4.2.12.2 Assessment Indicators

For the purposes of the HHRA, the assessment indicators are people whose health might be adversely affected as a result of exposures to the chemical emissions originating from increased Project-related marine vessel traffic through the marine shipping lanes. The assessment indicators included both permanent residents living within the HHRA LSA, as well as area users who might frequent the area for recreation or other purposes. The permanent residents were separated into Aboriginal peoples and non-Aboriginal people, with the latter residents further separated into urban and non-urban dwellers. Additional details are available in Section 4.3.

4.2.12.3 Framework

The HHRA for the Project was performed step-wise following a conventional risk assessment paradigm that is recognized world-wide. Its use has been endorsed by a number of leading federal, provincial and regional regulatory health authorities, including Health Canada, Environment Canada, the Canadian Council of Ministers of the Environment, BC MOE, and the US Environmental Protection Agency. The paradigm consists of several steps, highlights of which are outlined below.

- Problem Formulation – This step is concerned with defining the scope and nature of the assessment, and setting practical boundaries on the work such that it is directed at the principal areas of concern. The step focuses on five major areas.
  - Identification of the Project components that potentially could release chemicals of potential concern (COPCs) into the environment in a manner that provides some opportunity for exposure of people to the chemicals.
  - Identification of the area potentially impacted by the chemical releases from the Project components or sources of interest.
  - Identification of the specific COPCs released from the Project that might contribute to potential health risks.
  - Characterization of the people who might be exposed to the COPC, particularily sensitive or susceptible individuals (*e.g.*, young children, the elderly, and individuals with compromised health).
  - Identification of all potential exposure pathways by which the people might be exposed to the COPC.
- Exposure Assessment - This step is concerned with estimating the level of exposure to the COPC that might be received via the various exposure pathways. The step often relies on one or more forms of predictive modeling to arrive at the exposure estimates, with specific reliance on air dispersion modeling in the case of COPC emissions to air. Distinction is made between exposures of a short-term (or acute) nature extending over a few minutes to several hours and long-term (or chronic) exposures lasting for several months or years, possibly up to a lifetime. Note that the definition of short-term and long-term for the purposes of the HHRA is different than that used for significance evaluation (refer to Table 4.3.1.2).

- Toxicity Assessment – This step is concerned with identifying and understanding the potential health effects that can be caused by each of the COPC (acting either singly or in combination), and the conditions under which the effects can occur. A principal outcome of this step is the determination of exposure limits for the COPC, which refer to the levels of exposure that would not be expected to cause harm. The limits are typically based on guidelines, objectives or standards established by reputable regulatory authorities responsible for the protection of public health, and incorporate a high degree of protection to accommodate even vulnerable members of the population.
- Risk Characterization – This step is concerned with quantifying the potential health risks that could be presented to the local residents or general public by comparing the exposure estimates determined as part of the exposure assessment to the corresponding exposure limits determined as part of the toxicity assessment.

When interpreting the results of any health risk assessment, it is important to understand the uncertainty that is intrinsic to the prediction of health risks. By convention, the HHRA accommodated this uncertainty, in part, through the use of assumptions that embrace a high degree of conservatism and are often intentionally selected to represent worst-case conditions. Using this approach, any health risks identified by the assessment are unlikely to be understated, but may be considerably overstated. As a result, where the potential health risks are determined as part of the HHRA to be negligible or low, it can be concluded with confidence that adverse health effects would not be expected; conversely, where the screening level assessment suggests that potential health risks are elevated, this does not necessarily mean that health effects are certain or imminent. It does; however, indicate that further assessment is necessary in order to determine the actual extent of the human health risks. The increased detail and complexity of the comprehensive assessment that will be submitted in early 2014 will serve to reduce the uncertainty associated with the more simplistic HHRA, and provide for more realistic and reliable estimates of the potential human health risks.

4.2.12.4 Existing Conditions

This subsection outlines the current health status of people residing in the Marine Air Quality RSA, with the information consisting of population-based health statistics compiled by several Canadian and US-based health agencies from healthcare data collected by health authorities in BC and Washington. The information served as a benchmark for assessing the potential health impacts that might occur among people in the area from exposure to the chemical emissions associated with the marine transportation component of the Project. It represents one of several benchmarks that were examined as part of the HHRA. The baseline health status is described principally in terms of two parameters, namely cancer and respiratory health, since these indices have been identified as two of the more commonly-cited health concerns and they are among the most relevant parameters for assessing the potential effects of exposures to emissions of the COPC from marine vessels. The information presents an overall picture of the general health of the population residing in the Marine Air Quality RSA in relation to the two parameters of interest.

4.2.12.4.1 Coastal British Columbia

The Marine Air Quality RSA includes areas covered by three regional Health Authorities, specifically the Fraser Health Authority (FHA), the Vancouver Coastal Health Authority (VCHA) and the Vancouver Island Health Authority (VIHA). The FHA extends south to BC's border with the US, north across the Fraser River to the municipalities of Mission, Maple Ridge, Pitt Meadows, Port Coquitlam, Coquitlam, Port Moody and Burnaby, west to the municipality of Delta, and east to Hope. The VCHA includes two distinct areas along the southern and central mainland coast of BC. The first of these areas spans the southern BC coastline from Delta in the south through the Sunshine Coast to the Village of Lund in the north, and extends inland to the community of D'Arcy in the west. The second area includes the mainland communities of Bella Bella and Bella Coola and the surrounding areas of BC's central mainland coast. The VIHA includes all of Vancouver Island as well as the mainland communities bound by the southern and central areas of the VCHA. A limitation of using the population-based health statistics compiled by these Health Authorities is that the geographical coverage provided extends well beyond the Marine Air Quality RSA. However, the information obtained from these Health Authorities is still considered to be representative of the health status of people residing within the Marine Air Quality RSA since many of the communities that fall inside the three regional Health Authorities are comparable to those located along the marine shipping lanes to be used by marine vessel traffic. When available, sub-regional data that better represent the Marine Air Quality RSA were obtained and described.

For the sub-regional data, reliance was placed on the Health Service Delivery Areas (HSDAs) that operate under the auspices of the regional Health Authorities. These HSDAs include the Fraser East and Fraser North HDSAs, the North Shore/Coast Garibaldi and Vancouver HSDAs, and the Central Vancouver Island and South Vancouver Island HSDAs that serve as part of the FHA, VCHA and VIHA, respectively.

Table 4.2.12.1 presents region-specific health statistics for health parameters considered to be particularly relevant for assessing the potential health impacts that can result from chemical exposures associated with marine vessel traffic. These parameters include certain cancers and other chronic conditions, notably chronic respiratory illnesses. It is important to note that all these conditions arise from a complex combination of genetics, lifestyle, ethnicity, environment and other factors such as age and gender.

TABLE 4.2.12.1

RATES OF SELECT HEALTH CONDITIONS

Health Authorities	Fraser[1]		Vancouver Coastal		Vancouver Island		British Columbia
Health Service Delivery Areas	Fraser East	Fraser North	North Shore/Coast Garibaldi	Vancouver	Central Vancouver Island	South Vancouver Island	
Population Profile[1]							
Population	286,758	616,412	287,432	668,690	265,979	374,674	4,573,321
Health Conditions[2,3]							
Bladder cancer incidence (A-S per 100,000)	17.5		14.1		22.2		18.7
Bladder cancer mortality (A-S per 100,000)	4.7		3.6		5.4		4.6
Lung cancer incidence[4] (A-S per 100,000)	49.0	53.8	47.5	46.0	50.3	47.5	48.8

TABLE 4.2.12.1

RATES OF SELECT HEALTH CONDITIONS (continued)

Health Authorities	Fraser[1]		Vancouver Coastal		Vancouver Island		British Columbia
Health Service Delivery Areas	Fraser East	Fraser North	North Shore/Coast Garibaldi	Vancouver	Central Vancouver Island	South Vancouver Island	
Lung cancer mortality (A-S per 100,000)	37.1		28.1		38.7		37.5
Liver cancer incidence (A-S per 100,000)	4.1		6.8		5.1		4.8
Liver cancer mortality (A-S per 100,000)	1.9		3.9		1.7		2.2
Leukemia incidence (A-S per 100,000)	12.3		11.2		9.5		11.6
Leukemia mortality (A-S per 100,000)	4.4		4.6		4.4		4.7
Ischemic heart disease death rate[5] (A-S per 100,000)	M 105.4 F 63.2	M 110.7 F 65.9	M 94.7 F 48.6	M 76.6 F 38.4	M 97.7 F 52.4	M 92.1 F 41.0	M 99.7 F 51.0
Asthma[6] (%)	9.4	6.5	7.6	7.9	7.5	7.8	7.5
Bronchitis, emphysema and asthma deaths[5] (A-S per 100,000)	3.2	2.4	1.7	2.0	4.9	3.7	2.8
Chronic Obstructive Pulmonary Disorder[6] (%)	6.6	2.4	--	2.1	5.6	2.8	3.8

Sources: BC Cancer Agency 2011, Statistics Canada 2013

Notes:
1 Data were available for year 2011
2 M = male, F = female
3 Data were available for year 2009, unless otherwise noted
4 Data were available for years 2007 to 2009
5 Data were available for years 2005 to 2007
6 Data were available for year 2009 to 2010

4.2.12.5 Aboriginal Traditional Knowledge

Hunting, fishing and plant gathering are important activities for Aboriginal Peoples and are undertaken for both subsistence and traditional purposes. These activities allow for connection to the land and water and facilitate cultural continuity, including the ability to participate in, and continue practices and activities passed down by previous generations. The practice of these activities enables the ability to pass on collective knowledge and use of the environment according to tradition to members of the youth. Members of coastal Aboriginal communities in southern BC have traditionally harvested marine fish, birds, mammals, invertebrates and seaweed throughout the Marine Air Quality RSA. These harvesting activities are important for food and other resources.

The consumption of these traditional marine foodstuffs by the coastal Aboriginal Peoples living along the marine shipping lanes was examined as part of the HHRA.

4.2.12.6 US Waters

The Marine Air Quality RSA captures portions of Washington, including the counties of Whatcom, Jefferson, San Juan Islands, and Clallam. Consistent with the approach taken for coastal BC, Table 4.2.12.2 presents region-specific health statistics for health endpoints considered to be particularly relevant for assessing the potential health impacts that can result from COPC associated with marine vessel traffic. The health parameters include certain cancers and other chronic conditions, notably chronic respiratory illnesses.

TABLE 4.2.12.2

RATES OF SELECT CHRONIC CONDITIONS

Counties	Whatcom	Jefferson	San Juan Islands	Clallam	Washington State Department of Health
Population Profile[1]					
Population	200,434	29,676	15,484	71,413	6,664,195
Health Conditions[2,3]					
Bladder cancer incidence (A-S per 100,000)	24.8	29.2	--	23.9	22.2
Bladder cancer mortality (A-S per 100,000)	4.3[4]	--	--	--	4.7
Lung and bronchus cancer incidence (A-S per 100,000)	62.2	61.7	--	74.6	63.4
Lung and bronchus cancer mortality (A-S per 100,000)	39.7	54.1	--	49.6	47.7
Liver and intrahepatic bile duct cancer incidence[5] (A-S per 100,000) 2006 to 2010	7.4	--	--	--	7.4
Liver and intrahepatic bile duct cancer mortality[5] (A-S per 100,000)	6.2	--	--	--	6.0
Leukemia incidence (A-S per 100,000)	15.7	--	--	13.2	14.1
Leukemia mortality (A-S per 100,000)	8.0	--	--	--	7.3
Ischemic heart disease death rate (A-S per 100,000)	96.5	88.5	48.4	97.9	105.8
Asthma [4] (%)	--	--	--	--	9.6
Pneumonia and influenza, death rate[6] (per 100,000)	12.5	13.4	13.0	14.3	10.1

Sources: Washington State Cancer Registry 2013, National Center for Health Studies 2013

Notes: 1 Data were available for year 2009

2 Rates for relevant diseases were searched; however, data was not available for the following diseases: cerebrovascular diseases death rate, bronchitis, emphysema and asthma deaths, and COPD

3 Data were available for years 2008 to 2010, unless otherwise noted

4 Data were available for years 2010

5 Data were available for years 2006 to 2010

6 Data were available for years 2004 to 2010

4.3 Effects Assessment – Marine Vessel Traffic Operations

The description of the environmental and socio-economic setting (current state of the environment) within the Project area (Section 4.2), is compared against the description of activities (Section 2.0) to assess potential environmental and socio-economic effects that might be caused by the Project. Since oil is currently transported by tanker from the Westridge Marine Terminal, the assessment focuses on the increased Project-related marine transportation, to assess the change the Project could potentially produce in the environment.

The environmental and socio-economic effects assessment (ESA) uses the information provided in the environmental and socio-economic setting and description of activities to:

- evaluate the environmental and socio-economic elements of importance in the Project area;
- identify relevant industry standards and legislation that reduce the magnitude of the potential effects and develop appropriate technically and economically feasible mitigation;
- identify and evaluate potential Project effects associated with each environmental and socio-economic element of importance; and
- identify the potential effects of the environment on the Project.

In addition, the ESA determines the significance of potential residual effects resulting from the increased Project-related marine vessel traffic after taking into consideration proposed mitigation.

4.3.1 Methodology

The assessment evaluates the environmental and socio-economic effects of the increased marine vessel traffic associated with the Project. The assessment method includes the following steps:

- describe the environmental setting;
- identify key environmental elements that could be affected;
- define the indicators and measurement endpoints to be used to assess each element;
- determine spatial and temporal boundaries for each element;
- identify potential environmental effects for each indicator;
- develop appropriate technically and economically feasible site-specific mitigation and, where warranted, restitution measures that are technically and economically feasible;
- predict anticipated residual effects; and
- determine the significance of residual effects.

Each of the above steps is described below in the applicable Methodology subsection. This environmental and socio-economic effects assessment methodology is based on the following:

- The Responsible Authority's Guide to the *Canadian Environmental Assessment Act*: Part II The Practitioner's Guide (Federal Environmental Assessment Review Office [FEARO] 1994a).
- FEARO's A Reference Guide for the *Canadian Environmental Assessment Act*: Addressing Cumulative Environmental Effects (FEARO 1994b).
- FEARO's A Reference Guide for the *Canadian Environmental Assessment Act*: Determining Whether a Project is Likely to Cause Significant Environmental Effects (FEARO 1994c).
- The CEA Agency Cumulative Effects Assessment Practitioners Guide (Hegmann *et al.* 1999).
- The CEA Agency's Incorporating Climate Change Considerations in Environmental Assessment (CEA Agency 2012).
- The CEA Agency's Addressing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act*, 2012 (CEA Agency 2013).
- The *CEA Act, 2012*.
- The NEB Filing Manual (NEB 2013c).
- NEB Issues List released July 2013 (NEB 2013a).
- Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Marine Shipping Activities, Trans Mountain Expansion Project (NEB 2013b).

An ESA Approach Summary document was released in March 2013. The intent of the document was to provide an overview of Trans Mountain's understanding of the environmental and socio-economic context of the Project at that time. More detail on the ESA Approach Summary document is found in Volume 3A. The methods, indicators and spatial boundaries for the environmental and socio-economic elements were reviewed based on feedback received on the ESA Approach Summary document from participants of the ESA Workshops, consultation with government agencies and engagement with Aboriginal communities.

The ESA of the Project is a collaborative effort of several qualified professionals with element-specific expertise, under the guidance of representatives of TERA. Table 4.3.1.1 acknowledges the contribution of these experts and professionals by environmental and socio-economic element.

TABLE 4.3.1.1

ENVIRONMENTAL AND SOCIO-ECONOMIC EFFECTS ASSESSMENT TEAM

Environmental/Socio-Economic Element	Assessor
Marine Sediment and Water Quality	Stantec
Marine Air Emissions	RWDI
Marine Greenhouse Gas (GHG) Emissions	RWDI
Marine Acoustic Environment	RWDI
Marine Fish and Fish Habitat	Stantec
Marine Mammals	Stantec
Marine Birds	Stantec
Marine Species at Risk	Stantec
Traditional Marine Resource Use (TMRU)	TERA
Marine Commercial, Recreational and Tourism Use (MCRTU)	Vista Strategy and TERA
Human Health Risk Assessment (normal operations)	Intrinsik
Accidents and Malfunctions	Stantec and TERA
Credible Worst Case and Smaller Marine Spill Scenarios (Sections 5.6 and 5.7)	Stantec, Intrinsik, and TERA
Changes to the Project Caused by the Environment	Stantec and TERA

4.3.1.1 Environmental and Socio-Economic Elements

The potential environmental (*i.e.,* biophysical) and socio-economic elements interacting with the Project are identified through: engagement with Aboriginal communities, regulatory authorities, stakeholders and the general public; experience gained from operation of marine tankers from the existing Trans Mountain system; available research literature; and the professional judgment of the assessment team. Issues noted during engagement with Aboriginal communities, federal regulatory authorities, stakeholders and the general public were essential in the determination of element interactions with the Project (Section 3.0).

Environmental and socio-economic elements potentially interacting with the Project include:

- physical elements such as marine sediment and water quality, marine air emissions, marine GHG emissions, and marine acoustic environment;
- biological elements such as marine fish and fish habitat, marine mammals, marine birds, and marine species at risk; and
- socio-economic elements such as TMRU and MCRTU.

Effects arising from potential accidents and malfunctions, and changes to the Project caused by the environment are also considered. The assessment of various marine spill scenarios on the environment, including an HHRA and an Ecological Risk Assessment (ERA), is provided in Section 5.0.

4.3.1.2 Assessment Indicators and Measurement Endpoints

Beanlands and Duinker (1983) suggest that it is impossible for an impact assessment to address all potential environmental effects of a project. Therefore, it is necessary that the environmental attributes considered to be important in project decisions be identified. Environmental impact assessments should be required to identify at the beginning of the assessment an initial set of indicators (sometimes called Valued Ecosystem Components [VECs] or Valued Social Components [VSCs]) to provide a focus for subsequent study and evaluation (Beanlands and Duinker 1983).

For this assessment, an indicator is defined as a biophysical, social or economic property or variable that society considers to be important and is assessed to predict Project-related changes and focus the impact assessment on key issues. One or more indicators are selected to describe the present and predicted future condition of an element. Societal views are understood by the assessment team through published information such as management plans and engagement with regulatory authorities, the public, Aboriginal communities and other interested groups.

The indicators for each element have been identified based on: the NEB Filing Manual (2013c) and other regulatory guidelines; experience gained during current operations of the Westridge Marine Terminal; feedback from Aboriginal communities, regulatory authorities, stakeholders and the general public; public issues raised through media; available research literature; and the professional judgment of the assessment team.

Quantitative or qualitative measurement of potential Project effects was completed using one or more ‘measurement endpoint’ (measurable parameter) identified for each indicator. The degree of change in these measurable endpoints is used to characterize and evaluate the magnitude of Project-related effects. A selection of measurement endpoints may also be the focus of monitoring and follow-up programs, where applicable.

4.3.1.3 Spatial and Temporal Boundaries

The environmental and socio-economic effects assessment considers the potential effects of the Project on the environment in the context of defined spatial and temporal boundaries. These boundaries vary with the issues and environmental elements or interactions to be considered, and reflect:

- the natural variation of a population or environmental or socio-economic indicator;
- the timing of sensitive life cycle phases in relation to the scheduling of the proposed physical activities;
- the time required for an effect to become evident;
- the time required for a population or environmental or socio-economic indicator to recover from an effect and return to a natural condition;
- the area directly affected by proposed physical activities; and
- the area in which a population or environmental or socio-economic indicator functions and within which a Project effect may be experienced.

4.3.1.3.1 Temporal Boundaries

The time frame of the assessment of the increased Project-related marine vessel traffic includes the operation phase, (*i.e.*, the time during which increased marine vessel traffic operations are expected to occur, or more than 50 years).

Since the assumed pipeline in-service date is December 2017, the assumed start date of the increased marine tanker traffic is also December 2017. The increased marine vessel traffic associated with the Project is estimated to extend for a term exceeding 50 years. A detailed schedule for the construction of the various Project components, including the Westridge Marine Terminal, is provided in Volume 5A, Section 2.0.

4.3.1.3.2 Spatial Boundaries

The spatial boundaries of the assessment of the Project consider the element-specific LSA or the RSA. The LSAs and RSAs were developed on an element-specific basis and, therefore, may vary between environmental and socio-economic elements. The definitions for each spatial boundary are provided in Table 4.3.1.2.

Individually established ecological boundaries are described within the discussions in Section 4.0 for each applicable biological or socio-economic element.

4.3.1.4 Potential Environmental and Socio-Economic Effects

The potential environmental and socio-economic effects resulting from the Project are identified through: consultation and engagement with Aboriginal communities, government agencies, stakeholders and the general public; experience gained from operation of marine tankers from the existing Trans Mountain system; scientific studies; and the professional judgment of the assessment team.

The potential environmental and socio-economic effects arising from the increased Project-related marine vessel traffic are identified in Section 4.3.2.

TABLE 4.3.1.2

EVALUATION OF THE SIGNIFICANCE OF RESIDUAL EFFECTS - ESA CRITERIA[1]

Assessment Criteria	Definition
IMPACT BALANCE – of the Residual Effect	
Positive	Residual effect is considered to have a net benefit to the environmental or socio-economic indicator.
Neutral	Residual effect is considered to have no net benefit or loss to the environmental or socio-economic indicator.
Negative	Residual effect is considered to be a net loss or a detriment to the environmental or socio-economic indicator.
SPATIAL BOUNDARY - Location of Residual Effect	
Footprint	The area directly disturbed by surveying, construction and clean-up of the pipeline and associated physical works and activities (including, where appropriate, the permanent rights-of-way, pump stations, tanks, Westridge Marine Terminal, temporary construction workspace, dredging, filling, temporary stockpile sites, temporary staging sites, construction camps, access routes and power lines)
LSA	The zone of influence (ZOI) or area where the element and associated indicators are most likely to be affected by Project construction and operation. This generally represents a buffer from the centre of the proposed pipeline corridor or marine shipping lanes.

