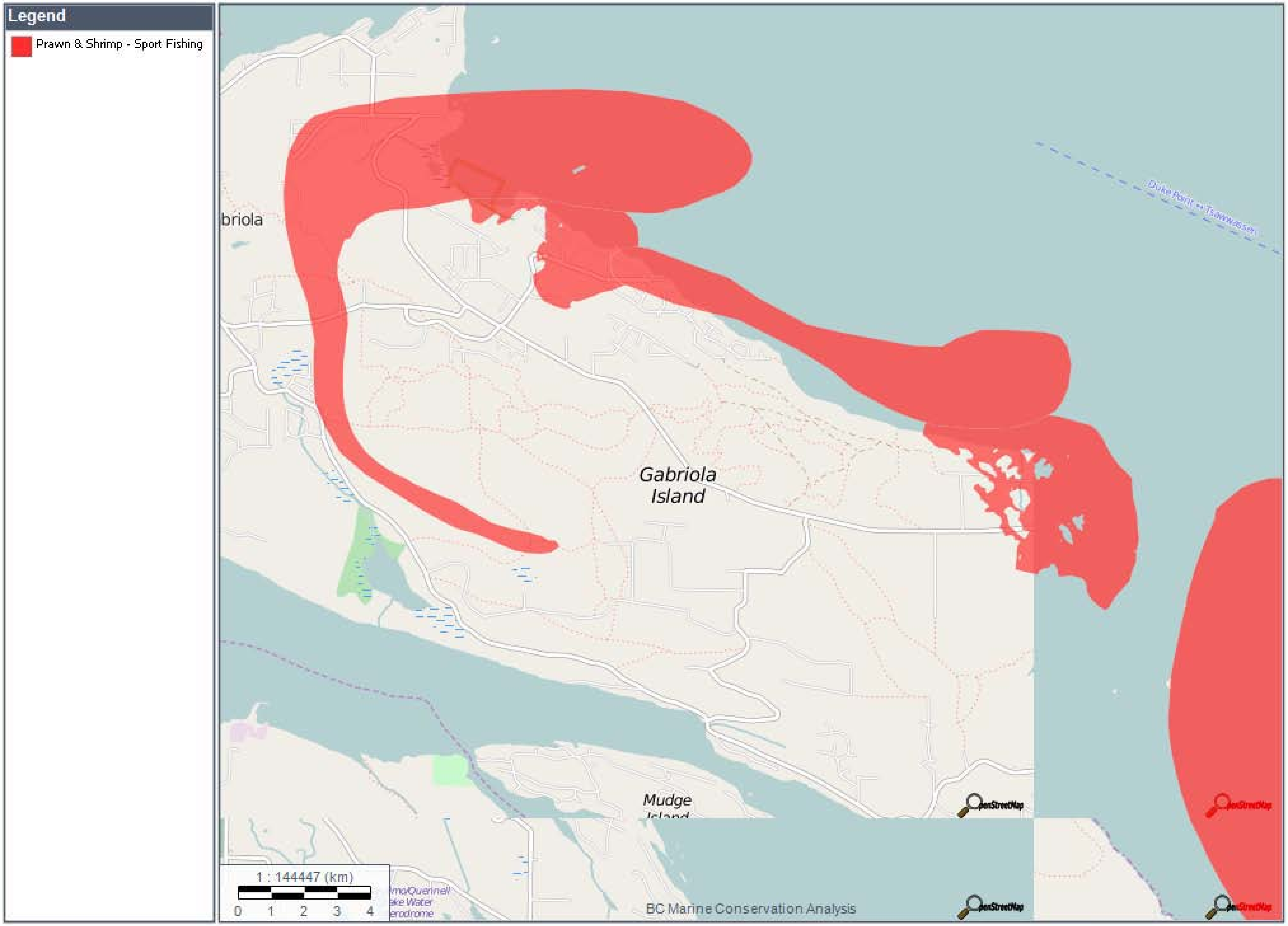
Groundfish - Sport Fishing



Historic Shipwrecks (since early 1900s)