TABLE 4.3.1.2

EVALUATION OF THE SIGNIFICANCE OF RESIDUAL EFFECTS - ESA CRITERIA (continued)

Assessment Criteria		Definition
RSA		The area extending beyond the LSA boundary where the direct and indirect influence of other activities could overlap with project-specific effects and cause cumulative effects on the environmental or socio-economic indicator. This varies for each element. For the marine transportation component, the RSA extends from the Westridge Marine Terminal to the 12 nautical mile limit and is of variable width extending from the marine shipping lanes, depending on the indicator.
Provincial		The area extending beyond regional or administrative boundaries but confined to Alberta and BC (*e.g.,* provincial permitting boundaries).
National		The area extending beyond Alberta and BC but confined to Canada.
International		The area extending beyond Canada.
TEMPORAL CONTEXT		
Duration – (period of the event causing the effect)	Immediate	Event is limited to less than or equal to two days during either the construction phase or operations phase.
	Short-term	Event occurs during the construction phase or is completed within any one year during the operations phase.
	Long-term	Ongoing event that is initiated during the construction phase and extends beyond the first year of the operations phase or is initiated during the operations phase and extends for the life of the Project.
Frequency[2] - (how often would the event that caused the effect occur)	Accidental	Event occurs rarely over assessment period.
	Isolated	Event is confined to a specified phase of the assessment period.
	Occasional	Event occurs intermittently and sporadically over the assessment period.
	Periodic	Event occurs intermittently but repeatedly over the assessment period.
	Continuous	Event occurs continually over the assessment period.
Reversibility – Environmental (period of time over which the residual effect extends)	Immediate	Residual effect is alleviated in less than or equal to two days.
	Short-term	Greater than two days and less than or equal to one year to reverse residual effect.
	Medium-term	Greater than one year and less than or equal to 10 years to reverse residual effect.
	Long-term	Greater than 10 years to reverse residual effects.
	Permanent	Residual effects are irreversible.
Reversibility – Socio-economic (period of time over which the residual effect extends)	Short-term	Residual effect limited to the construction phase or to less than any one year during operations phase.
	Medium-term	Residual effect extends more than one year but less than or equal to 10 years into the operations phase.
	Long-term	Residual effect extends beyond the first 10 years of the operations phase.
	Permanent	Residual effects are irreversible.
MAGNITUDE[3] - of the Residual Environmental Effect		
Negligible		Residual effects are not detectable from existing (baseline) conditions.
Low		Residual effects are detectable; however, are well within environmental and/or regulatory standards.
Medium		Residual effects are detectable and may approach; however, are still within the environmental and/or regulatory standards.
High		Residual effects are beyond environmental and/or regulatory standards.

TABLE 4.3.1.2

EVALUATION OF THE SIGNIFICANCE OF RESIDUAL EFFECTS - ESA CRITERIA (continued)

Assessment Criteria	Definition
MAGNITUDE[3] - of the Residual Socio-Economic Effect	
Negligible	No detectable change from existing (baseline) conditions.
Low	Change is detectable; however, has no effect on the socio-economic environment beyond that of an inconvenience or nuisance value.
Medium	Change is detectable and results in moderate modification in the socio-economic environment.
High	Change is detectable and is large enough to result in a severe modification in the socio-economic environment.
PROBABILITY OF OCCURRENCE - Likelihood of Residual Effect	
High	Likely.
Low	Unlikely.
LEVEL OF CONFIDENCE[4] - Degree of Certainty Related to Significance Evaluation	
Low	Determination of significance based on incomplete understanding of cause-effect relationships and incomplete data pertinent to the Project area.
Moderate	Determination of significance based on good understanding of cause-effect relationships using data from outside the Project area or incompletely understood cause-effect relationships using data pertinent to the Project area.
High	Determination of significance based on good understanding of cause-effect relationships and data pertinent to the Project area.

Notes:

1 **Significant Residual Environmental Effect:** A high probability of occurrence of a permanent or long-term residual effect of high magnitude that cannot be technically or economically mitigated.

Significant Residual Socio-economic Effect: A residual socio-economic effect is considered significant if the effect is predicted to be:

- high magnitude, high probability, short to medium-term reversibility and regional, provincial or national in extent that cannot be technically or economically mitigated; or
- high magnitude, high probability, long-term or permanent reversibility and any spatial boundary that cannot be technically or economically mitigated.

2 The assessment period for the effects assessment includes the lifetime of increased marine transportation activities while the assessment period for the cumulative effects assessment includes the above interval as well as the development, construction and operation phases of activities or projects that have previously occurred and those that are planned (publicly disclosed).

3 In consideration of magnitude, there is no environmental standard, threshold, guideline or objective for many of the marine transportation issues under evaluation. Therefore, the determination of magnitude of the adverse residual effect often entailed a historical consideration of the assessment of magnitude made by regulatory authorities, lessees, other stakeholders and the assessment team to adverse effects. The assessment team was also aware of the increasingly stringent societal norms related to environmental effects.

4 Level of confidence was affected by availability of data, precedence and degree of scientific uncertainty or other factors beyond the control of the assessment team.

The assessment of the increased Project-related marine vessel traffic is based on conservative assumptions. If there are substantive changes from the assumptions used in the ESA resulting from changes in Project design, additional assessment and regulatory consultation may be warranted.

4.3.1.5 Mitigation Measures

Mitigation measures, as defined under the *CEA Act, 2012*, means measures for the elimination, reduction or control of a project's adverse environmental effects, including restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means.

To ensure that the severity of potential adverse environmental and socio-economic effects is reduced, mitigation measures are recommended in this ESA based upon current industry accepted standards, consultation with government agencies, interested groups and individuals, engagement with Aboriginal communities, and the professional judgment of the assessment team.

Many of the mitigation measures presented in this ESA are to be/have been discussed with Aboriginal leaders or others that have been involved in specific supporting environmental and socio-economic studies. A comprehensive review of all the issues that have been raised by each community and the mitigation measures proposed are to be or have already been conducted (Section 3.0). Meetings will be held to confirm additional issues of concern identified through ongoing engagement with potentially affected Aboriginal communities. Additional issues of concern will be considered for incorporation into Project planning under the guidance of existing marine transport legislation and mitigation recommendations made to date and will be reported in the TMRU supplemental studies and submitted to the NEB (Section 4.5).

Mitigation measures are outlined in the Project effects assessment. Mitigation measures recommended or detailed in element-specific technical reports are incorporated into the assessment. Various international and federal regulatory authorities, and industry-accepted standards and guidelines are considered in the ESA, and are referenced for each element.

It is expected that through the engagement program, additional issues related to the Project may be identified and further mitigation measures may be determined. Any additional mitigation measures developed as a result, if any are deemed necessary, will be included in supplemental information submitted to the NEB (Section 4.5).

For the purposes of the marine transportation assessment, since Trans Mountain has little direct control over the actions of vessel owners and operators, mitigation is considered to include existing regulations and shipping standards that are monitored by several federal and international authorities (*e.g.*, PMV, the PPA, the CCG, Transport Canada, and the IMO).Trans Mountain expects that through its tanker acceptance process the calling vessels are maintained and operated to high industry standards. See Section 1.4.1 for a description of relevant regulatory authorities.

Since Project activities for marine transportation are limited to designated shipping lanes, regional planning documents are assumed not to be directly relevant. However, planning documents for marine environments under federal and provincial jurisdiction within the Marine RSA considered relevant to the Project include the following.

- BIEAP Annual Report (2012);
- BIEAP's Consolidated Environmental Management Plan (2011);
- BIEAP's Fraser River Estuary Management Plan (2003);

- Canadian Parks and Wilderness Society's First Nations and Marine Protected Areas (2009);
- Parks Canada's Feasibility Study for the Proposed Southern Strait of Georgia National Marine Conservation Area Reserve (ongoing);
- DFO's Integrated Fisheries Management Plans (various);
- DFO's Aboriginal Fisheries Strategy;
- DFO's Aboriginal Aquatic Resource and Oceans Management Program;
- Government of British Columbia plans, including Provincial Marine Protected Areas in British Columbia (2001); and
- British Columbia Ministry of Sustainable Resource Management's Provincial Marine Protected Areas in British Columbia.

4.3.1.6 Residual Effects

As defined in the NEB Filing Manual (NEB 2013c), residual effects are the environmental and socio-economic effects that are present after mitigation and enhancement measures are applied. Mitigation measures may be predicted to mitigate the potential adverse effect or the mitigation measures may lessen, but not entirely eliminate the effects. Elements for which no residual effects are predicted require no further analysis.

4.3.1.7 Significance Evaluation of Potential Residual Effects

The determination of the significance of potential residual effects generally followed the guidelines and principles provided by the NEB, CEA Agency and FEARO documents listed in Section 4.3.1. The agencies identify several possible methods for the determination of whether residual environmental or socio-economic effects are significant. These include:

- the use of regulatory environmental standards, guidelines or objectives in relation to potential residual effects;
- the use of quantitative risk assessment;
- quantitative assessment of residual effects; and
- qualitative assessment of the residual effects.

Some elements can be assessed using the standards and guidelines method. However, where there are no standards, guidelines, objectives or other established and accepted thresholds to define quantitative rating criteria or where quantitative thresholds are not appropriate, the qualitative method that is based on available research literature is considered to be the appropriate method for determining the significance of the potential residual effects,. Consequently, the determination of significance is evaluated by developing a set of qualitative criteria based on those identified by Hegmann *et al.* (1999). These criteria are identified below and their definitions are presented in Table 4.3.1.2.

- Spatial boundary (*i.e.,* the geographic extent in the element-specific LSA or RSA).

- Temporal context (*i.e.,* duration and frequency of the event causing the residual effect, reversibility of the residual effect). Note that the reversibility criteria for potential socio-economic effects have been modified subsequent to the release of the ESA Summary Approach document in March 2013.
- Magnitude (*i.e.,* severity of the residual effect in relation to environmental and/or regulatory standards or modification to the socio-economic environment).
- Probability or likelihood of occurrence of the residual effect.
- Level of confidence or uncertainty (*i.e.,* availability of data to substantiate the assessment conclusion, previous success of mitigation measures).

Ecological context (*e.g.,* levels of existing disturbance; resilience of the receiving environment) is not included in Table 4.3.1.2. However, ecological context is provided in Section 4.3.3 for each applicable element.

For environmental elements, a significant residual effect has a high probability of occurrence, is permanent or reversible in the long-term, is of high magnitude and cannot be technically or economically mitigated.

For socio-economic elements, a residual effect is considered significant if the effect is predicted to be:

- high magnitude, high probability, short to medium-term reversibility and regional, provincial or national in extent and cannot be technically or economically mitigated; or
- high magnitude, high probability, long-term or permanent reversibility, within any spatial boundary and cannot be technically or economically mitigated.

The impact balance or direction (*i.e.,* determination as to whether the effect is positive, neutral or negative) was also established for each predicted environmental and socio-economic residual effect. A positive effect balance is considered to have a net benefit to the environment or socio-economic indicator. A neutral balance is defined as no net benefit or loss to the environment or socio-economic indicator, while a negative balance is considered to be a net loss or detriment to the environment or socio-economic indicator.

All significance assessment criteria (*e.g.,* temporal context and magnitude) are considered by the assessment team for each residual environmental or socio-economic effect. Where appropriate, the key or most influential assessment criteria used to determine the significance of each residual effect are identified. It should be noted that the determination of a “not significant residual effect” is based on a pre-defined approach that incorporates magnitude, probability, reversibility and extent. However a “not significant residual effect” determination does not mean that the potential residual effect is not important to one or more Aboriginal communities, government agencies or stakeholders.

For the Project effects assessment, an evaluation of combined adverse residual effects is conducted for those indicators where more than one identified potential adverse residual effect may occur. The evaluation of the combined effects considers only those residual effects that are likely to occur (*i.e.,* of high probability). A discussion of the combined effects is included in each subsection, where relevant. In addition, the overall effects of the Project on the element are evaluated in consideration of the objectives or goals of applicable land and resource use management plans and government policies.

The extent to which professional judgment of the assessment team is used in the evaluation of significance of potential environmental and socio-economic residual effects is provided for each element. For this Project, the assessment team consisted of discipline experts, the TERA Project Manager, experienced assessment practitioners and senior reviewers.

A summary of the significance evaluation for residual environmental and socio-economic effects arising from the increased Project-related marine vessel traffic is provided in Section 4.3.3. It should be noted that the significance evaluation focuses on the potential residual effects resulting from the increased Project-related marine vessel traffic, recognizing that oil is currently transported by tanker from the Westridge Marine Terminal.

Using the assessment methodology described in Section 4.3.1, the following subsections evaluate the potential environmental and socio-economic effects associated with the increased Project-related marine vessel traffic.

Environmental and socio-economic elements potentially interacting with the increased Project-related marine vessel traffic are identified in Table 4.3.1.3. This table also indicates where elements listed in the NEB Filing Manual (2013c) are considered in the elements assessed for the increased Project-related marine vessel traffic. Since this assessment is of a different nature than projects that generally fall under the NEB Filing Manual (2013c), not all elements are considered (*i.e.*, physical and meteorological environment, soils, wetlands and heritage resources). This is consistent with direction given in the NEB's Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Marine Shipping Activities, Trans Mountain Expansion Project (NEB 2013b).

TABLE 4.3.1.3

ELEMENT INTERACTION WITH THE PROPOSED MARINE TRANSPORTATION COMPONENT

Element	Interaction with Marine Transportation	NEB Element(s) Considered
Marine Sediment and Water Quality	Yes	Water quality and quantity
Marine Air Emissions	Yes	Air emissions
Marine GHG Emissions	Yes	GHG emissions
Marine Acoustic Environment	Yes	Acoustic environment
Marine Fish and Fish Habitat	Yes	Fish and fish habitat; vegetation
Marine Mammals	Yes	Wildlife and wildlife habitat
Marine Birds	Yes	Wildlife and wildlife habitat
Marine Species at Risk	Yes	Wildlife and wildlife habitat; species at risk
TMRU	Yes	Vegetation; wildlife and wildlife habitat; traditional land and resource use

TABLE 4.3.1.3

ELEMENT INTERACTION WITH THE PROPOSED MARINE TRANSPORTATION COMPONENT (continued)

Element	Interaction with Marine Transportation	NEB Element(s) Considered
MCRTU	Yes	Human occupancy and resource use; social and cultural well-being; human health and aesthetics; infrastructure and services; employment and economy, navigation and navigation safety

The potential environmental and socio-economic effects associated with the increased marine vessel traffic, as well as the proposed mitigation measures and resulting residual effects on the environmental and/or socio-economic indicator, are presented in the following subsections for each environmental and socio-economic element as well as for accidents and malfunctions. In addition, the evaluation of significance using the criteria presented in Table 4.3.1.2 for the potential residual effects associated with the applicable environmental and socio-economic elements is also provided. A description of the potential effects of credible worst case and smaller marine spill scenarios, including an HHRA and an ERA, is provided in Section 5.0.

4.3.1.7.1 Transboundary Effects

Potential effects of the increased Project-related marine vessel traffic in the US are discussed under each element subsection. Where the effects are considered to be similar in Canadian and US waters for a particular element, the discussion of US waters refers back to the discussion of potential effects in Canadian waters. See Section 4.2 for environmental and socio-economic setting information for the US.

4.3.1.7.2 Environmental Conditions Not Considered

Based on the NEB Filing Manual (2013c) and preliminary discussions of potential effects, underwater noise was initially considered for inclusion in the marine transportation assessment as a stand-alone element as a counterpart to atmospheric noise. Since the potential effects of underwater noise are discussed under the marine fish and fish habitat and marine mammals elements, underwater noise was not included as a stand-alone element in the marine transportation assessment. Underwater noise related to marine birds was included in the assessment of sensory disturbance (Section 4.3.8.4).

4.3.2 Marine Sediment and Water Quality

Marine water and sediment quality are important components of the marine environment, since they provide the physical elements that support aquatic life. Contaminants that are introduced from human activities, such as releases from vessels and discharges from land-based activities (*e.g.*, industrial, municipal waste water, runoff from urban and agricultural areas), can alter water or sediment quality and present an increased risk of toxicity to marine organisms. For normal marine transportation operations, the assessment focuses on the potential for introduction of contaminants from vessels travelling to and from the Westridge Marine Terminal. Release of bilge water and erosion of marine paints from marine vessels are potential contaminant sources associated with routine shipping activities. Any release of bilge water containing fuels, oils and/or lubricants from vessels would be accidental, and is addressed in Section 4.3.13.

Potential concerns with ballast water are related to introduction of non-native invasive species, not contaminants, and are addressed in Section 7.6 of Volume 5A.

Bilge water and marine paints were well-known historical sources of contaminants and their presence is reflected in baseline conditions. These marine contaminants are now governed through legislation, as discussed in Section 4.2.2 and summarized here.

- Release of bilge water is regulated through the *Canada Shipping Act,* 2001 *(Vessel Pollution and Dangerous Chemicals Regulations)*. Bilge water must be treated prior to release to remove hydrocarbons (oils, grease, fuel).
- Use of marine anti-fouling paints is regulated through the IMO and through the *Canada Shipping Act,* 2001 *(Vessel Pollution and Dangerous Chemicals Regulations)*.

The *Canada Shipping Act,* 2001 (*Vessel Pollution and Dangerous Chemicals Regulations*) applies to Canadian vessels operating in all waters and to all vessels operating within Canadian waters. Bilge water must be treated by filtration or oily water separating equipment prior to release to remove hydrocarbons (oils, grease, fuel) to not more than 15 mg/L (applicable to discharges into waters other than inland waters). Release of oily water containing more than 15 mg/L of oil (total oil and grease) would be treated as accidental (see Section 4.3.13). Anti-fouling systems, mainly anti-fouling paints, are used in the marine transportation industry to control growth of aquatic organisms (*e.g.*, algae, mussels, barnacles and other invertebrates) on vessel hulls. They are used to avoid introduction of alien invasive species into foreign waters and to improve transportation efficiencies (heavy growth of organisms increases the surface drag, which increases fuel consumption and increases air emissions [Taylan 2010]). The paint is effective in two ways: a toxicological effect associated with a biocide (fungicide, bactericide, insecticide) such as the organotin compound tributyl tin (TBT); and the physical effect related to mechanical wearing away of the paint (making it difficult for organisms to remain attached to the hull).

Environmental concerns identified with use of TBT led to its prohibition in 2008 (IMO 2013b). The TBT is an effective biocide, released continuously from the paint to ensure its efficacy (US EPA 2003), but it is also released when paint sloughs off the hull. This has led to concerns, particularly in harbours, where many vessels are present year round, as the paint is deposited on sediment and TBT continues to leach into the water, affecting marine organisms. Butyltins can adversely affect development and growth of many species through exposure in the water column or sediment and through ingestion of contaminated organisms in the food chain (Leung *et al*. 2006, Morton 2009, Oehlmann *et al*. 1996). Marine birds with elevated TBT in their tissue have been shown to have reduced body condition, which may prevent them from migrating and breeding, leading to reduced population size (Elliott *et al*. 2007).

The IMO developed an *International Convention on the Control of Harmful Anti-Fouling Systems on Ships*, prohibiting the application or reapplication of anti-fouling systems acting as biocides as of January 1, 2008. Since then, all vessels over 400 GT-bearing organotin anti-fouling systems have had the organotin paint removed or coated to create a barrier preventing leaching (IMO 2013b). Canadian legislation regulates the use of organotins through the *Vessel Pollution and Dangerous Chemicals Regulations (SOR/2012-69)*, within the *Canada Shipping Act, 2001*. The *Regulations* mirror the IMO *Convention* (Transport Canada 2010). Since the ban of organotin as an active ingredient in anti-fouling paints in 2008, numerous studies have confirmed the effectiveness of the ban (Choi *et al*. 2013, Law *et al*. 2012, Morton 2009, Verhaegen *et al*. 2011). Within Canada, historical use has left measurable concentrations in some harbours; however, levels decrease over time, through physical (photolysis) and biological pathways (Hoch 2001). Effects of Project-related marine vessel traffic on marine water and sediment quality are not assessed further in this subsection since the activities that can be potential sources of contaminants are highly regulated; if present, the contaminants would occur at levels below a regulated threshold that would not create a concern. In Canadian and international waters, Project-related marine vessels are governed by MARPOL (IMO 2013c), to which Canada is a signatory. MARPOL has been in force since 1983, and is aimed at preventing and minimizing pollution from accidents and routine operations. MARPOL annexes cover oil, noxious liquid substances in bulk, harmful substances in packaged form, sewage, garbage, and air emissions.

Strict compliance with pollution prevention provisions of the *Canada Shipping Act,* 2001 and MARPOL by Project-related marine vessels will restrict harmful effects of marine water and sediment quality by these vessels during marine transportation operations. While KMC can actively enforce vessels docked at the Westridge Marine Terminal to comply with KMC operating practices and standards, once the vessel departs from the Westridge Marine Terminal, KMC has no authority over the operating practices of the vessel. Marine transportation in Canadian waters is authorized and regulated through the *Canada Shipping Act,* 2001 and related legislation and regulations administered by Transport Canada (TC) and the CCG. Consequently, mitigation to reduce the potential effects of the increased Project-related marine vessel traffic is the primary responsibility of regulatory authorities charged with administration of various marine regulations and laws on the west coast of Canada. Trans Mountain will encourage awareness and information sharing about Project-related shipping with other marine commercial, recreational and tourism users through the Chamber of Shipping of British Columbia's website.

4.3.2.1 United States Waters

Contaminant sources and concentrations are expected to be similar in US and Canadian waters, given the similar types of activities in the transboundary waters of Juan de Fuca Strait. Potential effects related to marine sediment and water quality are not expected to differ between Canada and the US. Potential concerns with ballast water are addressed in Section 7.6 of Volume 5A and potential concerns associated with the accidental release of bilge water are addressed in Section 4.3.13 of this volume.

4.3.3 Marine Air Emissions

Activities that occur during the marine operations phase have the potential to affect air quality, therefore, Project interactions with air quality were assessed. The Project will result in the following marine air emissions:

- Criteria air contaminants (CACs), a group of commonly found contaminants typically formed from combustion for which there are ambient air quality criteria, including particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2); and
- volatile organic compounds (VOCs), a group of organic compounds with sufficiently high vapour pressures under ambient conditions to evaporate from the liquid form of the compound and enter the surrounding air and participate in atmospheric photochemical reactions.

Combustion of fuel in the tanker engines and boilers will create CAC emissions. VOCs are released to atmosphere from evaporative losses of product from tanker holds and incomplete combustion of fuel. Ambient air quality objectives have been created for the CACs and VOCs of interest which are based on the potential for environmental and/or human health effect. Emissions were estimated based on a reasonable maximum operating scenario and concentrations were predicted using a dispersion model for operations only. This subsection considers the potential for marine air emissions to the atmospheric environment to change ambient air quality concentrations due to the increased Project-related marine vessel traffic.

4.3.3.1 Assessment Indicators and Measurement Endpoints

The assessment indicators and measurement endpoints used for the marine air quality assessment are summarized in Table 4.3.3.1.

The main air emissions associated with increased marine tanker traffic due to the Project are CACs and VOCs. Combustion of fossil fuels in main and auxiliary engines onboard tankers and tugboats are a source of CACs, including PM, CO, NO_2, and SO_2 and VOCs, including benzene, toluene, ethyl benzene, and xylene, known collectively as BTEX. In addition, fugitive emissions of VOCs are associated with tanker holds during transit.

In addition to these direct emissions from the Project, secondary pollutants will be formed from reactions between these primary pollutants in the atmosphere. In the presence of sunlight, pre-cursors such as nitrogen oxides (NO_X) and VOCs undergo a complex sequence of reactions to form ozone. Secondary PM can be formed from reactions between NO_X, sulfur oxides (SO_X) and ammonia. Primary and secondary PM can absorb and scatter sunlight, causing haze and obscuring visibility.