Prawn and fish sport fishing area

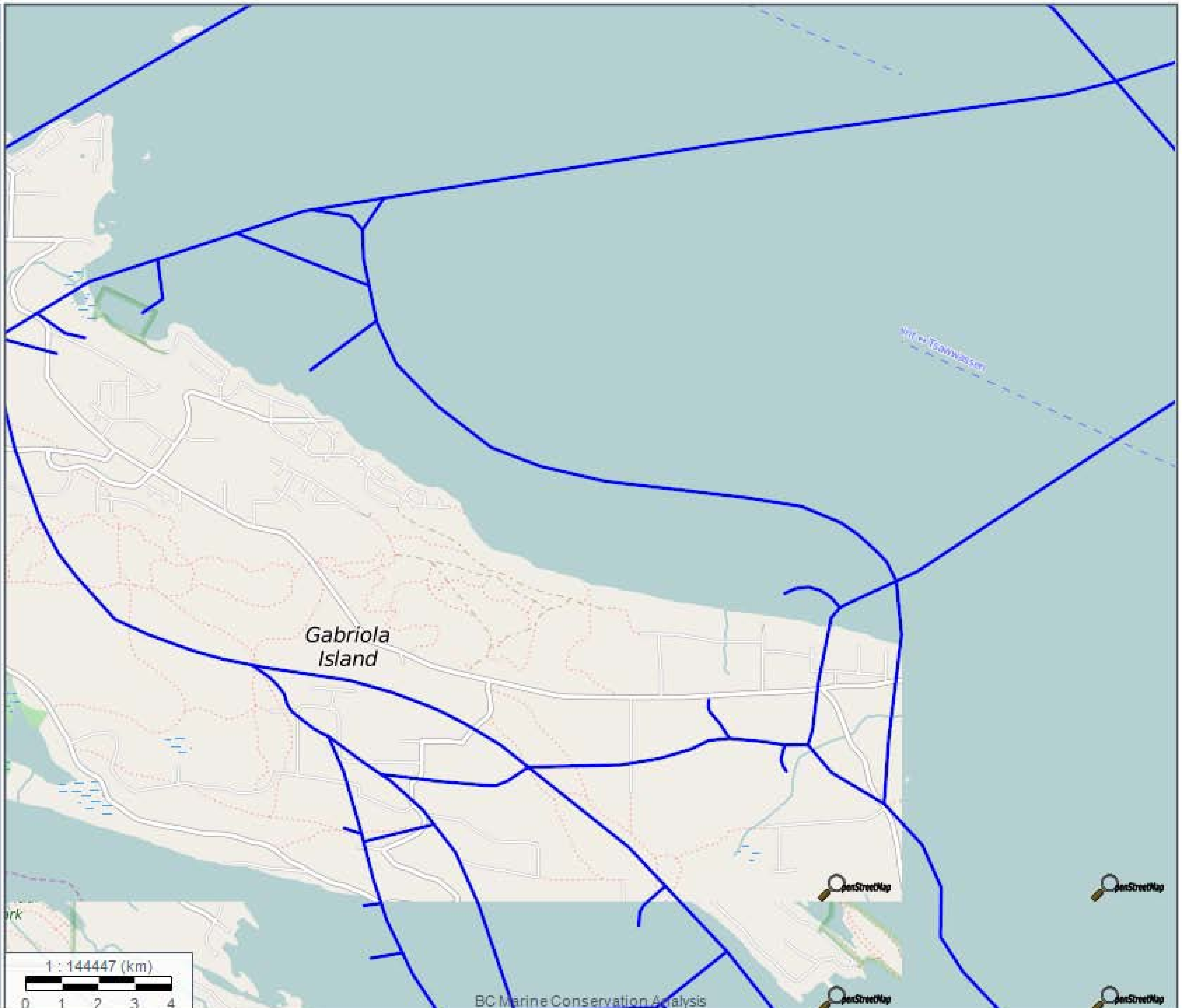


recreational boating routes

Legend

Recreational Boating Routes

- Unassigned
- Low
- Low to Moderate
- Moderate
- Moderate to High
- High



Scuba Diving Sites

Legend

Scuba Dive Sites

- Boat-based
- Shore-based
- Unknown