TABLE 4.3.3.1

ASSESSMENT INDICATORS AND MEASUREMENT ENDPOINTS FOR MARINE AIR EMISSIONS

Marine Air Emissions Indicator	Measurement Endpoint	Rationale for Indicator Selection
Primary emissions of criteria air contaminants	• Emissions from increased Project-related marine vessel traffic and comparison to emissions from existing marine traffic • Predicted levels of ground-level concentrations and comparison to ambient air quality criteria	The selection of indicators and measurement endpoints considered NEB Filing Manual requirements under the air emissions element in Table A-2, addressed concerns of participants of the ESA Workshops and was informed by government agencies (*i.e.*, Environment Canada, BC MOE, Metro Vancouver, Fraser Valley Regional District, PMV).
Primary emissions of volatile organic compounds	• Emissions from increased Project-related marine vessel traffic and comparison to emissions from existing marine traffic • Predicted levels of ground-level concentrations and comparison to ambient air quality criteria and odour thresholds	
Formation of secondary particulate and ozone	• Predicted levels of ambient ground-level concentrations and comparison to ambient air quality criteria	
Visibility	• Predicted change in light extinction	

4.3.3.2 Spatial Boundaries

Spatial boundaries for the assessment of potential Project effects on marine air emissions are as defined in Section 4.2.3.1, and as illustrated on Figure 4.2.4.

- **Marine Air Quality RSA** - a 150 km × 150 km area. The Marine Air Quality RSA is generally centered on the marine shipping lanes, which extend from the Westridge Marine Terminal through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, westward past Victoria and Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea.
- **LFV** - a 412 km × 688 km area at 4 km resolution centred on the LFV and covering southern BC and northern Washington State, including Vancouver Island, Juan de Fuca Strait and the Salish Sea. This inner domain is embedded in a larger 1,068 km × 840 km intermediate domain at 12 km resolution covering the southern half of BC plus Washington and Oregon states in the US. The intermediate domain is embedded in a 3,420 km × 3,348 km parent domain at 36 km resolution covering much of western North America including BC and Alberta, and the US Pacific states. Emissions scenarios for TMEP will be implemented over the inner 4 km resolution domain, with the boundary condition determined from baseline 36 km and 12 km model results.

The Marine Air Quality RSA includes the entire area in which shipping lanes are relatively defined, marine emissions will occur and can be reasonably represented in dispersion modelling. Beyond this point, shipping lanes will diverge into international waters depending on the destination. The RSA was specified based on discussions with PMV and has been approved as part of the detailed model plan for BC regulatory authorities (*i.e.*, Metro Vancouver and the BC MOE). The Marine Air RSA also follows guidance indicated by the NEB in the letter titled Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Increased Marine Shipping Activities, received by Trans Mountain on September 10, 2013. The letter indicates that the marine transportation assessment should extend to the 12 nautical mile limit of Canada's territorial seas.

For the photochemical modelling and CALPUFF modelling of formation of $PM_{2.5}$ and ozone, a larger modelling domain was created that includes the LFV as defined above. This larger domain was selected to account for a broader set of emissions from residential, transportation, and industrial sources, changes in land use and terrain, and varying meteorological conditions. In addition, the larger domain allows adequate time for atmospheric chemical reactions and allows for predictions at locations well outside the Marine Air Quality RSA. The LFV spatial boundary takes into account the results of consultation conducted to date with the Fraser Valley Regional District as well as BC MOE and Environment Canada. This regional model domain (LFV) is also consistent with an earlier study conducted by UBC (Steyn *et al.* 2011).

4.3.3.3 Marine Air Emissions Context

The shipping lanes to be used for the Project are well travelled routes that channel marine vessel traffic from open ocean through Juan de Fuca Strait to the BC Lower Mainland. The 2005 Corbett inventory provides an estimate of existing emissions from marine vessel traffic in the Marine Air Quality RSA and is modelled to provide context for increased emissions from the Project-related marine vessel traffic.

In addition to other existing marine traffic along the shipping lanes, there are other anthroprogenic and natural sources of CAC and VOC emissions in the Marine Air Quality RSA, primarily concentrated in the populated areas of Vancouver, Victoria, Duncan and Nanaimo. The man-made types of emissions are related to vehicle transportation, residential emissions like lawn mowers, small commercial facilities like restaurants, and dry cleaning and larger industrial plants (*i.e.*, cement, asphalt, etc).

Existing air quality conditions can be defined by ambient measurements from several stations that have been operating for a number of years. Ambient monitoring data of CACs are available from a number of stations operated by Metro Vancouver and the BC MOE. These stations are centered in urban areas and, therefore, it was deemed impractical to use these data to determine a single background concentration for the entire Marine Air Quality RSA which encompasses a wide range of land uses including water, urban and agricultural areas. The stations selected to represent the air quality setting at urban areas within the Marine Air Quality RSA were Vancouver-Kitsilano, Victoria Topaz, Duncan-Cairnsmore and Nanaimo Labieux.

4.3.3.4 Potential Effects and Mitigation Measures

Potential effects associated with increased Project-related marine vessel traffic on marine air emissions indicators are listed in Table 4.3.3.2. These interactions are based on the results of the literature review, desktop analysis, modelling, engagement with Aboriginal communities, government agencies, and other stakeholders (Section 3.0), and the professional experience of the assessment team. Dispersion modelling results indicate that ambient concentrations of hydrogen sulphide (H_2S), mercaptans, and other odorous VOC species are well below odour thresholds. Therefore, an air emissions indicator for nuisance odours was not assessed.

No mitigation measures were considered warranted other than emission limits mandated on marine vessels as part of the North American Emissions Control Area.

TABLE 4.3.3.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE AIR EMISSIONS

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1. Marine Air Emissions Indicator – Primary Emissions of Criteria Air Contaminants			
1.1 Increase in CAC emissions	RSA	• All Project-related tankers are required to adhere to federal standards that may reduce air emissions, including standards for bunker fuel.	• Increase in ambient ground-level concentrations of CACs.
2. Marine Air Emissions Indicator – Primary Emissions of Volatile Organic Compounds			
2.1 Increase in VOC emissions	RSA	• All Project-related tankers are required to adhere to federal standards that may reduce air emissions, including standards for bunker fuel.	• Increase in ambient ground-level concentrations of VOCs.

TABLE 4.3.3.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE AIR EMISSIONS (continued)

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
3. Marine Air Emissions Indicator – Formation of Secondary Particulate Matter and Ozone			
3.1 Increased formation of secondary PM and ozone due to increased ambient concentrations of CACs and VOCs	LFV	• All Project-related tankers are required to adhere to federal standards that may reduce air emissions, including standards for bunker fuel.	• Increase in ambient ground-level concentrations of secondary PM. • Increase in ambient ground-level concentrations of ozone.
4. Marine Air Emissions Indicator – Visibility			
4.1 Increased light extinction	LFV	• All Project-related tankers are required to adhere to federal standards that may reduce air emissions, including standards for bunker fuel.	• Reduced visibility.

Note: 1 RSA = Marine Air Quality RSA; LFV = Lower Fraser Valley Photochemical Model Domain.

4.3.3.5 Potential Residual Effects

The potential residual environmental effects on marine air emission indicators associated with increased Project-related marine vessel traffic are:

- increase in ambient ground-level concentrations of CACs;
- increase in ambient ground-level concentrations of VOCs;
- increase in ambient ground-level concentrations of secondary PM;
- increase in ambient ground-level concentrations of ozone; and
- reduced visibility.

4.3.3.6 Significance Evaluation of Potential Residual Effects

A quantitative assessment of marine air emissions using dispersion modelling (for CACs and VOCs) and photochemical modelling (for secondary PM, ozone and visibility) was determined to be the most appropriate approach to evaluate the significance of potential residual environmental effects, based on discussions with federal, provincial and local regulatory authorities. Details on the model approach and results are summarized in the Marine Air Quality and Greenhouse Gas – Marine Transportation Technical Report (Volume 8B, TR 8B-3).

After initiation of the marine air emissions modelling, and as a result of the quantitative risk assessment, Trans Mountain decided to consider the use of additional tug escort as a navigational safety measure to reduce the risk of an accidental spill from a laden Project-related tanker. Tug escort would be added for the entire route between the Westridge Marine Terminal and Buoy J where tugs are not currently used, as identified in Figure 5.3.2 and discussed in more detail in Section 5.3.2.1. Marine air emissions modelling numbers will be updated based on extended escort tug usage. Based on the professional judgment of the assessment team, the addition of the escort tug is not likely to change any of the significance conclusions presented for marine air emissions. Modeling results will be provided to the NEB in a supplemental filing in Q2 2014.

Table 4.3.3.3 presents the dispersion modelling results of increases in ambient concentrations of CACs and VOCs from increased Project-related marine vessel traffic. Values are shown separately for receptors over land and water. Note that the land-based receptors in this table are not the same as in the terrestrial assessment in Section 7 of Volume 5A, since the two RSAs and the Project-related emission sources are not identical. Regulatory standards are shown to facilitate the evaluation of the magnitude of the first two potential residual effects listed above: increases in ambient ground-level concentrations of CACs and of VOCs. Dependent on the location of the receptors with the maximum concentration shown in the table, the applicable regulatory authority is Metro Vancouver, the provincial government (BC), or the federal government. Therefore, standards for all three regulatory bodies are shown. Note that none of the three jurisdictions has regulatory standards for BTEX. Increases of CAC concentrations are mostly very small and none approach applicable regulatory standards. Therefore, the magnitude for these contaminants is evaluated as low. In the absence of regulatory standards for BTEX, a conservatively high assessment of medium magnitude was chosen.

TABLE 4.3.3.3

DISPERSION MODELLING RESULTS OF AMBIENT CAC AND VOC CONCENTRATIONS FROM EMISSIONS FROM INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC (EXPRESSED AS NET CHANGE FROM EXISTING CONDITIONS) AND COMPARISON WITH APPLICABLE REGULATORY STANDARDS (IN µG/M^3)

Pollutant	Averaging Period	Project, Over Land	Project, Over Water	MV Objective	BC Objective	National Objective[1]
Total Suspended Particulate (TSP)	24-hour	0.92	0.45	-	120	120
	Annual	0.20	0.08	-	60	60
Respirable Particulate Matter (PM_{10})	24-hour	0.90	0.44	50	50	-
	Annual	0.19	0.08	20	-	-
Inhalable Particulate Matter ($PM_{2.5}$)	24-hour	0.85	0.42	25	25	30, 28, and 27[2]
	Annual	0.18	0.07	8	8	10 and 8.8[3]
Carbon Monoxide (CO)	1-hour	16.2	21.8	30,000	14,300	15,000
	8-hour	18.6	8.3	10,000	5,500	6,000
Nitrogen dioxide (NO_2)	1-hour	80.3	82.7	200	-	400
	24-hour	50.8	27.5	-	-	200
	Annual	8.9	3.3	40	-	100
Sulphur Dioxide (SO_2)	1-hour	6.5	8.8	450	450	450
	24-hour	1.3	0.82	125	160	150
	Annual	0.27	0.10	30	25	30

TABLE 4.3.3.3

DISPERSION MODELLING RESULTS OF AMBIENT CAC AND VOC CONCENTRATIONS FROM EMISSIONS FROM INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC (EXPRESSED AS NET CHANGE FROM EXISTING CONDITIONS) AND COMPARISON WITH APPLICABLE REGULATORY STANDARDS (IN µG/M^3) (continued)

Pollutant	Averaging Period	Project, Over Land	Project, Over Water	MV Objective	BC Objective	National Objective[1]
Benzene	1-hour	1.0	1.1	-	-	-
	Annual	0.008	0.04	-	-	-
Ethylbenzene	1-hour	0.03	0.03	-	-	-
Toluene	1-hour	0.72	0.79	-	-	-
	24-hour	0.12	0.44	-	-	-
Xylenes	1-hour	0.25	0.27	-	-	-
	24-hour	0.04	0.15	-	-	-

Notes: 1 National objectives are NAAQO, with the exception of notes 2 and 3 below.

2 Values are the CWS effective since 2010 (30 µg/m3) and the CAAQS effective in 2015 (28 µg/m3) and 2020 (27 µg/m3). Metric is the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.

3 Values are the CAAQS effective in 2015 (10 µg/m3) and 2020 (8.8 µg/m3). Metric is the 3-year average of the annual average concentrations.

Table 4.3.3.4 presents the results of photochemical modelling of secondary ozone and $PM_{2.5}$ and visibility. Shown are the differences between model predictions with combined emissions from increased Project-related marine vessel traffic and operations at Burnaby, Sumas and Westridge Marine Terminals and without these emissions sources. The values provided are spatial maxima over all water-based receptors. The LFV and the Project-related emission sources are the same in the marine and terrestrial assessments. The assessment for land-based receptors is covered in the terrestrial assessment in Section 7 of Volume 5A and not repeated here. Concentration increases of ozone and $PM_{2.5}$ are small compared to current and future applicable standards; therefore their magnitude is rated low. No standard is applicable to visibility. A visibility reduction of one deciview (dv) is small but noticeable in a pristine environment with very good visibility (Colls and Tiwary 2009). The predicted visibility reduction of 2.6 dv in Table 4.3.3.4 is likely noticeable in the LFV, and a conservatively high assessment of medium magnitude was chosen.

TABLE 4.3.3.4

PHOTOCHEMICAL MODELLING RESULTS OVER WATER FOR OZONE, $PM_{2.5}$, AND VISIBILITY FOR COMBINED EMISSIONS FROM INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC AND OPERATIONS AT BURNABY, SUMAS, AND WESTRIDGE MARINE TERMINAL (EXPRESSED AS NET CHANGE FROM EXISTING CONDITIONS) AND COMPARISON WITH APPLICABLE REGULATORY STANDARDS

Indicator	Predicted[1]	CWS (2010)	CAAQS (2015)	CAAQS (2020)
Ozone (maximum rolling 8-hour average in ppb)[2]	0.2	65	63	62
$PM_{2.5}$ (maximum 24-hour average in μg/m^3)[3]	0.1	30	28	27
Visibility (maximum 1-hour in dv)[4]	2.6	N/A	N/A	N/A

Notes: 1 Maximum increase over water in the LFV predicted from CMAQ modelling of a ten-day episode of strong secondary formation from June 24 to July 3, 2006, caused by Project emissions.

2 Metric in CWS and CAAQS is the 3-year average of the annual 4th highest daily maximum 8-hour average concentrations.

3 Metric in CWS and CAAQS is the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.

4 The dv is unitless. The dv scale is linear in relation to humanly perceived changes in visibility due to changes in air quality. For example, a 400 km visual range corresponds to 0.0 dv, while a 4 km visual range is about 46 dv.

Table 4.3.3.5 provides a summary of the significance evaluation of the potential residual environmental effects of the increase in Project-related marine vessel traffic on air emissions. The rationale used to evaluate the significance of each of the residual environmental effects is provided below.

TABLE 4.3.3.5

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE AIR EMISSIONS

Potential Residual Effects	Impact Bal	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
1. Marine Air Emissions Indicator – Primary Emissions of Criteria Air Contaminants									
1(a) Increase in ambient ground-level concentrations of CACs.	Negative	RSA	Long-term	Periodic	Short-term	Low	High	Moderate	Not significant
Marine Air Emissions Indicator – Primary Emissions of Volatile Organic Compounds									
2(a) Increase in ambient ground-level concentrations of VOCs.	Negative	RSA	Long-term	Periodic	Short-term	Medium	High	Moderate	Not significant
Marine Air Emissions Indicator – Formation of Secondary Particulate Matter and Ozone									
3(a) Increase in ambient ground-level concentrations of secondary PM.	Negative	LFV	Long-term	Periodic	Short-term	Low	High	Moderate	Not significant

TABLE 4.3.3.5

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE AIR EMISSIONS (continued)

Potential Residual Effects	Impact Bal	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
3(b) Increase in ambient ground-level concentrations of ozone.	Negative	LFV	Long-term	Periodic	Short-term	Low	High	Moderate	Not significant
3(c) Combined effects of increased Project-related marine vessel traffic on the formation of secondary particulate matter and ozone indicator (3[a] and 3[b]).	Negative	LFV	Long-term	Periodic	Short-term	Low	High	Moderate	Not significant
4. Marine Air Emissions Indicator – Visibility									
4(a) Reduced visibility.	Negative	LFV	Long-term	Periodic	Short-term	Medium	High	Moderate	Not significant
5. Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Air Emissions									
5(a) Combined effects of increased Project-related marine vessel traffic on the marine air emissions indicators(1[a], 2[a], 3[c] and 4[a]).	Negative	LFV	Long-term	Periodic	Short-term	Medium	High	Moderate	Not significant

Notes: 1 RSA = Marine Air Quality RSA; LFV = Lower Fraser Valley photochemical model domain

2 Significant Residual Environmental Effect: A high probability of occurrence of a permanent or long-term residual effect of high magnitude that cannot be technically or economically mitigated.

4.3.3.6.1 Marine Air Emissions Indicator - Primary Emissions of Criteria Air Contaminants

The increase in ambient ground-level concentrations of CACs is considered to have a negative impact balance. As shown in Table 4.3.3.5 point 1(a), the increase in ambient ground-level concentrations of CACs is confined to the Marine Air Quality RSA. Marine emissions are expected to change ambient concentrations of CACs periodically (*i.e.*, approximately twice daily) when Project-related marine vessel traffic enters and travels through the Marine Air Quality RSA. The change will be long-term in duration, reversible in the short-term as the marine vessel traffic leaves the Marine Air Quality RSA, and the magnitude is expected to be low. The probability of this occurring is high, and confidence in the residual effects assessment is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine Air Quality RSA – changes to ambient ground-level concentrations of CACs resulting from Project-related marine vessels are expected to occur within the Marine Air Quality RSA.
- **Duration** - long-term – emissions of CACs and subsequent changes to ambient ground-level concentrations are expected to occur for the life of the Project and; therefore, are considered long-term.

- **Frequency** - periodic – emissions of CACs will occur from Project-related marine vessels transiting through the Marine Air Quality RSA, which is expected to occur intermittently with approximately two vessel transits per day.
- **Reversibility** - short-term – emissions of CACs will cease and increases in ambient ground-level concentrations will reverse shortly after Project-related marine vessels exit the Marine Air Quality RSA.
- **Magnitude** - low – the increase in ambient ground-level concentrations of CACs is expected to be small relative to existing conditions and within regulatory limits; therefore, the magnitude of effect is rated as being low.
- **Probability** - high – an increase in Project-related marine vessel traffic will result in emissions of CACs.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between the Project and air emissions; however, vessel-specific data are limited.

4.3.3.6.2 Marine Air Emissions Indicator - Primary Emissions of Volatile Organic Compounds

The increase in ambient ground-level concentrations of VOCs is considered to have a negative impact balance. As shown in Table 4.3.3.5 point 2(a), the increase in ambient ground-level concentrations of VOCs is confined to the Marine Air Quality RSA. Marine emissions are expected to change ambient VOC concentrations periodically when Project-related marine vessel traffic travels through the Marine Air Quality RSA. The change will be long-term in duration, reversible in the short-term as the Project-related marine vessel traffic leaves the Marine Air Quality RSA, and the magnitude is expected to be medium. The probability of this occurring is high, and confidence in the residual effects assessment is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine Air Quality RSA – changes to ambient ground-level concentrations of VOCs resulting from Project-related marine vessels are expected to occur within the Marine Air Quality RSA.
- **Duration** - long-term – emissions of VOCs and subsequent changes to ambient ground-level concentrations are expected to occur for the life of the Project and, therefore, are considered long-term.
- **Frequency** - periodic – emissions of VOCs will occur from Project-related marine vessels transiting through the Marine Air Quality RSA, which is expected to occur intermittently with approximately two vessel transits per day.
- **Reversibility** - short-term – emissions of VOCs will cease and increases in ambient ground-level concentrations will reverse shortly after Project-related marine vessels exit the Marine Air Quality RSA.
- **Magnitude** - medium – the increase in ambient ground-level concentrations of VOCs is expected to be small relative to existing conditions; in the absence of regulatory standards to compare with, the magnitude of effect is rated conservatively as medium.

- **Probability** - high – an increase in Project-related marine vessel traffic will result in emissions of VOCs.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between the Project and air emissions; however, vessel-specific data are limited.

4.3.3.6.3 Marine Air Emissions Indicator - Formation of Secondary Particulate Matter and Ozone

The following subsections provide the evaluation of significance of the potential residual effects on the formation of secondary particulate matter and ozone indicator.

Increase in Ambient Ground-Level Concentrations of Secondary Particulate Matter

The increase in ambient ground-level concentrations of secondary PM is considered to have a negative impact balance. As shown in Table 4.3.3.5 point 3(a), the increase in ambient ground-level concentrations of secondary PM is confined to the photochemical model domain or LFV. Some of the marine emissions will contribute chemical pre-cursors for secondary pollutants periodically when Project-related marine vessel traffic travels through the Marine Air Quality RSA. The change will be long-term in duration, reversible in the short-term as the Project-related marine vessel traffic leaves the Marine Air Quality RSA, and the magnitude is expected to be low. The probability of this occurring is high, and confidence in the residual effects assessment is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - LFV – changes to ambient ground-level concentrations of secondary PM resulting from Project-related marine vessels are expected to occur within the LFV.
- **Duration** - long-term – emissions of pre-cursors from Project-related marine vessels and subsequent changes to ambient ground-level concentrations of secondary PM are expected to occur for the life of the Project and, therefore, are considered to be long-term.
- **Frequency** - periodic – formation of secondary PM resulting from the intermittent release of pre-cursor emissions associated with Project-related marine vessels with approximately two vessel transits per day.
- **Reversibility** - short-term – emissions of pre-cursors will cease and any increases in ambient ground-level concentrations of secondary PM will reverse shortly after Project-related marine vessels exit the Marine Air Quality RSA.
- **Magnitude** - low – the increase in ambient ground-level concentrations of secondary PM is expected to be small relative to existing PM concentrations and within regulatory limits; therefore, the magnitude of effect is rated as being low.
- **Probability** - high – an increase in Project-related marine vessel traffic will result in pre-cursor emissions, which will react to form secondary PM.

- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between Project pre-cursor emissions and resultant ambient PM concentrations via atmospheric reactions; however, vessel-specific data are limited.

Increase in Ambient Ground-Level Concentrations of Ozone

The increase in ambient ground-level concentrations of ozone is considered to have a negative impact balance. As shown in Table 4.3.3.5 point 3(b), the increase in ambient ground-level concentrations of ozone is confined to the photochemical model domain or LFV. Some of the marine emissions will contribute chemical pre-cursors for secondary pollutants periodically when Project-related marine vessel traffic travels through the Marine Air Quality RSA. The change will be long-term in duration, reversible in the short-term as the marine vessel traffic leaves the Marine Air Quality RSA, and the magnitude is expected to be low. The probability of this occurring is high, and confidence in the residual effects assessment is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - LFV – changes to ambient ground-level concentrations of ozone resulting from Project-related marine vessels are expected to occur within the LFV.
- **Duration** - long-term – emissions of pre-cursors and subsequent changes to ambient ground-level concentrations of ozone are expected to occur for the life of the Project and, therefore, are considered long-term.
- **Frequency** - periodic – formation of ozone due to intermittent release of pre-cursor emissions from Project-related marine vessel traffic will occur intermittently with approximately two vessel transits per day.
- **Reversibility** - short-term – emissions of pre-cursors will cease and increases in ambient ground-level concentrations of ozone will reverse shortly after Project-related marine vessel traffic exit the Marine Air Quality RSA.
- **Magnitude** - low – the increase in ambient ground-level concentrations of ozone is expected to be small relative to existing conditions and well below regulatory limits; therefore, the magnitude of effect is rated as being low.
- **Probability** - high – an increase in Project-related marine vessel traffic will result in an increase of pre-cursor emissions, which will react to form ozone.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between Project pre-cursor emissions and resultant ambient PM concentrations via atmospheric reactions; however, vessel-specific data are limited.

Combined Effects on Formation of Secondary Particulate Matter and Ozone Indicator

The combined effects of marine air emissions on the indicator of formation of secondary particulate matter and ozone indicator are considered to have a negative impact balance. As shown in Table 4.3.3.5 point 3(c), the increase in ambient ground-level concentrations of secondary PM and ozone is confined to the photochemical model domain or LFV. Some of the marine emissions will contribute chemical pre-cursors for secondary pollutants periodically when Project-related marine vessel traffic travels through the Marine Air Quality RSA. The change will be long-term in duration, reversible in the short-term as the marine vessel traffic leaves the Marine Air Quality RSA, and the magnitude is expected to be low. The probability of this occurring is high, and confidence in the residual effects assessment is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - LFV – changes to ambient ground-level concentrations of secondary PM and ozone resulting from Project-related marine vessels are expected to occur within the LFV.
- **Duration** - long-term – emissions of pre-cursors and subsequent changes to ambient ground-level concentrations of secondary PM and ozone are expected to occur for the life of the Project and, therefore, are considered long-term.
- **Frequency** - periodic – formation of secondary PM and ozone due to intermittent release of pre-cursor emissions from Project-related marine vessel traffic will occur intermittently with approximately two vessel transits per day.
- **Reversibility** - short-term – emissions of pre-cursors will cease and increases in ambient ground-level concentrations of secondary PM and ozone will reverse shortly after Project-related marine vessels exit the Marine Air Quality RSA.
- **Magnitude** - low – the increase in ambient ground-level concentrations of secondary PM and ozone is expected to be small relative to existing conditions and well below regulatory limits; therefore, the magnitude of effect is rated as being low.
- **Probability** - high – an increase in Project-related marine vessel traffic will result in an increase of pre-cursor emissions, which will react to form secondary PM and ozone.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between Project pre-cursor emissions and resultant ambient PM concentrations via atmospheric reactions; however, vessel-specific data are limited.

4.3.3.6.4 Marine Air Emissions Indicator - Visibility

Reduced visibility is considered to have a negative impact balance. As shown in Table 4.3.3.3 point 4(a), the increase in reduced visibility is confined to the LFV. Some of the marine emissions will contribute chemical pre-cursors that could lead to the formation of aerosols periodically when Project-related marine vessel traffic travels through the Marine Air Quality RSA. The change will be long-term in duration, reversible short-term as the marine vessel traffic leaves the Marine Air Quality RSA, and the magnitude is expected to be medium. The probability of this occurring is high and confidence in the residual effects assessment is moderate. As shown in Table 4.3.3.5 point 4(a), the reduced visibility is confined to the LFV. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - LFV – changes to visibility from Project-related marine vessel traffic are expected to occur within the LFV.

- **Duration** - long-term – emissions of pre-cursors causing light absorption are expected to occur for the life of the Project and, therefore, the duration of effect is considered long-term.
- **Frequency** - periodic – light absorption and reduced visibility due to intermittent release of pre-cursor emissions from Project-related marine vessels will occur intermittently with approximately two vessel transits per day.
- **Reversibility** - short-term – emissions of pre-cursors will cease and reduced visibility will reverse shortly after Project-related marine vessels exit the Marine Air Quality RSA.
- **Magnitude** - medium – the change in light extinction and visibility is expected to be small relative to existing conditions, and in the absence of regulatory limits, the magnitude of effect is rated conservatively as being medium.
- **Probability** - high – an increase in Project-related marine vessel traffic will result in an increase of pre-cursor emissions and secondary species, which will scatter light and reduce visibility.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between Project pre-cursor emissions and light absorption; however, vessel-specific data are limited.

4.3.3.6.5 Combined Effects on Marine Air Emissions

The combined effects on the marine air emissions indicators is considered to have a negative impact balance. Effects are assessed with a setting of high volume vessel activity within the Marine Air Quality RSA and with the standards set by the existing regulatory framework. The results of the marine air emissions assessment does not contradict any management objectives of established regional marine conservation plans. As shown in Table 4.3.3.5 point 5(a), the combined effects on the marine air emissions indicators are confined to the LFV for the photochemical products (visibility, ozone and $PM_{2.5}$), which includes the Marine Air Quality RSA. Marine emissions are expected to change ambient concentrations intermittently when tanker traffic travels through the Marine Air Quality RSA. The change will be long-term in duration, reversible short-term as the Project-related marine vessel traffic leaves the Marine Air Quality RSA, and the magnitude is expected to be medium. The probability of this occurring is high, and confidence in the residual effects assessment is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - LFV – changes to ambient concentrations associated with Project-related marine vessel traffic are expected to occur within the LFV, which includes the Marine Air Quality RSA.
- **Duration** - long-term – chemical emissions are expected to occur for the life of the Project; therefore, the duration of effect considered long-term.
- **Frequency** - periodic – Project effects on air emission concentrations due to release of emissions from Project-related marine vessel traffic will occur intermittently with approximately two tanker transits per day.

- **Reversibility** - short-term – emissions will cease and the effect on ambient concentrations will reverse shortly after the Project-related marine vessels exit the Marine Air Quality RSA.
- **Magnitude** - medium – the changes in ambient concentrations are expected to be small relative to existing conditions; no applicable regulatory limits are approached; for some residual effects, no regulatory standards are applicable, and, therefore, the magnitude of effect is rated conservatively as being medium.
- **Probability** - high – an increase in Project-related marine vessel traffic will result in an increase of emissions, and ambient concentrations will likely change.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between Project air emissions and ambient concentrations of primary and secondary pollutants and associated reductions in visibility; however, vessel-specific data are limited.

4.3.3.7 Potential United States Effects

Project effects on air emissions in US waters are expected to be similar to Canadian waters. The same vessels will travel through both Canadian and US waters and will emit the same emissions along the shipping lanes. Residual effects on land (*i.e.,* the Olympic Peninsula) may be similar to residual effects at the coastline along shipping lanes in Canadian waters. The dispersion climate and important factors such as wind direction will materially affect the extent and magnitude of the predicted impacts and effects.

4.3.3.8 Summary

As identified in Table 4.3.3.5, there are no situations where there is a high probability of occurrence of a permanent or long-term residual environmental effect on marine air emissions of high magnitude that cannot be technically or economically mitigated. Consequently, it is concluded that the residual environmental effects of increased Project-related marine vessel traffic on marine air emissions will be not significant.

4.3.4 Marine GHG Emissions

Activities that occur during the marine operations phase have the potential to affect GHG levels. Therefore, Project interactions with GHGs were assessed. The Project will result in combustion of fuel in the tanker engines. Boilers will create GHG emissions and GHGs are also released to atmosphere from evaporative losses of product from tanker holds. Emissions are estimated based on a reasonable maximum operating scenario. This subsection considers the potential for marine GHG emissions to the atmospheric environment to change ambient concentrations due to the increased Project-related marine vessel traffic.

GHGs are a group of gases that build up in concentration in the atmosphere and have the potential to contribute incrementally to climate change. Individual GHGs are typically aggregated into “CO_2 equivalents” (CO_2e) which represent an equivalent quantity of CO_2 that would have the same global warming potential as the combined gases.

4.3.4.1 Assessment Indicators and Measurement Endpoints

The assessment indicators and measurement endpoints used for the marine GHG assessment are summarized in Table 4.3.4.1.

TABLE 4.3.4.1

ASSESSMENT INDICATORS AND MEASUREMENT ENDPOINTS FOR GHG EMISSIONS

Marine GHG Indicator	Measurement Endpoint	Rationale for Indicator Selection
Emissions of CO_2, CH_4 and N_2O	• Emissions of CO_2e from Project-related marine vessel traffic; comparison to emissions from existing marine traffic and to federal totals	The selection of indicators and measurement endpoints considered NEB Filing Manual requirements for the GHG emissions element under Table A2, addressed concerns by participants of the ESA Workshops and was informed by government agencies (*i.e.*, Environment Canada, BC MOE, Metro Vancouver, Fraser Valley Regional District, PMV).
Effect on overall climate change	• Effects of CO_2e emissions from Project-related marine vessel traffic on change in environmental parameters. such as global average temperatures	

4.3.4.2 Spatial Boundaries

The spatial boundary of the potential effects of GHG emissions is international. All GHG are long lived gases that are dispersed globally over the course of years and alter the world's climate by increasing the fraction of outgoing long wave radiation that is absorbed by the atmosphere and emitted back towards the ground.

4.3.4.3 Marine Greenhouse Gas Context

The atmospheric lifetime (half-life) of the three GHG that are explicitly considered in the GHG emission indicators ranges from 12 years for CH_4 to 114 years for N_2O (Technical Summary, Table TS.2 in IPCC 2007). GHG emissions from Project-related marine vessel traffic will be dispersed globally over a few years. They accumulate in the atmosphere and have the potential to contribute incrementally to climate change on a global scale. Therefore, the marine effects assessment of GHG emissions is based on total annual Project-related marine vessel traffic.

After global dispersion, the GHG emissions from any single industrial activity contribute very little to global emissions. Therefore, the current framework for environmental impact assessments is unlikely to trigger collective actions to reduce GHG emissions. Federal and provincial legislation has been put in place to address this issue. All facilities emitting more than 50,000 tonnes of GHGs are required to submit a report under Environment Canada's *Greenhouse Gas Emissions Reporting Program* (Environment Canada 2013). BC's *Reporting Regulation under the Greenhouse Gas Reduction (Cap and Trade) Act* sets out the requirements for reporting GHG emissions from BC facilities emitting 10,000 tonnes or more of GHGs (BC MOE 2013). Facilities emitting 25,000 tonnes or more are required to have emissions reports verified by a third party.

Note that no absolute GHG emission limits are set by the regulations discussed in the previous paragraph. Therefore, the following numbers are provided for comparison only. Environment Canada's National Inventory Report estimates total GHG emissions from Canada to be 702 Mt in 2011. Of the 702 Mt, 6.0 Mt was estimated to be from domestic marine traffic. In BC alone, the total GHG emissions in 2011 were estimated to be 59.1 Mt, with 2.4 Mt generated from domestic marine traffic (Part 3, Tables A11-20 and A12-3 in Environment Canada 2013). The 2005 Corbett inventory (Wang *et al.* 2008) estimates a total of 35,872 tonnes (or 0.04 Mt) of CO_2 emissions from existing marine traffic in the Marine Air Quality RSA. Note; however, that a rough estimate of 2012 marine traffic suggests 15,000 to 20,000 tanker, cargo-ship, and ferry transits within the RSA. The associated GHG emissions would be roughly one to two orders of magnitude greater than the estimates in Wang *et al*. (2008). This would also be more consistent with total BC marine emissions, because emissions within the RSA should be a substantial percentage of the BC total.

4.3.4.4 Potential Effects and Mitigation Measures

Potential effects associated with increased Project-related marine vessel traffic on marine GHG indicators are listed in Table 4.3.4.2. These potential effects are based on the results of the literature review, desktop analysis, engagement with Aboriginal communities, government agencies, and other stakeholders (Section 3.0), and the professional experience of the assessment team.

No mitigation measures were considered in the marine GHG assessment. It is recognized; however, that new energy efficiency standards were adopted by the IMO in July 2011 and that these standards may improve GHG emissions from new vessels in the future.

TABLE 4.3.4.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE GHG EMISSIONS

Potential Effect	Spatial Boundary	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1. Marine GHG Indicator –Emissions of CO_2, CH_4, and N_2O			
1.1 Increase in CO_2e emissions	International	• All Project-related tankers are required to adhere to federal standards that may reduce GHG emissions, including standards for bunker fuel.	• Increase in CO_2e emissions.
2. Marine GHG Indicator – Effect on Overall Climate Change			
2.1 Changes in environmental parameters	International	• All Project-related tankers are required to adhere to federal standards that may reduce GHG emissions, including standards for bunker fuel.	• Changes in environmental parameters (global average temperature increase, precipitation events, heavy rainfall, crop yield, etc.).

4.3.4.5 Potential Residual Effects

The potential residual environmental effects on marine GHG indicators associated with the increase in Project-related marine vessel traffic are:

- increase in CO_2e emissions; and

- changes in environmental parameters such as global average temperature increase; change in precipitation, increase in heavy rainfall, yield reduction in a number of crops, changes in stream flow, and decreases in the extent of annually averaged and September Arctic sea ice.

4.3.4.6 Significance Evaluation of Potential Residual Effects

A quantitative assessment of marine GHG emissions was determined to be the most appropriate approach to evaluate the significance of potential residual environmental effects, based on discussions with federal, provincial and local government agencies. Details on the GHG emission calculations for increased Project-related marine vessel traffic are summarized in the Marine Air Quality and Greenhouse Gas – Marine Transportation Technical Report (Volume 8B, TR 8B-3).

Table 4.3.4.3 summarises the marine GHG emissions that were calculated for the Project. Specifically, the vessel type, number of transits per month and year, and GHG emissions by component are provided.

TABLE 4.3.4.3

SUMMARY OF ANNUAL PROJECT-RELATED MARINE VESSEL TRANSITS AND ASSOCIATED GHG EMISSIONS (EXPRESSED AS NET CHANGE FROM EXISTING CONDITIONS) (GHG EMISSIONS IN TONNES)

Vessel Type	Number of Transits Per Month	Number of Transits Per Year	CO_2	CH_4	N_20	$CO2_e$
Panamax tanker (including tug escorts)[1]	0	0	-99.0	-0.005	-0.003	-100.0
Aframax tanker (including tug escorts)[2]	29	348	71,500	1.3	1.9	72,200
Total	29	348	71,400	1.3	1.9	72,100

Notes:
1 GHG emission were calculated with tug escorts in two areas of the voyage. The first tug escort (three tugs) is in the Vancouver harbour, from Berry Point just east of Second Narrows to English Bay west of First Narrows. The second tug escort area is in Boundary Passage and Haro Strait. After initiation of GHG modeling, KMC added the safety mitigation measure of an escort tug for assistance in Georgia Strait and Juan de Fuca Strait. GHG emissions will be recalculated with the extra tug in 2014 and submitted to the NEB.
2 No Panamax tankers are added by the Project. Emissions by current Panamax activities are expected to drop slightly during Project operations because of decreases berth time at the Westridge Marine Terminal.

To put Project-related marine vessel traffic GHG emissions into context, Table 4.3.4.4 shows comparisons with various inventories. Project-related marine emissions are less than one percent of total annual Canadian and BC emissions and on the order of a few percent of Canadian and BC marine emissions. Compared to the last available inventory for total annual GHG emissions in the marine RSA, the expected Project-related emissions are twice as large. The marine RSA inventory is likely a substantial underestimation and the relative size of the Project emissions a conservatively high estimate. Given that this is a substantial contribution but that there is currently no regulatory limit for GHG emissions in the RSA, the magnitude is rated as medium.

TABLE 4.3.4.4

COMPARISON OF PROJECT-RELATED MARINE VESSEL TRAFFIC GHG EMISSIONS (EXPRESSED AS NET CHANGE FROM EXISTING CONDITIONS) WITH AVAILABLE INVENTORIES

GHG Inventory	GHG Emissions (kt CO_2e)	Relative Size of Project Emissions (%)
Canadian Total (2011)	702,000	0.01
Canadian Marine (2011)	6,000	1.4
BC Total (2011)	59,100	0.14
BC Marine (2011)	2,400	3.5
Marine RSA (2005)[1]	35.9	235

Note: 1 This is most likely an underestimate of one to two orders of magnitude.

Table 4.3.4.5 shows best estimates of changes in environmental parameters caused by 50-year total GHG emissions from project-related marine vessel traffic. These estimates are based on numerical modelling results with Earth-systems models of medium complexity with integrated carbon cycle (NRC 2010). The model runs show that the changes are equivalent to total GHG emissions and do not reverse for hundreds to thousands of years, therefore are practically permanent. The predicted changes are too small to be measureable; therefore, the magnitude of the residual effect is negligible.

TABLE 4.3.4.5

BEST ESTIMATES OF CHANGES IN ENVIRONMENTAL PARAMETERS CAUSED BY 50-YEAR TOTAL PROJECT-RELATED MARINE VESSEL TRAFFIC GHG EMISSIONS

Change in Environmental Parameter[1]	Best Estimate
Global warming (°C)	1.7×10^{-6}
Precipitation changes (%)	±0.000015
Increase in heavy rainfall (%)	0.000014
Yield reduction in a number of crops (%)	0.000021
Changes in streamflows (%)	±0.000015
Decrease in the extent of annually averaged Arctic sea ice (%)	0.000038
Decrease in the extent of September Arctic sea ice (%)	0.000038

Note: 1 Calculated for 50 years of estimated annual GHG emissions provided in Table 4.3.4.3.

After initiation of the marine GHG emissions modelling, and as a result of the quantitative risk assessment, Trans Mountain decided to consider the use of additional tug escort as a navigational safety measure to reduce the risk of an accidental spill from a laden Project-related tanker. Tug escort would be added for the entire route between the Westridge Marine Terminal and Buoy J where tugs are currently not in use, as identified in Figure 5.3.2 and discussed in more detail in Section 5.3.2.1. Marine GHG emissions modelling numbers will be updated based on extended escort tug usage. Based on the professional judgment of the assessment team, the addition of the escort tug is not likely to change any of the significance conclusions presented for marine GHG emissions. Modeling results will be provided to the NEB in a supplemental filing in Q2 2014.

Table 4.3.4.6 provides a summary of the significance evaluation of the potential residual environmental effects increased Project-related marine vessel traffic on GHG emissions. The rationale used to evaluate the significance of each of the residual environmental effects is provided below.

TABLE 4.3.4.6

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSELTRAFFIC ON MARINE GHG EMISSIONS

Potential Residual Effects	Impact Balance	Spatial Boundary	Temporal Context			Magnitude	Probability	Confidence	Significance[1]
			Duration	Frequency	Reversibility				
1. Marine GHG Indicator – Emissions of CO_2, CH_4, and N_2O									
1(a) Increase in CO_2e emissions.	Negative	International	Long-term	Periodic	Immediate	Medium	High	Moderate	Not significant
2. Marine GHG Indicator – Effect on Overall Climate Change									
2(a) Changes in environmental parameters.	Negative	International	Long-term	Periodic	Permanent	Negligible	High	Moderate	Not significant
3. Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Greenhouse Gas Emissions									
3(a) Combined effects of increased Project-related marine vessel traffic on the marine GHG indicators (1[a] and 2[a]).	Negative	International	Long-term	Periodic	Immediate to permanent	Medium	High	Moderate	Not significant

Note: 1 **Significant Residual Environmental Effect:** A high probability of occurrence of a permanent or long-term residual effect of high magnitude that cannot be technically or economically mitigated.

4.3.4.6.1 Marine Greenhouse Gas Emissions Indicator - Emissions of CO_2, CH_4, and N_2O

The increase in CO_2e emissions related to Project marine vessel traffic is considered to have a negative impact balance. Marine GHG emissions are expected to increase when Project-related marine vessel traffic travels through the Marine Air Quality RSA. As shown in Table 4.3.4.6 point 1(a), the increase in CO_{2e} emissions has an international spatial boundary. The change will be long-term in duration, reversible immediately as the Project-related marine vessel traffic leaves the Marine Air Quality RSA, and the magnitude is expected to be low. The probability of this occurring is high, and confidence in the residual effects assessment is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - international – emissions of GHG associated with Project-related marine vessel traffic disperse globally and overlap with global GHG emissions to cause potential effects.
- **Duration** - long-term – emissions of GHG are expected to occur for the life of the Project and, therefore, are considered long-term.

- **Frequency** - periodic – emissions of GHG will occur upon Project-related marine vessels transiting through the Marine Air Quality RSA, which is expected to occur intermittently with one to two vessels per day.
- **Reversibility** - immediate – emissions of GHG within the Marine Air Quality RSA will cease immediately when vessels exit the Marine Air Quality RSA.
- **Magnitude**:- medium – the increase in GHG emissions is quantifiable and more than twice that of current marine-related GHG emissions in the Marine Air Quality RSA, but in the absence of regulatory GHG emissions limits, the magnitude is rated as being medium.
- **Probability** - high – an increase in Project-related marine vessel traffic will result in emissions of GHG.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between the Project and GHG emissions; however, vessel-specific data are limited.

4.3.4.6.2 Marine Greenhouse Gas Emissions Indicator - Effect on Overall Climate Change

Project-related 50-year total GHG emissions are predicted to cause changes in environmental parameters that are considered to have mostly a negative impact balance. Examples for changes in environmental parameters are shown in Table 4.3.4.5. As shown in Table 4.3.4.6 point 2(a), the changes in environmental parameters have an international spatial boundary. The events causing these changes (Project-related marine vessels travelling through the Marine Air Quality RSA) will occur periodically (typically one to two vessels per day) and long-term over the duration of the Project. As pointed out in the discussion of Table 4.3.4.5, the changes in environmental parameters caused by Projected-related GHG emissions are predicted to last for centuries to millennia and, therefore, are practically permanent. The table also demonstrates that the changes are not measureable; therefore the magnitude is negligible. The probability of this occurring is high. Confidence in the residual effects assessment is moderate, because the residual effects assessment is based on a good understanding of cause-effect relationships between the Project-related marine GHG emissions and changes in environmental parameters, but vessel-specific data are limited. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - international – global changes in environmental parameters are expected from GHG emissions associated with Project-related marine vessel traffic.
- **Duration** - long-term – the events (Project-related marine vessel transiting) that will likely change environmental parameters are expected to occur for the life of the Project and, therefore, are considered long-term.
- **Frequency** - periodic – changes in environmental parameters will likely result from GHG emissions from Project-related marine vessels transiting through the Marine Air Quality RSA, which is expected to occur intermittently but repeatedly with one to two vessels per day.

- **Reversibility** - permanent – permanent – changes in environmental parameters are proportional to total GHG emissions and predicted to last for centuries to millennia and are, therefore, effectively permanent.
- **Magnitude** - negligible – changes in environmental parameters likely resulting from the Project's vessels transiting are not detectable from existing (baseline) climate variability.
- **Probability**- high – an increase in Project-related marine vessel traffic will increase GHG emissions, which is extremely likely to change environmental parameters.
- **Confidence** - high – determination of significance is based on a good understanding of cause-effect relationships between Project-related GHG emissions from marine vessel traffic and overall climate change. Observational and numerical modelling data also support the significance determination.

4.3.4.6.3 Combined Effects on Marine Greenhouse Gas Emissions

The combined effects on the marine GHG indicators are considered to have a negative impact balance. Effects are assessed with a setting of high volume vessel activity within the Marine Air Quality RSA and with the standards set by the existing regulatory framework. The results of the marine GHG assessment do not contradict any management objectives of established regional marine conservation plans. As shown in Table 4.3.4.6 point 3(a), the combined effects on marine GHG emissions have an international spatial boundary. Marine GHG emissions are expected to increase when Project-related marine vessel traffic travels through the Marine Air Quality RSA, and they will contribute to global GHG levels and likely change environmental parameters. Project-related marine vessel traffic will occur periodically and long-term over the duration of the Project. The reversibility of changes in environmental parameters caused by Project-related marine GHG emissions is permanent. Estimated annual Project-related marine GHG emissions are more than twice the current emissions in the marine RSA, but there are no regulatory limits for GHG emissions in the RSA; therefore, the magnitude is rated as medium. The probability of this occurring is high, and confidence in the residual effects assessment is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - International – marine GHG emissions disperse globally and the associated changes in environmental parameters are global in nature.
- **Duration** - long-term – the events (Project-related marine vessel transiting) that will emit GHG and likely change environmental parameters are expected to occur for the life of the Project and, therefore, are considered long-term.
- **Frequency** - periodic – the events emitting GHG and likely changing environmental parameters will occur from Project-related marine vessels transiting through the Marine Air Quality RSA, which is expected to occur intermittently with one to two vessels per day.
- **Reversibility** - permanent – likely changes in environmental parameters will last past the life of the Project for hundreds to thousands of years, and, therefore, are effectively permanent.

- **Magnitude** - medium – Project-related emissions of GHG from marine traffic are expected to be more than twice that of current marine-related GHG emissions in the RSA, but in the absence of regulatory GHG emissions limits, the magnitude is rated as being medium.
- **Probability** - high – an increase in Project-related marine vessel traffic will increase GHG emissions and is extremely likely to contribute to changes in environmental parameters.
- **Confidence** - moderate – determination of significance is based on a good understanding of cause-effect relationships between Project-related GHG emissions from marine vessel traffic and changes in environmental parameters. Observational and numerical modelling data also support the significance determination; however, vessel-specific data are limited.

4.3.4.7 Potential United States Effects

As noted in the previous section, GHG emissions and their effect on overall global climate change are international in nature, the effects described are expected to be similar for US lands and waterways.

4.3.4.8 Summary

As identified in Table 4.3.4.6 there are no situations where there is a high probability of occurrence of a permanent or long-term residual environmental effect on marine GHG emissions of high magnitude. Consequently, it is concluded that the residual environmental effects of increased Project-related marine vessel traffic on marine GHG emissions will be not significant.

4.3.5 Marine Acoustic Environment

Atmospheric sound is considered to be an issue due to the potential to affect people and wildlife. Changes in sound levels can result in annoyance and sleep disturbance for people, and in changes in behaviour for wildlife.

Changes in sound levels can be noticed at specific thresholds by humans. Project-related sounds contribute to the local environment and are viewed as potentially affecting the nature of the acoustic environment in a community or the environmental aesthetic for recreational marine users. Noise events during mooring or departure currently noticed by people in some onshore areas have the potential to increase in the frequency of occurrence. This subsection of the assessment considers the potential for sound levels in the atmospheric acoustic environment to change due to increased Project-related marine vessel traffic.

4.3.5.1 Assessment Indicators and Measurement Endpoints

The key issue anticipated in the marine acoustic environment as a result of the Project is the potential for increased atmospheric sound levels as a result of increased Project-related marine vessel traffic along the marine shipping lanes. The indicator for this element is atmospheric sound levels. Ambient sound levels (ASLs) and permissible sound levels (PSLs) will be used in comparison against the predicted noise from the increased Project-related marine vessel traffic to determine its potential impact. The rationale for the selection of this indicator is provided in Table 4.3.5.1.

The measurement endpoints for marine acoustic environment include quantitative measurement of potential Project effects. As environmental noise varies over time, a single number descriptor known as the energy equivalent sound level (L_{eq}) is used to quantify noise. The L_{eq} value, expressed in A-weighted decibels (dBA), is the energy-averaged A-weighted sound level for a specified time period. It is defined as the steady, continuous sound level over a specified time period that has the same acoustic energy as the actual varying sound levels occurring over the same time period. The A-weightings are assigned to account for the frequency response of the human ear, which is most sensitive to mid-frequency sounds. Table 4.3.5.1 provides a summary of the measurement endpoints considered for the marine acoustic environment indicator.

TABLE 4.3.5.1

ASSESSMENT INDICATOR AND MEASUREMENT ENDPOINTS FOR MARINE ACOUSTIC ENVIRONMENT

Marine Acoustic Environment Indicator	Measurement Endpoints	Rationale for Indicator Selection
Atmospheric sound levels	• Ambient atmospheric sound levels in dBA • Permissible atmospheric sound levels ($L_{eqNight}$ and L_{eqDay}) in dBA	• Represents potential increased atmospheric noise associated with increased marine vessel traffic and can be used to determine potential impacts to receptors

The BC Oil and Gas Commission (BC OGC) Noise Control Guideline (BC OGC 2009) is receptor based guidance, such that noise is assessed to meet PSLs at the point of the receptor. Where a receptor (dwelling) is not present, the PSL should be met at 1.5 km from the facility under assessment. A receptor is defined as any permanent or seasonally occupied dwelling. As such, the assessment for the Marine Acoustic Environment is focussed on human receptors. The potential effects of atmospheric sound on marine mammals and marine birds are discussed under Section 4.3.7 and Section 4.3.8, respectively.

The BC OGC Guideline has different allowable noise levels for daytime, which it defines as the hours of 07:00 to 22:00, and nighttime, defined as 22:00 to 07:00. The L_{eq} for daytime is the 15-hour A-weighted L_{eq}. Similarly, the L_{eq} during nighttime periods is a 9-hour A-weighted L_{eq}. PSLs are set based on dwelling density and proximity to heavily travelled, road, rail or aircraft routes (BC OGC 2009).

4.3.5.2 Spatial Boundaries

Spatial boundaries for the assessment of potential Project effects on the acoustic environment are as defined in Section 4.2.5.1:

- **Marine LSA** - includes the inbound and outbound marine shipping lanes, the area between the shipping lanes, where it exists, and a 2 km buffer extending from the outermost edge of each shipping lane. The shipping lanes extend from the Westridge Marine Terminal in Burnaby, through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, then westward past Victoria and through the Juan de Fuca Strait out to the 12 nautical mile limit of Canada’s territorial sea, corresponding to the line of longitude of Buoy J.

- **Marine RSA** - comprised of a large portion of the Salish Sea, including the inland marine waters of the southern Strait of Georgia and the Juan de Fuca Strait and their connecting channels, passes and straits. The Marine RSA is generally centred on the marine shipping lanes, which extend from the Westridge Marine Terminal through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, westward past Victoria and through Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea. The western boundary of the Marine RSA extends further out to sea than the western boundary of the Salish Sea and the northern boundary of the Marine RSA is limited to the southern portion of the Strait of Georgia. Puget Sound is excluded from the Marine RSA.

4.3.5.3 Marine Acoustic Environment Context

The shipping lanes to be used by the increased Project-related marine vessel traffic are well-travelled routes that channel thousands of ships from the open ocean through Juan de Fuca Strait to the BC lower mainland each year. Existing atmospheric sound in the vicinity of the marine shipping lanes is a combination of natural and man-made sound. The dominance of man-made sound varies along the shipping lanes based on the proximity to land and the density of shoreline developments.

Tankers travel at various speeds and with or without tug escorts and tethered tugs throughout the shipping lanes at various points of travel. Sounds occur as individual events for each tanker or tanker/tug combination that passes by a specific location. All vessel activity in the Marine RSA is a source of sound, and the existing Trans Mountain related shipping forms part of the existing acoustic environment.

No changes to the types of sound generated or the intensity of the individual vessels is expected. The only change in sound level that is expected to occur due to the Project is the number of pass-by occurrences due to the increase in tanker traffic, which is expected to be on average one laden tanker and one empty tanker daily. This increase in events could increase day and night average sound levels, which forms the basis for the assessment.

4.3.5.4 Potential Effects and Mitigation Measures

The potential effects to the marine acoustic environment along the shipping lanes are considered on the basis of the numbered segments within the Marine LSA, as defined in Section 4.2.5 and on the type of activity within each segment. Specifically, Segments 1, 2, 5 and 6 (Figure 4.2.17) have shoreline areas that may be affected by changes in noise level.

Marine transportation for the Project within Segments 1 and 2 (First and Second Narrows of the Burrard Inlet) will consist of tankers idling at anchor or moving with engine load of approximately 25 per cent, and escorted by up to three tugboats depending on the actual location within the segments. Ships can be stopped and anchored in Burrard Inlet or at the Westridge Marine Terminal. Sound emissions related to the engine noises of Project-related marine vessel traffic do not change from existing conditions so are pre-dominated by the tugboats used for these areas, as shown in Section 4.2.5. The type of engine sound generated is steady when the ship transits occur or when generators are operating while the vessel is not moving. Transits occur intermittently. Singular noise events can occur when a tanker is anchored in Burrard Inlet. Ship horns can be used in specific weather conditions or as part of normal navigation.

For Segment 5 (Haro Strait and along southeastern Vancouver Island), the tankers are held at approximately 40 per cent engine power and, when laden, are escorted by one tugboat. Therefore, sound levels in this segment are a combination of both tanker and tugboat. Along Segment 6 (between Port Angeles and Victoria in the Juan de Fuca Strait), the tankers travel under their own power, at between an engine load of 70 to 80 per cent. The type of engine sound generated is steady when the ship transits occur. Transits will occur intermittently (approximately twice daily). Singular, impulsive noise events can occur when ship horns are used in specific weather conditions or as part of normal navigation, for safety purposes.

The Project-related tankers and tugboats will be fitted with exhaust silencers similar to those already in place, so all sound emitted by all vessels passing through the Marine RSA calling at the Westridge Marine Terminal is equivalent. Singular events cannot be predicted and depend on the shipping schedules, weather conditions and type of vessel, therefore, mitigation is limited to best practices that consider nuisance effects from activities. The potential effects and mitigation measures are summarized in Table 4.3.5.2.

TABLE 4.3.5.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE ACOUSTIC ENVIRONMENT

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1. Marine Acoustic Environment Indicator – Atmospheric Sound Levels			
1.1 Consistent increase in average daytime or nighttime atmospheric sound level	LSA	• All Project-related marine vessels will be fitted with exhaust silencers similar to those already in use through industry standards.	• Increase in average daytime or night time sound levels for human receptors in the Marine LSA.
1.2 Singular sound level events	LSA	• No mitigation measures recommended for effects of singular sound level events.	• Annoyance of human receptors by singular sound level events.

Note: 1 LSA = Marine LSA

4.3.5.5 Potential Residual Effects

The potential residual effects on the marine acoustic environment indicator associated with an increase in Project-related marine vessel traffic are:

- increase in average daytime or nighttime sound levels for human receptors in the Marine LSA; and
- annoyance of human receptors by singular sound level events.

4.3.5.6 Significance Evaluation of Potential Residual Effects

The measurement endpoints for the marine acoustic environment include both quantitative and qualitative evaluation of potential Project effects. Quantitative assessment examines potential for changes in day and night sound levels based on proposed changes in ship traffic. Regarding singular, or impulsive sound level events, there is a lack of regulatory thresholds and data regarding these events for all marine activity within the Marine LSA. Consequently, a qualitative discussion of the potential for increase in these events based on changes in ship traffic is provided, which relies on the professional judgment of the assessment team.

The approach to the assessment of average daytime and nighttime sound levels was to compare existing and future daily average ship traffic levels with the ship traffic levels including the increased Project-related marine vessel traffic in each relevant segment to evaluate changes over time. In addition, the potential effects for increases in singular noise events are discussed on the basis of the increase in ship traffic as a proportional indicator of the increase in events.

After initiation of the marine acoustic environment assessment, and as a result of the quantitative risk assessment, Trans Mountain decided to consider the use of additional tug escort as a navigational safety measure to reduce the risk of an accidental spill from a laden Project-related tanker. Tug escort would be added for the entire route between the Westridge Marine Terminal and Buoy J where tugs are not currently in use, as identified in Figure 5.3.2 and discussed in more detail in Section 5.3.2.1. The marine acoustic environment assessment will be updated based on extended escort tug usage. Based on the professional judgment of the assessment team, the addition of the escort tug is not likely to change any of the significance conclusions presented for marine acoustic environment. Results will be provided to the NEB in a supplemental filing in Q2 2014.

The significance evaluation of these results is summarized in Table 4.3.5.3 and further described below.

TABLE 4.3.5.3

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE ACOUSTIC ENVIRONMENT

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
1. Marine Acoustic Environment Indicator – Atmospheric Sound Levels									
1(a) Increase in average daytime or nighttime sound levels for human receptors in the Marine LSA.	Negative	LSA	Long-term	Periodic	Immediate	Low	High	Moderate	Not significant
1(b) Annoyance of human receptors by singular sound level events.	Negative	LSA	Long-term	Periodic	Immediate	Low to medium	High	Moderate	Not significant
1(c) Combined effects on the atmospheric sound levels indicator (1[a] and 1[b]).	Negative	LSA	Long-term	Periodic	Immediate	Low to medium	High	Moderate	Not significant

Note: 1 LSA = Marine LSA

2 **Significant Residual Environmental Effect:** A high probability of occurrence of a permanent or long-term residual effect of high magnitude that cannot be technically or economically mitigated.

4.3.5.6.1 Marine Acoustic Environment Indicator – Atmospheric Sound Levels

The following subsection provides the evaluation of significance of the potential residual effect on the atmospheric sound levels indicator.

Increase in Atmospheric Sound Levels for Human Receptors in the Marine LSA

Significance of an increase in sound levels is primarily defined by the magnitude of the change. To establish magnitude ratings, PSL threshold limits from the BC OGC Noise Control Guideline (BC OGC 2009) combined with the "just noticeable difference" of 3 dBA (Crocker 2007) were used. A change in ambient conditions of less than 3 dBA along with compliance with the BC OGC PSL was considered low magnitude. Project noise predictions that result in a more than 3 dBA change from ambient sound levels; however, still comply with BC OGC guidance were considered to be of medium magnitude and non-compliance with BC OGC guidance was considered high magnitude regardless of the amount of change in sound level.

The Project will add approximately 29 to 30 tankers per month to the shipping lanes. This changes the number of Project-related round trips made by a tanker from about two per week to one, occasionally two, per 24 hour period. The typical case was defined as one round trip taken within a 24 hour period for the assessment. On this basis, the number of individual events that occur within a 24 hour period is expected to remain relatively constant once the operation of Project-related marine vessel traffic begins.

The change in total traffic on a daily basis for Segments 1, 2 5 and 6 are provided in Table 4.3.5.4. This table shows that a change in atmospheric sound levels due to increased Project-related marine vessel traffic is expected in the Second Narrows segment near the Westridge Marine Terminal; however, will remain within the BC OGC PSL values.

TABLE 4.3.5.4

POTENTIAL CHANGE IN ATMOSPHERIC SOUND LEVEL BASED ON INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC FOR MARINE ACOUSTIC ENVIRONMENT

Shipping Lane Segment	Existing Vessel Transits per 24-hr period (average)[1]	Project Vessels per 24-hr period (average)	% Increase in Vessel Traffic	Day/Night Ambient Sound Level (dBA)	Project Day/Night Sound Level[2] (dBA)	Day/Night PSL (dBA)
1. Second Narrows	20	2	10%	56/46	56/46	61/51
2. First Narrows	51	2	4%	56/46	56/46	61/51
5. Haro Strait to Boundary Pass	24	2	8%	45/35	45/35	50/40
6. Victoria to Race Rocks	26	2	8%	45/35	45/35	50/40

Notes: 1 Includes existing Westridge Marine Terminal traffic

2 Project Day/Night Sound Level is the logarithmic increase of the ambient sound level based on the percent increase in vessel traffic.

The analysis above is a high level overview of potential changes in sound levels due to tanker movements. Sound will also attenuate with distance from the tankers and tug boats, and will occur only for short periods (less than ½ hour) at a particular point of reception. These events occur as variations in sound during the day and night. There would be occasional 24-hour periods (about four times per month) where the number of events within the defined day and nighttime periods may increase from two (one in/ from? each direction) to four (two in/from? each direction).

In reviewing the existing atmospheric sound level contributions for the three tanker pass-by configurations (Figure 4.2.18), the amount of variability in sound levels would depend on the proximity of the receiver to the shipping lanes. The nearest shoreline receptors are located within Burrard Inlet, past the Second Narrows. Vessel/tug configurations would be within 400 m of homes, where, based on Figure 4.2.18, atmospheric sound level as the tanker plus three tugs pass-by would momentarily be 39 dBA. When compared with the Westridge Marine Terminal ambient monitoring data (Section 6.0 of Volume 5A), this degree of variation is within the normal range of values that occur during the day or night. Marine users may be present at a variety of distances from the shipping lanes; however, the occurrences of atmospheric sound events for marine users are at most a 12 per cent increase in the number of events based on average daily total vessel traffic along the shipping lanes (Table 4.3.5.4).

Details on the calculation and analysis supporting these results are provided in the Marine Noise (Atmospheric) – Marine Transportation Technical Report (Volume 8B, TR 8B-4). The potential for the increase in daytime or nighttime atmospheric sound levels for human receptors associated with increased Project-related marine vessel traffic is considered to have a negative impact balance. The results in Table 4.3.5.4 show the potential change in atmospheric sound levels due to the increased number of events over a 24-hour period compared to the BC OGC PSL for all shipping lane segments is less than 3 dBA and, consequently, of low magnitude. The effect of sound from vessel traffic is periodic, occurring approximately twice per day for any given receptor, and the change in atmospheric sound levels is completely reversible, with sound from Project–related marine vessel traffic pass-bys ending as soon as the Project ends. As shown in Table 4.3.5.3 point 1(a), the increase in atmospheric sound levels is confined to the Marine LSA. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA – changes to atmospheric sound levels are expected to occur only within the Marine LSA.
- **Duration** - long-term – the sound emissions from Project-related marine vessels will occur for the life of the Project.
- **Frequency** - periodic – sound level increases from Project-related marine vessel pass-bys will occur intermittently but repeatedly for the life of the Project due to the regularity of vessel transits (approximately twice daily).
- **Reversibility** - immediate – Project-related marine vessel sound emissions will cease when the Project is no longer in operation, so sound level increases from Project vessel pass-bys will last less than two days.
- **Magnitude** - low – the increases in atmospheric sound level are within the BC OGC Guideline PSL values and show a degree of variability consistent with existing conditions.

- **Probability** - high – the Project vessels will generate sound and more trips will occur.
- **Confidence** - moderate – the confidence in the evaluation is based on data relevant to the Project area as well as good understanding of noise propagation.

Annoyance of Human Receptors by Singular Sound Level Events

Singular noise events, such as the movement of anchor chains, audible ship signals or ship horns, are considered to have a negative impact balance. These events can be sources of annoyance and have been noted by community stakeholders during the Vancouver ESA Workshop, and a qualitative assessment was conducted of the potential effect. The significance of sudden changes in noise level is usually addressed through quantitative means that establish the number of events that result in a greater than 10 dBA change indoors. Effects of noise events can result in sleep disturbance if more than 10 of these events occur within the nighttime period (WHO 1999).

Sound level or event count data that defines discrete noise events from all shipping in Burrard Inlet is not available. Therefore, the significance of changes in noise events is based on the change in Project-related marine vessel traffic, using the assumption that any existing noise events associated with the ships would increase at the same rate.

The type of singular sound level events from vessels that currently exist in Burrard Inlet would not change due to the Project. However, the frequency of occurrences will change proportionally to the total ship traffic in an area, which is estimated at 12 per cent (Table 4.3.5.4). Events are not expected to change for anchorages outside Burrard Inlet.

The number of singular sound level events occurring at night is expected to increase from tankers in the vicinity of the Westridge Marine Terminal. Project-related singular sound level events are anticipated to occur on occasion due to ship anchors or ship horns being used. These events are expected to be mostly during daylight hours, as Aframax tankers are not able to transit Second Narrows at night and will anchor off English Bay if they arrive at night. Even if two Project-related events took place on the same night and resulted in a 10 dBA indoor change in sound levels, inside a home, the number of events would still be less than the level where sleep disturbance occurs (WHO 1999). The change from existing conditions increases the potential of noise events occurring up to twice per day.

The changes in atmospheric sound level from singular sound level events are not expected to change within a day or night period when Project-related marine vessels are active; however, the number of days or nights on which they occur does increase, which is considered to be a low to medium magnitude consequence. The frequency of occurrence is periodic, as use of anchors and horns are operational safety requirements for normal ship movements. The magnitude identified in Table 4.3.5.3 point 1(b) for this change is considered low to medium.

- **Spatial Boundary** - Marine LSA – changes to atmospheric sound levels are expected to occur only within the Marine LSA.
- **Duration** - long-term – the sound emissions from Project-related marine vessels will occur for the life of the Project.

- **Frequency** - periodic – sound level increases from Project-related marine vessel anchors or horns will occur intermittently; however, repeatedly over the assessment period. Anchors are generally raised or lowered twice per day for only a few minutes, and ship horns are used only when signalling required or weather conditions dictate safety requirements.
- **Reversibility** - immediate – sound level increases from Project-related singular sound level events will cease when the Project is no longer in operation, so sound level increases will last less than two days.
- **Magnitude** - low to medium – changes in atmospheric sound level from singular sound level events are not expected to change within a day or night period when Project-related marine vessels are active; however, the number of days or nights on which they occur does increase.
- **Probability** - high – the Project-related marine vessels will generate sound and more trips will occur.
- **Confidence** - moderate – no numerical data for singular sound level events from ships in Burrard Inlet are available; however, the evaluation is based on a good understanding of operational conditions.

Combined Effects on Atmospheric Sound Levels

The evaluation of the combined effects of increased Project-related marine vessel traffic on marine acoustic environment considers collectively the assessment of the likely potential residual effects on the atmospheric sound levels indicator. Effects are assessed with a setting of high volume vessel activity within the Marine RSA and with the standards set by the existing regulatory framework. The results of the marine acoustic environment assessment do not contradict any management objectives of established regional marine conservation plans. The effects of singular sound level events on human receptors are considered more sensitive than the effects on average daytime or nighttime sound levels due to the increased uncertainty of when singular sound levels will occur and the low level of the effect on average day-time and nighttime sound levels. Both potential effects are considered to have a negative impact balance. Each potential effect of noise is an assessment of a different time period as well as a distinct type of sound. Therefore, the combined effects on marine acoustic environment in Table 4.3.5.3 point 1(c) represent the worst case effect for each evaluation criteria between the two residual effects.

- **Spatial Boundary** - Marine LSA – changes to sound levels are expected to occur only within the Marine LSA.
- **Duration** - long-term – the sound emissions and singular sound level events from Project-related marine vessels will occur for the life of the Project.
- **Frequency** - periodic – sound level increases from Project-related marine vessel pass-bys, anchors or horns will occur infrequently but at intervals. Typically, two ships per day will travel the shipping route. Anchors are generally raised or lowered twice per day for only a few minutes, and ship horns are used only when signalling required or weather conditions dictate safety requirements.

- **Reversibility** - immediate – Project-related marine vessel sound emissions will cease when the Project is no longer in operation.
- **Magnitude** - low to medium – changes in atmospheric sound level from vessel pass-bys are within the BC OGC Guideline PSL values and show a degree of variability consistent with existing conditions. Atmospheric sound levels from singular sound level events are not expected to change within a day or night period when Project-related marine vessels are active, but the number of days or nights on which they occur does increase.
- **Probability** - high – the Project vessels will generate sound and more trips will occur.
- **Confidence** - moderate – the confidence in the evaluation of the combined effects is based on data relevant to the Project area as well as good understanding of noise propagation.

4.3.5.7 Potential United States Effects

Project sound levels in US waters, specifically the various shoreline areas in US waters are expected to be similar to those in Canadian waters at the same distances from the shipping lanes. No differences in acoustic environment conditions in the US and Canadian portions of the Marine RSA were identified that would change the nature of the effects assessment. The same types of effects assessed as key issues in Canadian waters are expected to be present in US waters since the acoustic environment conditions are expected to be similar.

4.3.5.8 Summary

As identified in Table 4.3.5.4, there are no situations where there is a high probability of occurrence of a permanent or long-term residual environmental effect of high magnitude on marine acoustic environment indicators. Consequently, it is concluded that the residual environmental effects of operation activities associated with increased Project-related marine vessel traffic on marine acoustic environment will be not significant.

4.3.6 Marine Fish and Fish Habitat

Marine fish have high ecological, economic and cultural importance in BC. They support valuable commercial, recreational and Aboriginal food, social and ceremonial (FSC) fisheries, they provide food for a diversity of marine and terrestrial birds and mammals, and they have cultural value that transcends their economic and ecological importance. This subsection of the ESA considers the potential effects of the increased Project-related marine vessel traffic on marine fish and their habitats. Key issues for marine fish and fish habitat were identified through discussions with federal government agencies, including DFO, Environment Canada (EC) and PMV, feedback received from public participants at open houses and ESA workshops held in the Lower Mainland and southern Vancouver Island, and the professional judgment of the assessment team based on extensive experience working on marine transportation projects in BC. Key issues for marine fish and fish habitat are listed below.

- potential effects of vessel wake on shoreline habitats and associated biota; and
- potential introduction of invasive species during discharge of ballast water.

This subsection of the ESA considers only those effects that could arise during routine operations of Project-related marine vessels (*i.e.,* tankers and tugs) and is, therefore, limited to the assessment of wake effects on marine fish and fish habitat. Bilge and ballast water releases in Canadian waters are strictly regulated by Transport Canada under the *Canada Shipping Act,* 2001 in order to prevent the release of contaminated substances and/or invasive species. Since tankers typically release their ballast water while berthed at the Westridge Marine Terminal, the potential introduction of invasive species from Project-related tankers is discussed in the marine fish and fish habitat assessment for the Westridge Marine Terminal (Volume 5A, Section 7.6). The release of contaminated bilge water is illegal in Canadian waters and would therefore occur only as a result of an accident or malfunction. The potential effects of a contaminated bilge water release are discussed in Section 4.3.13.3.

4.3.6.1 Assessment Indicators and Measurement Endpoints

Indicators for the assessment of marine fish and fish habitat have been identified through consideration of marine fish species and habitats that occur in the Marine RSA and that could be affected by the increased Project-related marine vessel traffic. The list of candidate species and habitats was refined by focusing on those that support commercial, recreational and/or Aboriginal FSC fisheries. For the species-based indicators, marine fish and invertebrates representative of broader taxonomic groups were considered. Preference was given to species that are: 1) likely to occur seasonally or year-round in the Marine RSA; 2) sensitive to Project-related marine vessel traffic; and 3) considered to be of conservation concern. For the habitat-based indicators, all marine habitat types potentially affected by Project-related marine vessel traffic were considered. Preference was given to habitat types that could be sensitive to Project-related marine vessel traffic. The final selection of indicators took into consideration: experience gained during previous projects with similar ecological conditions and potential issues; feedback from regulatory authorities, Aboriginal communities and stakeholders; and the professional judgment of the assessment team.

The assessment indicators selected for marine fish and fish habitat are: intertidal habitat; Pacific herring (*Clupea pallasii*); and Pacific salmon (*Oncorhynchus* spp.). The rationale for the selection of each of these indicators is provided in Table 4.3.6.1.

The measurement endpoints for marine fish and fish habitat include both quantitative and qualitative measurement of potential Project effects. For the assessment of intertidal habitat, the measurement endpoints are: predicted wake wave heights at the shoreline; length of shoreline potentially affected by vessel wake; and length of shore types potentially affected by vessel wake. Supported by findings from previous vessel wake studies, the predicted wake wave heights at the shoreline resulting from the increased Project-related marine vessel traffic were calculated using established methods. The length of the shoreline and the length of shore types potentially affected by vessel wake were calculated using geospatial information from previous coastal resource studies and GIS analysis.

For the assessment of Pacific herring and Pacific salmon, the measurement endpoint is the likelihood of injury or mortality due to vessel wake. The likelihood of injury or mortality was qualitatively assessed based on the known or inferred spatial and temporal distribution of Pacific herring and Pacific salmon and their sensitivity to vessel wake in the marine environment. Table 4.3.6.1 provides a summary of the measurement endpoints considered for each indicator.

TABLE 4.3.6.1

ASSESSMENT INDICATORS AND MEASUREMENT ENDPOINTS FOR MARINE FISH AND FISH HABITAT

Marine Fish and Fish Habitat Indicator	Measurement Endpoints	Rationale for Indicator Selection
Intertidal habitat	• Predicted wake wave height at the shoreline • Length (km) of shoreline potentially affected by vessel wake • Length (km) of shore types potentially affected by vessel wake	• Present along all shorelines within the Marine LSA and Marine RSA • Ecologically important for sustaining marine biological communities • Provides spawning and migration habitat for commercial, recreational and Aboriginal fish stocks including Pacific herring and Pacific salmon
Pacific herring	• Likelihood of injury or mortality	• Representative small pelagic forage fish • Spawning areas include intertidal and shallow subtidal habitats in the Marine LSA and Marine RSA • DFO Important Areas for Pacific herring overlap with the Marine LSA and Marine RSA • Important forage fish for marine fish, marine birds, and marine mammals • Supports commercial, recreational and Aboriginal fisheries
Pacific salmon	• Likelihood of injury or mortality	• Representative large pelagic fish • Migration route includes nearshore areas in the Marine RSA • DFO Important Areas for Pacific salmon overlap with the Marine LSA and Marine RSA • Preyed upon by marine fish, marine birds, and marine mammals • Supports commercial, recreational and Aboriginal fisheries

4.3.6.2 Spatial Boundaries

Spatial boundaries for the assessment of potential Project effects on marine fish and fish habitat are defined as follows:

- **Marine LSA** - includes the inbound and outbound marine shipping lanes, the area between the shipping lanes, where it exists, and a 2 km buffer extending from the outermost edge of each shipping lane. The shipping lanes extend from the Westridge Marine Terminal in Burnaby, through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, then westward past Victoria and through Juan de Fuca Strait out to the 12 nautical mile limit of Canada’s territorial sea.
- **Marine RSA** - comprised of a large portion of the Salish Sea, including the inland marine waters of the southern Strait of Georgia and Juan de Fuca Strait and their connecting channels, passes and straits. The Marine RSA is generally centred on the marine shipping lanes, which extend from the Westridge Marine Terminal through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, westward past

Victoria and through Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea. The western boundary of the Marine RSA extends further out to sea than the western boundary of the Salish Sea and the northern boundary of the Marine RSA is limited to the southern portion of the Strait of Georgia. Puget Sound is excluded from the Marine RSA.

The boundaries of the Marine LSA are selected to encompass the area along the shipping lanes within which vessel wake from a tanker or escort tug would be expected to reach adjacent shorelines at a magnitude that could potentially affect marine fish and fish habitat. The 2 km buffer around the shipping lanes was selected based on a literature review of previous studies on wake from tankers including Moffatt and Nichol (2010, 2011) and Force Technology and Danish Hydraulic Institute (DHI) (2012). Based on the findings of these studies, the 2 km buffer was determined to be appropriate for the assessment because the predicted height of wake waves outside of this buffer (≤ 0.1 m) are well within the range of natural wave conditions (see Section 4.2.1.4).

The boundaries of the Marine RSA are selected to encompass the diversity of intertidal habitat types found along the shipping lanes and the regional distribution of resident and seasonally-present marine fish species. The Marine RSA encompasses over 3,800 km of shoreline habitat representing 15 shore types, seasonally important foraging areas and migration routes for Pacific salmon and Pacific herring, and spawning habitats for Pacific herring.

The marine fish and fish habitat study areas also follow guidance indicated by the NEB in the letter titled Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Increased Marine Shipping Activities (NEB 2013b), received by Trans Mountain on September 10, 2013. The letter indicates that the marine transportation assessment should take place out to the 12 nautical mile limit of Canada's territorial seas.

Study area boundaries for marine fish and fish habitat are shown in Figure 4.2.2.

4.3.6.3 Marine Fish and Fish Habitat Context

The shipping lanes extend from the Westridge Marine Terminal through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, westward past Victoria and Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea. The shipping lanes are an established route for all types of vessels and are among the busiest shipping lanes in BC (see Volume 8C TERMPOL Studies, BC MCA 2010). These waterways are all within the Salish Sea, an inland area of ocean that extends from Olympia, Washington northward to Campbell River, BC. The total length of Canadian shoreline adjacent to the shipping lanes is approximately 2,315 km. The average channel width in the Strait of Georgia and Juan de Fuca Strait is approximately 22–28 km (Thompson 1981). Maximum significant wave heights in the Strait of Georgia and Juan de Fuca Strait are typically less than 5 m and the average significant wave heights range from approximately 0.1 to 0.3 m (DFO 2013).

A total of 409 species of marine fish have been reported in Canadian Pacific waters (Peden 2013). Shoreline habitats adjacent to the shipping lanes are used for spawning, rearing, migration and foraging by many species of marine fish and invertebrates. For example, Pacific herring use intertidal substrates, seagrass and algae as spawning substrate for their eggs (Humphreys and Hourston 1978, Levings and Thom 1994, Taylor 1964), and Pacific salmon use nearshore habitat and estuaries for rearing and migration (Healey 1980, Levings and Jamieson 2001, Levings and Thom 1994).

Typically, five partially-laden tankers per month are currently loaded with heavy crude oil or diluted bitumen at the Westridge Marine Terminal. The expanded system will be capable of serving 34 partially-laden Aframax vessels per month, with actual seasonal and annual demand driven by market conditions (see Section 2.2). The maximum size of vessels served at the terminal is not forecast to change as part of the Project.

In addition to tanker traffic, the Westridge Marine Terminal also currently loads about two barges with crude oil per month. Westridge Marine Terminal also operates a system to receive about one barge of jet fuel per month using a separate pipeline system that serves YVR. Barge activity is not expected to change as a result of the Project.

4.3.6.4 Potential Effects and Mitigation Measures

4.3.6.4.1 Effects Considerations

This subsection describes issues/effects that were considered for inclusion in the assessment of potential Project effects on marine fish and fish habitat but were scoped out of the assessment. Some of these issues were raised through consultation with Aboriginal communities, government agencies and other stakeholders, and others were identified by the assessment team based on past experience with similar projects. For each issue/effect identified below, a rationale is provided for why it was not carried through the assessment.

Behavioural Disturbance to Marine Fish and Invertebrates Due to Underwater Noise

Exposure to sound typically includes a measure of the received sound level and the duration of the sound signal (Popper and Hastings 2009a). In general, there are two types of anthropogenic sounds: short pulses of high-intensity sounds such as those from blasting, pile driving and seismic guns; and long-lasting, low-intensity sounds that result in increased background noise such as sound from vessel traffic (Popper and Hastings 2009b).

Several reviews on the effects of anthropogenic sounds on fish and invertebrates have concluded that there is a lack of empirical data and knowledge about the effects of underwater noise on marine fish and invertebrates (Hastings and Popper 2005, Moriyasu *et al*. 2004, Popper and Hastings 2009a,b). Potential effects of anthropogenic sound on fish and invertebrates include physical injury or mortality and behavioural responses (Hastings and Popper 2005, Moriyasu *et al*. 2004, Popper and Hastings 2009a,b). At present there are no standard criteria or thresholds for the effects of underwater noise from vessel traffic on marine fish or invertebrates. Existing information indicates that noise levels from vessel traffic are not likely to cause physical injury or mortality to marine fish (Popper and Hastings 2009b), therefore, physical injury and mortality were not considered further in this assessment. Underwater noise from vessel traffic could; however, potentially trigger behavioural responses by marine fish. Consequently, this potential effect was considered for inclusion in the assessment.

The effects of short-term and long-term exposure to underwater noise from vessel traffic on marine fish and invertebrate behaviour are unknown and studies on the effects of anthropogenic sound on fishes have largely been focused on acoustic disturbances associated with impulsive sources such as explosives, pile driving and seismic air guns (Moriyasu *et al*. 2004, Popper and Hastings 2009a). Nearly all studies to date on behavioural responses of fish to sound have been conducted in a laboratory setting which does not necessarily provide accurate insight as to how animals will behave in their natural habitat (Popper and Hastings 2009a,b). Popper and Hastings (2009b) also note that it is very difficult to extrapolate data on the effects of sound between different fish species and sound sources. Potential behavioural responses of fish to anthropogenic sounds range from: no change in behavior; small temporary movements for the duration of the sound; large movements that displace fish from their normal locations; and large-scale changes in migration routes (Popper and Hastings 2009b). In theory, the large-scale displacement of a fish or invertebrate population from foraging, spawning, rearing or migration areas could potentially affect long-term survival.

Scientific literature is sparse regarding behavioural responses of marine fish and invertebrate species found in the Marine RSA to noise from vessel traffic. A single study on the behavioural responses of Pacific herring to noise from fishing vessels was identified. Schwarz and Greer (1984) studied behavioural responses of net-penned Pacific herring to a variety of tape-recorded underwater sounds. They found that the fish exhibited a mildly negative response to the sound of large fishing vessels approaching by slowly moving away from the sound source.

Marine fish and invertebrates located near berthed or transiting tankers and escort tugs may respond to the underwater noise by moving away from the sound source for the duration of the disturbance; however, there is no evidence in the literature that vessel traffic will result in the large-scale displacement of fish or invertebrate populations from foraging, spawning, rearing or migration areas or will otherwise affect their distribution or abundance. This conclusion is supported by the existing overlap of areas of high shipping activity and Pacific herring and Pacific salmon migration areas, such as the Haro Strait and the Fraser and Columbia rivers.

For the reasons discussed above and according to the judgment of the assessment team, behavioural disturbance to marine fish and invertebrates due to underwater noise from vessel traffic was not considered further in this assessment.

4.3.6.4.2 Identified Potential Effects

Vessel wake associated with the transit of Project-related tankers and tugs has the potential to affect marine fish and fish habitat. The severity of this effect depends on a number of factors including: the height of the wake when it reaches the shoreline; the natural wave environment; and the type of habitat affected. Potential effects associated with vessel wake include: 1) the physical disturbance of fish habitat due to increased erosion of sediments or dislodging of structure-forming organisms along the shoreline (*e.g.*, algae, sessile invertebrates); and 2) injury or mortality of marine fish due to the dislodging of fish eggs (roe) from shoreline substrates and/or the stranding of fish migrating or foraging along the shoreline.

Table 4.3.6.2 shows the identified potential effects associated with Project-related marine vessel traffic on marine fish and fish habitat indicators as well as mitigation measures and potential residual effects. The potential effects listed in Table 4.3.6.2 are based on the results of literature reviews, desktop analyses, consultation/engagement with government agencies, Aboriginal communities and other stakeholders (Section 3.0), and the experience of the assessment team.

Based on a review of federal regulatory guidelines, industry best management practices and the experience of the assessment team, it was determined that no measures are necessary to mitigate the effects of vessel wake on marine fish and fish habitat (Table 4.3.6.2).

TABLE 4.3.6.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE FISH AND FISH HABITAT

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1. Marine Fish and Fish Habitat Indicator – Intertidal Habitat			
1.1 Disturbance to intertidal habitat	LSA	No mitigation measures recommended for effects of vessel wake.	Disturbance to intertidal habitat due to vessel wake.
2. Marine Fish and Fish Habitat Indicator – Pacific Herring			
2.1 Injury or mortality to Pacific herring	LSA	No mitigation measures recommended for effects of vessel wake.	Injury or mortality to Pacific herring due to vessel wake.
3. Fish and Fish Habitat Indicator – Pacific Salmon			
3.1 Injury or mortality to Pacific salmon	LSA	No mitigation measures recommended for effects of vessel wake.	Injury or mortality to Pacific salmon due to vessel wake.

Note: 1 LSA = Marine LSA

4.3.6.5 Potential Residual Effects

The potential residual environmental effects on marine fish and fish habitat indicators associated with an increased Project-related marine vessel traffic are:

- disturbance to intertidal habitat due to vessel wake;
- injury or mortality to Pacific herring due to vessel wake; and
- injury or mortality to Pacific salmon due to vessel wake.

4.3.6.6 Significance Evaluation of Potential Residual Effects

The measurement endpoints for marine fish and fish habitat include both quantitative and qualitative measurement of potential Project effects. There is a lack of regulatory thresholds, standards or guidelines for evaluating potential residual effects from vessel wake on marine fish and fish habitat. Consequently, the findings of the quantitative analyses were considered in concert with the professional judgment of the assessment team.

Predicted wake wave heights at the shoreline were estimated using methods established in previous vessel wake studies. The length of the shoreline and the length of shore types potentially affected by vessel wake were calculated using geospatial information from previous coastal resources studies and GIS analysis. The likelihood of injury or mortality to Pacific herring and Pacific salmon was evaluated qualitatively based on a thorough review of relevant scientific literature.

Table 4.3.6.3 provides a summary of the significance evaluation of the potential residual environmental effects of Project-related increases in marine vessel traffic on marine fish and fish habitat. The rationale used to evaluate the significance of each of the residual environmental effects is provided below.

TABLE 4.3.6.3

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS FROM INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE FISH AND FISH HABITAT

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
1. Marine Fish and Fish Habitat Indicator – Intertidal Habitat									
1(a) Disturbance to intertidal habitat.	Negative	LSA	Long-term	Periodic	Immediate	Negligible	High	High	Not significant
2. Marine Fish and Fish Habitat Indicator – Pacific Herring									
2(a) Injury or mortality to Pacific herring.	Negative	LSA	Long-term	Periodic	Medium-term	Negligible	Low	High	Not significant
3. Fish and Fish Habitat Indicator – Pacific Salmon									
3(a) Injury or mortality to Pacific salmon.	Negative	LSA	Long-term	Periodic	Medium-term	Negligible	Low	High	Not significant
4. Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Fish and Fish Habitat									
4(a) Combined effects of increased Project-related marine vessel traffic on the marine fish and fish habitat indicators (1[a], 2[a] and 3[a]).	Negative	LSA	Long-term	Periodic	Immediate	Negligible	High	High	Not significant

Notes: 1 LSA: Marine LSA.

2 **Significant Residual Environmental Effect:** A high probability of occurrence of a permanent or long-term residual effect of high magnitude that cannot be technically or economically mitigated.

4.3.6.6.1 Marine Fish and Fish Habitat Indicator - Intertidal Habitat

The following subsection provides the evaluation of significance of the potential residual effect on the intertidal habitat indicator.

Disturbance to Intertidal Habitat Due to Vessel Wake

Several recent studies have focused on the predicted wake wave heights from tankers and associated escort tugs in confined channels in BC. Moffatt and Nichol (2010, 2011) conducted studies on vessel wake from very large crude carriers (VLCC), liquefied natural gas (LNG) carriers, and escort tugs in Douglas Channel, BC where depths ranged up to 365 m. Key points and findings from these studies includes the following.

- Moving vessels generate two types of waves: primary (drawdown waves) and secondary waves. The height of drawdown waves generated by ships depend on vessel speed, vessel cross-sectional area, channel depth and channel cross-sectional area. Drawdown waves do not break at the shoreline; however, instead cause the water level to slowly rise and fall as the vessel passes. The height of secondary waves generated by ships depend on vessel speed, channel depth and vessel type. Like normal ocean waves, secondary waves break at the shoreline.

- Drawdown wave heights generated by tankers are very low (*i.e.*, 0.015 to 0.025 m) due to the relative size of the channel cross-sectional area compared to the ship cross-sectional area.
- At a distance of 10 m from the VLCC (this is a larger vessel than the Aframax tankers currently used at Westridge Marine Terminal) and LNG carrier hull, and at a speed of 16 knots, the secondary wave height is approximately 0.3 m, decreasing to a height of approximately 0.1 m at distances of 1,000 to 1,500 m from the vessel.
- At a distance of 10 m from the escort tug hull and at a speed of 16 knots, the secondary wave height is approximately 0.4 m, decreasing to a height of approximately 0.1 m at distances of 1,000 to 1,500 m from the vessel.

A supplemental study by Force and DHI (2012) modelled vessel wake from a loaded VLCC moving at a speed of 16 knots, a loaded Aframax tanker at a speed of 12 knots, and an escort tug at speed of 12 knots in Douglas Channel and in Principe Channel where channel depths are 250 m and 90 m respectively. Wave heights of wind-generated waves were also modelled at these locations. Key points and findings from this study are as follows.

- Waves generated by the Aframax tanker moving at a speed of 12 knots with an escort tug 60 m behind was of the same magnitude as the VLCC moving at 16 knots.
- Results from the models show maximum wave heights of 0.05 – 0.10 m at Kikiata Inlet in the Douglas Channel from a loaded VLCC at a speed of 16 knots and an escort tug at a speed of 12 knots; and a maximum wave height of 0.15 m at the outer islands in Principe Channel from a loaded VLCC at a speed of 16 knots; with wave periods in the range of 3.0–4.5 seconds at both locations.
- Results from the models support the findings of Moffatt and Nichol (2010).
- Assuming 500 vessel transits per year, vessel generated waves would occur less than 0.14 per cent of the year at Kikiata Inlet in the Douglas Channel.
- Wind-waves of similar height to the vessel-generated waves occur approximately 10 times more frequently than the vessel-generated waves at Kikiata Inlet in the Douglas Channel and Dixon Island in Principe Channel.

The height of secondary waves generated by ships depends on vessel speed, channel depth, and vessel type, therefore, the findings of the vessel wake studies described above do not necessarily apply to Project-related marine vessel traffic due to potential differences in these three parameters. The applicability of the parameters used in Moffatt and Nichol (2010, 2011) to the proposed Project-related marine vessel traffic is evaluated here.

- **Vessel speed** - Vessel speeds of Trans Mountain tankers along the shipping lanes will range from 6.0–14.5 knots. These speeds, although lower, are comparable for purpose of the ESA to the speeds used in Moffatt and Nichol (2010, 2011) and Force and DHI (2012) (*i.e.*, 8–16 knots).

- **Channel depth** - Average depths in the Douglas Channel are considerably greater than those in the Strait of Georgia or Juan de Fuca Strait. Moffatt and Nichol (2010, 2011) and Force and DHI (2012) used average depths of 250–365 m in their studies of vessel wake in the Douglas Channel. However, average depths in the Strait of Georgia are approximately 155 m, and depth ranges from 55–250 m in Juan de Fuca Strait (Thompson 1981).

- **Vessel type** - Calculations of secondary wave height used by Moffatt and Nichol (2010, 2011) used a coefficient α^1, which varies depending on vessel type. In those studies, a α^1 value of 0.7 was chosen for VLCCs and LNG carriers based on recommendations from laboratory and field tests. Given that VLCCs are much larger than the Aframax tankers proposed for use in the TMEP, and Force and DHI (2012) found that waves generated by an Aframax tanker are of the same magnitude as the VLCC, a α^1 value of 0.7 seems conservative for calculating secondary wave heights generated by Aframax tankers.

Average channel depth in the Douglas Channel is substantially greater than average channel depths in the Strait of Georgia and Juan de Fuca Strait, and the shallower depths may result in larger secondary wave heights from Project-related marine vessel traffic along the shoreline of the Marine RSA, which may be somewhat mitigated by the lesser draft and speeds of the Aframax tankers that transit to the Westridge Marine Terminal employed for the Project. Therefore, in summary, the vessel speeds and vessel types used in the vessel wake studies are broadly comparable to those proposed for the Project.

Using the methods outlined in Moffatt and Nichol (2010, 2011), the secondary wave heights at various distances generated by Aframax tankers and escort tugs moving at various speeds can be calculated for channel depths along the shipping lanes in the Strait of Georgia and Juan de Fuca Strait. Distances used in the calculations range from 10 to 2,000 m, corresponding to the outer limit of the 2 km buffer on either side of the shipping lanes that defines the boundaries of the Marine LSA. Secondary wave height is calculated from the following formula:

- $H = h\alpha^1(S/h)^{-0.33}(F_h^4)$; and
- where F_h = Froude number, $F_h = V_s/(\sqrt{gh})$:
  - S = distance from vessel's side and a point of interest;
  - α^1 = coefficient depending on vessel type (0.7 for tankers, 1.0 for escort tugs);
  - h = channel depth; and
  - V_s = vessel speed.

The predicted wave heights from tankers traveling at various speeds in channel depths of 55 m and 155 m are shown in Table 4.3.6.4. In channel depths of 55 m, at a distance of 10 m from the tanker hull, and at a speed of 14 knots, the secondary wave height is approximately 0.6 m, decreasing to a height of approximately 0.1 m at a distance of 2,000 m from the vessel. In channel depths of 155 m, at a distance of 10 m from the tanker hull, and at a speed of 14 knots, the secondary wave height is approximately 0.3 m decreasing to a height of approximately 0.05 m at a distance of 2,000 m from the vessel.

TABLE 4.3.6.4

PREDICTED WAVE HEIGHTS FROM TANKERS BY VESSEL SPEED AND CHANNEL DEPTH IN MARINE LSA

Vessel Speed (knots)	Predicted Wave Height at Distance from Tanker Traveling in Channel Depth of 55 m					
	10 m	100 m	500 m	1,000 m	1,500 m	2,000 m
16	1.07	0.50	0.29	0.23	0.20	0.19
14	0.63	0.29	0.17	0.14	0.12	0.11
12	0.34	0.16	0.09	0.07	0.06	0.06
10	0.16	0.08	0.04	0.04	0.03	0.03
8	0.07	0.03	0.02	0.01	0.01	0.01
Vessel Speed (knots)	**Predicted Wave Height at Distance from Tanker Traveling in Channel Depth of 155 m**					
	10 m	**100 m**	**500 m**	**1,000 m**	**1,500 m**	**2,000 m**
16	0.53	0.25	0.15	0.12	0.10	0.09
14	0.31	0.15	0.09	0.07	0.06	0.05
12	0.17	0.08	0.05	0.04	0.03	0.03
10	0.08	0.04	0.02	0.02	0.02	0.01
8	0.03	0.02	0.01	0.01	0.01	0.01

The predicted wave heights from escort tugs traveling at various speeds in channel depths of 55 m and 155 m are shown in Table 4.3.6.5. In channel depths of 55 m, at a distance of 10 m from the tug hull, and at a speed of 14 knots, the secondary wave height is approximately 0.9 m decreasing to a height of approximately 0.16 m at a distance of 2,000 m from the vessel. In channel depths of 155 m, at a distance of 10 m from the tug hull, and at a speed of 14 knots, the secondary wave height is approximately 0.5 m decreasing to a height of approximately 0.1 m at a distance of 2,000 m from the vessel.

TABLE 4.3.6.5

PREDICTED WAVE HEIGHTS FROM ESCORT TUGS BY VESSEL SPEED AND WATER DEPTH

Vessel Speed (knots)	Predicted Wave Height at Distance from Escort Tug Traveling in Channel Depth of 55 m					
	10 m	100 m	500 m	1,000 m	1,500 m	2,000 m
16	1.53	0.71	0.42	0.33	0.29	0.27
14	0.89	0.42	0.25	0.20	0.17	0.16
12	0.48	0.23	0.13	0.11	0.09	0.08
10	0.23	0.11	0.06	0.05	0.04	0.04
8	0.10	0.04	0.03	0.02	0.02	0.02
Vessel Speed (knots)	**Predicted Wave Height at Distance from Tanker Traveling in Channel Depth of 155 m**					
	10 m	**100 m**	**500 m**	**1,000 m**	**1,500 m**	**2,000 m**
16	0.76	0.36	0.21	0.17	0.15	0.13
14	0.45	0.21	0.12	0.10	0.09	0.08
12	0.24	0.11	0.07	0.05	0.05	0.04
10	0.12	0.05	0.03	0.03	0.02	0.02
8	0.05	0.02	0.01	0.01	0.01	0.01

Due to the average channel width of 22–28 km in the Strait of Georgia and Juan de Fuca Strait (Thompson 1981) and the relatively rapid rate at which wake waves decrease in height away from the transiting tankers and escort tugs (Tables 4.3.6.4 and 4.3.6.5), vessel wake is not expected to be detectable from existing wave conditions along most of the shoreline in the Marine RSA.

Approximately 109 km of shoreline representing only 5 per cent of the total length of shoreline in the Canadian portion of the Marine RSA is located within 2,000 m of the shipping lanes (see Figure 4.2.2). These areas include shoreline in Burrard Inlet, Haro Strait and the area around Victoria on Vancouver Island. Within Burrard Inlet, Project-related tankers and tugs travel at speeds of 8 knots or less (typically around 6 knots), resulting in maximum predicted wave heights of 0.03 m at a distance of 500 m and 0.02 m at a distance of 1,000 m (Tables 4.3.6.4 and 4.3.6.5). Outbound tankers transiting between East Point on Saturna Island and Race Rocks on southern Vancouver Island are accompanied by an escort tug and are restricted to a maximum speed of 10 knots. Inbound tankers do not require an escort tug outside of Burrard Inlet and, typically, transit Haro Strait and Boundary Pass at around 12 knots. At these speeds, the maximum predicted wave heights generated by Project-related marine vessels are 0.09 m at a distance of 500 m, 0.07 m at a distance of 1,000 m and 0.06 m at a distance of 2,000 m (Tables 4.3.6.4 and 4.3.6.5).

Intertidal habitats located within the Marine LSA may be subject to increased wave action due to vessel wake resulting in temporary disturbance to intertidal sediment and vegetation, which is considered to have a negative impact balance. Habitat types most susceptible to disturbance are those dominated by fine-grained sediments (*e.g.*, sand and mud). Of the 109 km of shoreline in the Marine LSA, only 3.8 per cent are soft sediment ('sand beach' – 0.4 per cent; 'sand flat' – 1.0 per cent, 'mud flat' - 1.6 per cent, 'estuary, marsh or lagoon' – 0.8 per cent) (Figure 4.2.19a-d) (BC MFLNRO 2005). Dominant habitat types in the Marine LSA are 'man made' (44.7 per cent), 'sand and gravel flat' (11.2 per cent), 'rock cliff' (10.2 per cent), 'sand and gravel beach' (9.1 per cent), 'rock, sand and gravel beach' (7.8 per cent), and 'rock with gravel beach' (7.6 per cent) (Figure 4.2.19a-d) (BC MFLNRO 2005). These coarser substrates are more resistant to the physical forces imparted by waves and are often located in areas subject to higher wave exposure.

Shoreline erosion from vessel wake may result from high-speed vessels, such as high-speed passenger ferries, or deep-draft vessels operating in sheltered to semi-sheltered estuaries and river environments (Garel *et al*. 2008, Soomere *et al*. 2009, Velegrakis *et al*. 2007). However, these effects are unlikely from vessels moving at conventional speeds (*e.g.*, 12 to 15 knots) in the marine environment. Shoreline erosion from vessel wake typically only occurs in cases where the heights of vessel wake waves are different from those of natural waves (Velegrakis *et al*. 2007).

Although information on natural wave conditions within the Marine LSA and Marine RSA is limited, long-term data from three ocean buoys located in the Marine RSA suggest that wave conditions vary considerably with location and time of year (DFO 2013a). At the Patricia Bay buoy located in Saanich Inlet, significant wave heights, defined as the average height of the highest third of waves observed, range from 0 to 4.33 m, with an average of 0.06 m (DFO 2013a). At the La Perouse Bank buoy located off the west coast of Vancouver Island, significant wave heights range from 0 to 19.51 m, with an average of 2.23 m (DFO 2013a). Although neither of these buoys are positioned directly along the shipping route, they are representative of sheltered inshore waters (Patricia Bay) and exposed offshore waters (La Perouse Bank), and therefore encompass much of the variability in regional marine conditions. Within the Marine

LSA, wave heights likely vary depending on water depth, fetch, and local topography; however, the available data suggest that the predicted tanker and tug wake wave heights at the shoreline (*i.e.*, < 0.1 m) are well within the range of natural wave conditions. Therefore, any disturbance to intertidal habitat due to vessel wake will not be detectable from existing conditions and, consequently, is considered to be of negligible magnitude (Table 4.3.6.3, point 1[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA – residual effects on intertidal habitat will be limited to the area of overlap between intertidal habitat and the Marine LSA due to the low height of wake waves outside of the Marine LSA.
- **Duration** - long-term – vessel transits along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.
- **Frequency** - periodic – the event causing vessel wake is the transit of Project-related tankers and tugs, which will occur, on average, two times per day (one inbound and one outbound) for the operational life of the Project.
- **Reversibility** - immediate – residual effects on intertidal habitat will be limited to the period during which wake waves are interacting with the shoreline.
- **Magnitude** - negligible – residual effects of vessel wake on intertidal habitat will not be detectable from existing conditions.
- **Probability** - high – Project-related marine vessel traffic is likely to generate wake waves and these waves will interact with intertidal habitat.
- **Confidence** - high – based on a good understanding by the assessment team of the cause-effect relationships between vessel wake and the disturbance to intertidal habitat.

4.3.6.6.2 Marine Fish and Fish Habitat Indicator - Pacific Herring

The following subsection provides the evaluation of significance of the potential residual effect on the Pacific herring indicator.

Injury or Mortality to Pacific Herring Due to Vessel Wake

In the Strait of Georgia, Pacific herring spawn in late-winter between January and June, with the peak spawning period occurring in March (DFO 2013f, Hart 1973, Hay 1985, Hay and McCarter 2012). Spawning occurs along the shoreline in the intertidal to shallow subtidal zones between high tide and depths of 11 m (Hart 1973, Rooper *et al*. 1999). The eggs are very sticky and once deposited, they adhere in large masses to a variety of substrates (Hart 1973, Taylor 1964). The eggs sometimes adhere to rocks, pilings, and debris; but primarily adhere to marine vegetation (Hart 1973, Taylor 1964). The dominant substrate in sheltered bays and along sandy beaches is eelgrass (*Zostera marina*) and surfgrass (*Phyllospadix scoulerii*), along rocky shores it is rockweed (*Fucus gardneri*), and in shallow subtidal areas it is kelp (*Laminaria* sp.) (Hart 1973, Taylor 1964). The dominant substrates available for herring spawn in the Strait of Georgia are eelgrass, surfgrass, Japanese wireweed, and rockweed; while the dominant substrates available for herring spawn on the west coast of Vancouver Island are eelgrass and surfgrass (Taylor 1964).

Pacific herring will spawn every year and each female may deposit as many as 20,000 eggs (Hay 1985, DFO 2013f). However, the rate of spawn mortality is high, with estimates ranging from 56 to 100 per cent depending on the spawning location (Rooper *et al*. 1999, Taylor 1964). Major causes of spawn mortality are predation by birds, disruption from wave action (depending on the degree of exposure), and desiccation from exposure to air (Taylor 1964). The mortality rate attributed to predation by birds is estimated to be 30 to 55 per cent (Taylor 1964). When spawning is followed by poor weather and increased wave action, eelgrass can become dislodged or the eggs themselves can break loose and wash up on shore (Hart 1973).

Studies on spawn mortality due to wave action during storm events have estimated resulting mortality rates of 26 to 74 per cent (Hart and Tester 1934, Hay and Miller 1982, Rooper 1996). Rooper *et al*. (1999) studied a variety of habitat factors controlling egg loss in Prince William Sound, Alaska including depth of spawn, wave exposure, substrate type and vegetation type, among others. They found that depth of spawn was the primary factor determining egg loss. Analysis of wave exposure at spawning sites found that egg loss was consistently higher in protected areas than in exposed areas, but the factors driving this trend were not known. Substrate type and vegetation type were not found to be predominate factors in rates of egg loss. Taylor (1955) notes that spawn survival is highest near zero tide level and in locations partially protected from wave action and least in both exposed and well protected localities. This suggests that a moderate amount of wave action may improve hatching success (Gustafson *et al*. 2006). According to Hay and Miller (1982), most of the herring spawn in BC is deposited in the subtidal zone and, therefore, is relatively protected from wave action.

Historic data on herring spawning areas in BC from 1941 to 2002 suggest that herring spawn in only one small area within the Marine LSA south of Victoria on Vancouver Island (Hay and McCarter 2012; see Figure 4.2.20). This spawning area is approximately 2,000 m from the shipping lanes along the outer edge of the Marine LSA, where wake wave heights from Project-related marine vessels are predicted to be less than 0.1 m when they reach the shoreline. Wake waves of this height are well within the range of natural wave conditions (DFO 2013a, Thompson 1981) and are not likely to be of sufficient force to dislodge herring roe. Outside of the Marine LSA, the nearest herring spawning locations are located in Whytecliff Park in West Vancouver and Roberts Bank in Tsawwassen (Figure 4.2.20). These locations are 3 to 4 km away from the shipping lanes. Given this distance, wake waves reaching these areas are not expected to be detectable from existing wave conditions.

The Marine RSA encompasses some of the busiest shipping lanes in BC as well as herring spawning areas and DFO Important Areas for Pacific herring (see Volume 8C [TERMPOL Studies], BC MCA 2010, Jamieson and Levesque 2012a,b), yet there are no instances of stranding of Pacific herring or egg loss due to vessel wake documented in the literature. The impact balance of injury or mortality to Pacific herring due to vessel wake is considered to be negative due to the potential for egg loss from intertidal substrate. However, based on available information, wake waves generated by Project-associated tankers and tugs are not expected to result in a detectable change in spawn mortality rate and consequently are considered to be of negligible magnitude (Table 4.3.6.3, point 2[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA – residual effects to Pacific herring will be limited to intertidal habitats within the Marine LSA due to the low magnitude of the predicted wake wave heights outside of the Marine LSA.

- **Duration** - long-term – vessel transits along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.
- **Frequency** - periodic – the event causing vessel wake is the transit of Project-related tankers and tugs, which will occur, on average, two times per day (one inbound and one outbound) for the operational life of the Project.
- **Reversibility** - medium-term – in the unlikely event that Pacific herring are injured or killed as a result of vessel wake, this effect will be reversible within one generation of Pacific herring, which is approximately 4 years.
- **Magnitude** - negligible – residual effects of vessel wake on Pacific herring will not be detectable from existing conditions.
- **Probability** - low – residual effects of vessel wake on Pacific herring are unlikely.
- **Confidence** - high – based on a good understanding by the assessment team of the cause-effect relationships between vessel wake and the intertidal spawning areas of Pacific herring.

4.3.6.6.3 Marine Fish and Fish Habitat Indicator - Pacific Salmon

The following subsection provides the evaluation of significance of the potential residual effect on the Pacific salmon indicator.

Injury or Mortality to Pacific Salmon Due to Vessel Wake

In the Strait of Georgia and Juan de Fuca Strait, adult Pacific salmon migrate along coastal routes to their natal rivers to spawn and juvenile salmon often remain in shallow inshore waters for several months before moving offshore (DFO 2001, Hart 1973). Within the Marine RSA, salmon migration routes include Boundary Pass, Haro Strait, Saanich Inlet, and nearshore areas around the Gulf Islands and Victoria (DFO 2004) (see Figure 4.2.21).

Wake waves generated by vessels have the potential to strand juvenile Pacific salmon foraging or migrating along shoreline habitats, resulting in injury or mortality. Consequently, this residual effect is considered to have a negative impact balance. In general, fish strandings are more likely to occur in sheltered environments with low relief beaches, where wave run-up is more pronounced. Along steeper, rockier shorelines, waves typically break over shorter distances and are unlikely to result in fish stranding. The natural exposure of the shoreline habitat is also an important factor in determining the likelihood of strandings. Juvenile salmon migrating or foraging along shorelines routinely exposed to wind-driven waves are more likely to be acclimated to the physical forces imparted by breaking waves and are less likely to be inadvertently stranded.

Studies that have investigated that juvenile salmon strandings have focused on the lower reaches of large river systems, suggesting that this effect is a greater concern in the sheltered environments of rivers than it is in the marine environment. Several studies have documented strandings in the lower Columbia River by vessel wake from large, deep-draft vessels (Hinton and Emmett 1994, Pearson *et al*. 2006, Pearson and Skalski 2011). In these studies, 0+ year Chinook salmon were found to be most often affected (51 to 91 per cent of all fish stranded). Coho and chum salmon represented a low percentage of fish strandings. Pearson and Skalski

(2011) found that strandings were the result of an interaction between various factors including river location, salmon density in the shallows, ship characteristics, river elevation and beach characteristics. Given the complexity of factors controlling the incidence of fish strandings, the results of these studies are applicable only to the habitats in which the research was conducted (*i.e.*, low relief beaches in a riverine environment) and cannot be applied to the marine environment.

As discussed previously, shoreline areas within the Marine LSA may be subject to increased wave action due to wake waves from Project-related marine vessel traffic. However, the height of these waves is predicted to be well within the range of natural wave conditions, suggesting that juvenile salmon occupying nearshore habitats throughout the Marine LSA are acclimated to this level of wave exposure. In addition, shoreline habitats within the Marine LSA are dominated by anthropogenic structures and mixed substrates (*e.g.*, rock and sediment), with only 3.8 per cent comprised of fine-grained sediments (BC MFLNRO 2005) (Figure 4.2.19a-d). In these rockier habitats, wave run-up from wake waves on the order of 0.1 m is expected to be minimal and fish strandings are considered unlikely.

The Marine RSA encompasses some of the busiest shipping lanes in BC as well as Pacific salmon migration routes and DFO Important Areas for Pacific salmon (see Volume 8C [TERMPOL Studies], BC MCA 2010, Jamieson and Levesque 2012a,b), yet there are no instances of stranding of Pacific salmon due to vessel wake along marine shorelines documented in the literature. While fish strandings from vessel wake may be a concern in river environments, there is no evidence to suggest that this is a concern in the marine environment. Therefore, there is a low probability of injury or mortality to Pacific salmon due to vessel wake (Table 4.3.6.3, point 3[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA – residual effects on Pacific salmon will be limited to intertidal habitats within the Marine LSA due to the low magnitude of the predicted wake wave heights outside of the Marine LSA.
- **Duration** - long-term – vessel transits along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.
- **Frequency** - periodic – the event causing vessel wake is the transit of Project-related tankers and tugs, which will occur, on average, two times per day (one inbound and one outbound) for the operational life of the Project.
- **Reversibility** - medium-term – in the unlikely event that Pacific salmon are injured or killed as a result of vessel wake, this effect will be reversible within one generation of the species affected, which ranges from 2 years for pink salmon to 5 or 6 years for Chinook salmon.
- **Magnitude** - negligible – residual effects of vessel wake on Pacific salmon will not be detectable from existing conditions.
- **Probability** - low – residual effects of vessel wake on Pacific salmon are unlikely.
- **Confidence** - high – based on a good understanding by the assessment team of the cause-effect relationships between vessel wake and nearshore habitat use by juvenile Pacific salmon.

4.3.6.6.4 Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Fish and Fish Habitat

The evaluation of the combined effects of increased Project-related marine vessel traffic on the marine fish and fish habitat indicators considers collectively the assessment of the likely potential residual effects on the following indicators: intertidal habitat; Pacific herring and Pacific salmon. Given that the residual effects on both the Pacific herring and Pacific salmon indicators are unlikely to occur, the potential residual effects associated with the intertidal habitat are considered to represent the combined effects of increased Project-related marine vessel traffic on marine fish and fish habitat (Table 4.3.6.3, point 4[a]). Readers should refer to the intertidal habitat indicator above for the evaluation of significance.

4.3.6.7 Potential United States Effects

Vessel wake is not expected to be detectable from existing wave conditions along most of shoreline in the Marine RSA due to the average channel width of 22–28 km in the Strait of Georgia and Juan de Fuca Strait (Thompson 1981) and the relatively rapid rate at which wake waves decrease in height away from the transiting tankers and escort tugs (Tables 4.3.6.4 and 4.3.6.5).

Only 10 km of US shoreline along the San Juan Islands is located within 2,000 m of the shipping lanes. These areas may be subject to increased wave action due to wake waves from Project-related marine vessel traffic; however, wake wave heights at the shoreline are predicted to be less than 0.1 m. Based on a review of natural wave conditions and long-term buoy data in the Marine RSA (DFO 2013a, Thompson 1981), the wake waves would be well within the range of natural wave conditions.

No differences in intertidal habitats, Pacific herring or Pacific salmon populations, or natural wave conditions in the US and Canadian portions of the Marine RSA were identified that would change the nature of the effects assessment. Therefore, the effects are expected to be similar in Canadian and US waters.

4.3.6.8 Summary

As identified in Table 4.3.6.3, there are no situations where there is a high probability of occurrence of a permanent or long-term residual environmental effect of high magnitude on marine fish and fish habitat indicators. Consequently, it is concluded that the residual environmental effects of operation activities associated with increased Project-related marine vessel traffic on marine fish and fish habitat will be not significant.

4.3.7 Marine Mammals

Marine mammals are a key component of the marine environment, and play important roles in marine food webs, both as top predators and as prey. In addition to their high ecological value, marine mammals have high cultural and socio-economic importance to Aboriginal communities, British Columbians, Canadians, and visitors from abroad. The waters along the Project shipping lanes provide important habitat for a large number of marine mammal species, and are often a key destination for whale-watching and marine tourism activities on the coast of BC.

This subsection of the ESA considers the potential effects of the increase in Project-related marine vessel traffic on marine mammals. The increase in Project-related marine vessel traffic, and associated underwater noise from tankers and tugs, may cause sensory disturbance for marine mammals. Potential disturbance responses include temporary displacement, startle responses, increased energy expenditure, reduced foraging efficiency, communication masking, change in activity state, and/or increased stress. The potential for permanent or temporary auditory injury is also evaluated. Potential effects associated with marine mammal-vessel strikes are assessed under Accidents and Malfunctions (see Section 4.3.13). Potential Project-related effects on marine fish and fish habitat (*i.e.,* potential prey) were assessed in Section 4.3.6 above and were determined to be unlikely and of negligible magnitude. Potential Project-related effects on freshwater fish and fish habitat (*i.e.,* potential prey) were assessed in Section 7.2.7 of Volume 5A and were determined to be of low to medium magnitude. Potential for effects associated with contaminants is addressed in Sections 4.3.2 Marine Sediment and Water Quality, Section 4.3.13 (bilge water release), and Section 5.0(oil spills).

The assessment of potential effects to marine mammals from Project-related marine vessel traffic has been developed to support the following regulatory, policy and cultural objectives:

- compliance with the *Fisheries Act, 1985* and Marine Mammal Regulations with respect to disturbing a marine mammal in Canadian waters;
- protection for species at risk, consistent with the objectives of the federal *SARA*, and in compliance with prohibitions against killing, harming, harassing, capturing or taking an individual of a wildlife species that is listed as endangered or threatened;
- compliance with the NEB Filing Manual (2013c), the *CEA Act, 2012*, and provincial and local policies;
- management of marine mammal species within the context of any relevant recovery strategies or management plans, and in consideration of key threats identified in such plans;
- special attention to species of importance to the culture of Aboriginal communities whose traditional territories overlap the shipping lanes; and
- consideration of the *Endangered Species Act, 1973* and *Marine Mammal Protection Act, 1972* with respect to disturbing a marine mammal in US waters.

4.3.7.1 Assessment Indicators and Measurement Endpoints

Development of this assessment has considered potential Project-related effects with respect to all marine mammal species within the Marine RSA. However, it is impractical and unnecessary to conduct a detailed assessment for every species that may be present in the Marine RSA. Best practice for the assessment of potential effects on a wide range of species that share much in common with respect to Project-related risks is to select a representative group of indicator species upon which to focus the assessment. Therefore, three marine mammal indicator species have been selected for more detailed assessment to represent the full range of potential effects to a broad range of marine mammal species. The process for selecting indicators for marine mammals began with a review of marine mammal species known to be present year-round or seasonally within the Marine RSA (see Section 4.3.7.2).

The indicator species were selected to fit all or most of the following criteria:

- they have life requisites shared by a broad group of other marine mammal species;

- they are likely to regularly or seasonally use habitats within the Marine RSA;
- they are a species of conservation concern, are considered restricted in range, or are associated with critical habitat or a sensitive ecological community in the Marine RSA;
- they are sensitive to effects associated with increased Project-related marine vessel traffic or have been documented as a species susceptible to anthropogenic disturbances;
- measurement endpoints and the mechanism by which they are affected by potential Project-related impacts are comparable across the group of species they have been selected to represent;
- there is an established baseline of information on their biology, population abundance, and distribution;
- they are a species whose disappearance could alter or disrupt the function of the ecosystem;
- they have been identified as important to coastal Aboriginal communities; and
- they have previously been used as indicators in regional effects-based assessments and, therefore, have been the focus of academic and/or regulatory studies within the Marine RSA.

The final selection of indicators took into consideration: experience gained during previous projects with similar ecological conditions and potential issues; feedback from government agencies and stakeholders; and professional judgment of the assessment team.

Ultimately, the three indicator species selected to represent potential effects from the increase in Project-related marine vessel traffic are: southern resident killer whale (*Orcinus orca*); humpback whale (*Megaptera novaeangliae*); and Steller sea lion (*Eumetopias jubatus* ssp. *monteriensis*). These species are broadly representative of the three diverse taxonomic groups of marine mammals (*i.e.,* toothed whales, baleen whales, and pinnipeds) that are found in the Marine RSA and each indicator meets most or all of the criteria described above. All of the indicator species are highly mobile and are, at times, widely distributed throughout the Marine RSA.

An overview of the marine components of the Marine Transportation ESA was presented at the North Vancouver Marine ESA Workshop on May 22, 2013. The presentation included identification of key issues and effects, proposed indicators, and spatial boundaries for all marine elements. During this workshop, feedback was received from marine mammal researchers from the Vancouver Aquarium concerning the need to explicitly consider fin whales with respect to potential vessel strikes. This recommendation was considered as part of the indicator selection process.

Fin whales are seasonally present within the Marine RSA in small numbers. Although a recognized species of conservation concern, fin whales are considered sufficiently represented within the assessment of potential routine effects through the humpback whale indicator, due to their similar physiology (*i.e.,* baleen whales), functional hearing group (*i.e.,* low-frequency specialists), and the humpback whale's more abundant local population (*i.e.,* greater likelihood for interaction). While fin whales are recognized as being at potentially higher risk of vessel strikes (relative to humpback whales), vessel strikes are assessed under Accidents and Malfunctions (see Section 4.3.13) and appropriate consideration of baleen whales in general (including both fin and humpback whales) is provided in that subsection.

A similar concern was raised by a member of the North Vancouver Marine ESA Workshop audience over the lack of inclusion of the harbour porpoise as a separate indicator. In the initial selection of a marine mammal indicator representative of odontocetes (*i.e.,* toothed whales), both the harbour porpoise and the southern resident killer whale were considered. The southern resident killer whale was ultimately selected because its designated critical habitat overlaps almost entirely with the Marine RSA and because it is considered to be of greater conservation concern (*i.e.,* it is listed as Endangered under *SARA*). In contrast, the harbour porpoise is listed as Special Concern. However, the harbour porpoise was included as an additional indicator in the acoustic modelling study and, therefore, results can be assessed for comparability with killer whales.

A meeting was also held with DFO in Kamloops on September 25, 2013 to present a high-level overview of the Marine ESA approach, including spatial boundaries, key issues and effects, and indicators. DFO did not raise any concerns with the information provided and did not provide any specific feedback regarding marine mammals.

A summary of the rationale for the selection of each of these indicators, based on the criteria listed above, is provided in Table 4.3.7.1.

For the assessment of effects on marine mammals associated with increased Project-related marine traffic, the measurement endpoints include both quantitative and qualitative metrics as follows:

- the potential for injury and/or sensory disturbance, evaluated qualitatively based on predicted potential increases in underwater sound pressure levels (SPLs; in dB re: 1µPa) and sound exposure levels (SELs; dB re: 1 µPa2-s); and
- the spatial extent of marine mammal habitat affected (*i.e.*, instantaneous distance from sound source in km) and relative importance and quality of that habitat.

The qualitative potential for effects of increased underwater noise was assessed based on a comparison between results of predicted modeling of underwater SPLs and commonly-applied injury and disturbance thresholds for marine mammals. The spatial extent of potentially affected habitat was also calculated based on the acoustic modeling exercise and noise criteria, and importance of this habitat was assessed qualitatively relative to importance and availability of suitable habitat in the rest of BC. The degree of change in these endpoints was used to characterize and determine the significance of the residual environmental effects of the increased Project-related marine vessel traffic on marine mammals within the context of existing conditions.

Table 4.3.7.1 provides a summary of the measurement endpoints considered for each indicator.

TABLE 4.3.7.1

ASSESSMENT INDICATORS AND MEASUREMENT ENDPOINTS FOR MARINE MAMMALS

Marine Mammals Indicator	Measurement Endpoints	Rationale for Indicator Selection
Southern resident killer whale (*Orcinus orca*)	• Qualitative potential for (1) injury, and (2) sensory disturbance, based on predicted underwater sound pressure levels (in dB re: 1μPa) and sound exposure levels (in dB re: 1 μPa^2-s), due to the increase in Project-related marine traffic. • Spatial extent of marine mammal habitat affected (*i.e.*, instantaneous distance from sound source in km) and relative importance and quality of that habitat.	• Representative odontocete (*i.e.,* toothed whale; other species in the Marine RSA include harbour porpoise, Dall's porpoise, and Pacific white-sided dolphin) • Known presence and abundance in the Marine RSA, particularly during summer and fall • *SARA*-listed species: Endangered • Critical habitat overlaps the shipping lanes • Potential sensitivity to underwater noise, as noted in DFO Recovery Strategy • Best hearing sensitivity to mid to high-frequency noise (*i.e.,* represents a separate functional hearing group from the other two indicators) • Well-studied species with an established baseline of population information • Valued for socio-economic and cultural importance
Humpback whale (*Megaptera novaeangliae*)		• Representative mysticete (*i.e.,* baleen whale; other species in the Marine RSA include fin whale, grey whale, and minke whale) • Known presence in portions of the Marine RSA, particularly during summer and fall • *SARA*-listed species: Threatened • Critical habitat partially overlaps the shipping lanes • Potential sensitivity to underwater noise, as noted in DFO Recovery Strategy • Best hearing sensitivity to low-frequency noise (*i.e.,* represents a separate functional hearing group from the other two indicators) • Well-studied species with an established baseline of population information • Known to have high site fidelity to feeding areas • Valued for socio-economic and cultural importance
Steller sea lion (*Eumetopias jubatus* ssp. *monteriensis*)		• Representative pinniped (*i.e.,* seal or sea lion; other species in the Marine RSA include harbour seal and California sea lion) • Known presence in the Marine RSA year-round, peak numbers during fall and winter • *SARA*-listed species: Special Concern • Major year-round and seasonal haulout sites identified near the shipping lanes • Uses both marine and terrestrial habitat within the Marine RSA • Potential sensitivity to Project-related effects noted in DFO Management Plan • While less sensitive to underwater noise than other two indicators, represents a separate functional hearing group • Well-studied species with an established baseline of population information • Valued for socio-economic and cultural importance

4.3.7.2 Spatial Boundaries

Spatial boundaries used for the assessment of potential effects of increased Project-related marine traffic on marine mammals are defined as follows:

- **LSA** - There is no separately defined LSA for marine mammals; residual effects are all assessed within the Marine RSA (below).
- **Marine RSA** - comprised of a large portion of the Salish Sea, including the inland marine waters of the southern Strait of Georgia and Juan de Fuca Strait and their connecting channels, passes and straits. The Marine RSA is generally centred on the marine shipping lanes, which extend from the Westridge Marine Terminal through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, westward past Victoria and through Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea. The western boundary of the Marine RSA extends further out to sea than the western boundary of the Salish Sea and the northern boundary of the Marine RSA is limited to the southern portion of the Strait of Georgia. Puget Sound is excluded from the Marine RSA.

Many species of marine mammals are migratory, with ranges that may cover tens of thousands of kilometres and encompass large sections of the North Pacific Ocean. The spatial boundaries of the Marine RSA were not selected to cover the entire range of all marine mammal species found there. However, the boundaries reasonably reflect the potential extent of residual effects associated with increased Project-related marine traffic within Canada's territorial sea waters. The Marine RSA encompasses diverse populations of resident and seasonally-present marine mammals, seasonally important foraging areas, breeding habitat, terrestrial haulout sites for pinnipeds, and critical habitat under *SARA* for both southern resident killer whales and humpback whales.

Study area boundaries for marine mammals are shown in Figure 4.2.2.

4.3.7.3 Marine Mammals Context

4.3.7.3.1 Shipping

The assessment of potential effects of the increase in Project-related marine vessel traffic is centered on the established in-bound and out-bound marine shipping lanes and considered in the context of the volume and activity of existing traffic in the Marine RSA. The shipping lanes are officially determined and set by Transport Canada. In the Marine RSA, they provide designated routes through the Salish Sea, commencing at Burrard Inlet and extending through several major waterways, including the southern part of the Strait of Georgia, Haro Strait and Juan de Fuca Strait, out to the 12 nautical mile limit of Canada's territorial sea. The lanes are confined within narrow waterways for only a small portion of the route out to sea, primarily within Burrard Inlet east of First Narrows, and within Boundary Pass and Haro Strait where the vessels pass a complex of small islets and channels. The shipping lanes are generally centred in the middle of the channels and only 5 per cent of the total length of shoreline in the Canadian portion of the Marine RSA is located within 2,000 m of the shipping lanes.

These marine shipping lanes, among the busiest in the province, are an established route for all types of commercial vessels and are the mandatory routing for cargo ships, cruise ships, and tankers that transit these waters on a daily basis (see Volume 8C, BC MCA 2010, CCG 2013b).

In 2012, cargo and bulk carrier traffic made up approximately 32 per cent of the number of reportable vessel movements in the Marine RSA, with tug and passenger traffic making up a further 28 per cent and 14 per cent, respectively ('vessel movements' based on counts of vessels within 5 cross sections; see Table 5-1 of TERMPOL 3.2, Volume 8C, TR8C-2). All tanker traffic in 2012 (including vessels not associated with the existing Westridge Marine Terminal operations) accounted for 4 per cent of overall vessel movements in the Marine RSA.

While current loadings at the Westridge Marine Terminal fluctuate based on market conditions, five tankers and three barges are typically handled each month. These are accounted for in the above estimates. The expansion of the terminal is expected to result in an increase in Project-related traffic of approximately 29 partially-loaded Aframax tanker calls per month. To account for potential fluctuations and to allow the assessment to be conservative, the marine mammals modelling was conducted for approximately 30 partially-loaded Aframax tanker calls (*i.e.,* 60 transits) per month. There will also be an increase in tug traffic associated with these vessel movements (*e.g.*, 240 movements per month in Burrard Inlet and 120 movements per month in Haro Strait). Based on current conditions (*i.e.,* not accounting for growth, future developments, or Project-related increases in tug traffic), the increase in Project-related tankers will make up approximately 58 per cent of all tanker movements in the Marine RSA, and will increase the relative number of tanker movements to approximately 9 per cent of total vessel movements in and out of the shipping lanes. Overall, the additional Project-related vessels (tugs and tankers) will make up approximately 11.9 per cent of reportable vessel movements in and out of the shipping lanes, and account for an increase of 13.5 per cent over current vessel movements (extrapolated from TERMPOL 3.2, Volume 8C-2). The above estimates for vessel traffic do not account for projected increases in traffic or future developments, nor do they include smaller commercial vessels such as fishing charters and whale-watching fleets, as well as the many recreational vessels that transit the same waters as the shipping lanes and wind through the numerous inlets and waterways of the Gulf and San Juan islands.

Project-specific underwater noise resulting from the increase in tanker and tug numbers is most meaningful when considered relative to existing underwater sound levels. Existing underwater noise in the vicinity of the marine shipping lanes is a combination of natural and man-made sound. The introduction of underwater noise occurs as an individual event for each vessel that passes by a specific location. All vessel activity in the Marine RSA is a source of underwater noise, and the existing Trans Mountain-related shipping forms part of the existing acoustic environment. Relative to current Trans Mountain-related shipping, no changes to the types of noise generated or the intensity of the individual tankers or tanker/tug combinations is expected. The change in underwater sound levels that are expected to occur due to increased Project-related traffic is the result of the increased number of pass-by vessel occurrences, which are expected to be on average one laden tanker (plus associated escort tugs) and one empty tanker daily. This increase in events could increase day and night average ambient underwater sound levels in the Marine RSA.

4.3.7.3.2 Marine Mammal Presence

A total of 33 species (or ecotypes) of marine mammals can be found in BC, and 22 of these have been recorded in the Marine RSA on at least one occasion (see Section 4.2.7.4). While many of these species are observed year-round, some are seasonal or migratory, while others are considered only rare or accidental sightings. Marine mammals use many habitats within the Marine RSA, from terrestrial use of rocky islets, sandbars, docks and piers to all marine waterways from the deeper waters of the shipping lanes to the shallower backwater shorelines and inlets. Large aggregations of a particular species may gather in certain areas, often attracted by ocean conditions that are favourable for concentrating prey. At other times, individuals may be distributed broadly, so that specific occurrence and distribution within the Marine RSA is in a state of constant flux.

The most commonly observed species of toothed whales in the Marine RSA include killer whales, harbour porpoises (*Phocoena phocoena*), Dall's porpoises (*Phocoenoides dalli*), and large aggregations of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*). DFO Important Areas for harbour porpoises in the Marine RSA are shown in Figure 4.2.22. Critical habitat for southern resident killer whales has been officially designated for the trans-boundary waters of Haro Strait, Boundary Pass, Juan de Fuca Strait and the southern portion of the Strait of Georgia, as well as Puget Sound (DFO 2009b) (see Figure 4.2.22).

The most commonly observed baleen whale is the humpback whale, although the minke whale (*Balaenoptera acutorostrata*) and grey whale (*Eschrichtius robustus*), as well as the occasional fin whale (*Balaenoptera physalus*) are also observed. The western-most portion of the Marine RSA overlaps humpback whale critical habitat (DFO 2013h) (see Figure 4.2.22). This area, which extends offshore beyond the Marine RSA and Canada's 12 nautical mile limit, has been identified as an area of importance for a potentially distinct sub-population of humpback whales that occupies southern BC and northern Washington State waters (DFO 2013h).

The most common pinniped is the harbour seal (*Phoca vitulina richardsi*), followed by the Steller and California (*Zalophus californianus*) sea lions. Northern fur seal (*Callorhinus ursinus*), and northern elephant seal (*Mirounga angustirostris*) may be seen in small numbers in the western extent of the Marine RSA. Male sea otters (*Enhydra lutris*), mostly from the Washington State population, are also observed in small numbers in the western part of Juan de Fuca Strait and Gulf Islands, though do not appear to have established permanently in the Marine RSA at this time.

Up until the late nineteenth century, large baleen whales, including the humpback whale, were a common sight in the Strait of Georgia. Even fin whales, generally more common to offshore and exposed coastal waters, were historically seen on occasion in these more protected waters (Pike and MacAskie 1969 in Gregr *et al.* 2006). At least 95 humpback whales were commercially hunted and killed in the Strait of Georgia and Queen Charlotte Strait between 1866 and 1873 (Nichol *et al.* 2002). A whaling station was established at Page's Lagoon near Nanaimo from 1907 to 1909 to hunt humpback whales that overwintered in the Strait of Georgia (Merilees 1985 in Nichol *et al.* 2002). Whaling-related BC coastal geographical names in the Strait of Georgia, such as Whaling Station Bay (Hornby Island), Blubber Bay (Texada Island), and Whaletown (Cortes Island) attest to previous whale presence in this region (Merilees 1985 in Nichol *et al.* 2002). While they have not returned to historic levels, sightings of humpback whales in the Marine RSA have increased in recent years, particularly in the westward portion, which has recently been designated as critical habitat (DFO 2013h).

Historically, marine mammals such as harbour seals were a major source of food for the Aboriginal people of Burrard Inlet (BIEAP 1995). DFO Important Areas for harbour seals in the Marine RSA are shown in Figure 4.2.22. Currently, marine mammals are a major viewing attraction for tourists and local residents, and whale watching companies from Victoria, Vancouver and some Gulf Islands run multiple trips daily during the peak whale watching season of late spring, summer and early fall.

4.3.7.3.3 Existing Marine Mammal Stressors

Marine mammals in the Marine RSA and in many similarly urbanized marine waterways in North America and throughout the world's oceans face a variety of anthropogenic threats and stressors. These vary in intensity and relative importance for individual species, but broadly speaking, include: chemical contamination from both legacy contaminants and current inputs; reductions in prey abundance or quality; physical disturbance; acoustic disturbance or injury from both acute and chronic sources; risk of collisions; risk of entanglements; and, climate change. Many of these threats are identified in DFO's Recovery Strategies and Management Plans for *SARA*-listed marine mammal species (*e.g.,* DFO 2010a, 2011, 2013a).

These effects may act cumulatively and in an additive fashion. For example, some disturbances reduce time available for or efficiency of foraging (*e.g.,* Williams *et al.* 2006) and may be of greater consequence for populations that are already prey-limited.

4.3.7.4 Potential Effects and Mitigation Measures

4.3.7.4.1 Effects Considerations

A thorough review of possible issues to include in the assessment of potential Project effects on marine mammals was based on the professional experience of the assessment team and relevant literature. Identified potential effects included auditory injury or sensory disturbance from both underwater and atmospheric noise. Effects of atmospheric noise were eventually scoped out by the assessment team based on past experience with similar projects and a determination of low likelihood of effects of importance for marine mammals. The rationale for this decision is discussed briefly below.

Potential Effects on Prey

Potential Project-related effects of increased Project-related marine vessel traffic on marine fish and fish habitat (*i.e.,* potential prey) were assessed in Section 4.3.6 above. This assessment determined that residual effects of the Project on both the Pacific herring and Pacific salmon indicators are unlikely and of negligible magnitude. Potential Project-related effects on freshwater fish and fish habitat (*i.e.,* potential prey) were assessed in Section 7.2.7 of Volume 5A and were determined to be of low to medium magnitude. As such, indirect effects to marine mammals associated with potential Project-related loss of prey (as the result of direct effects to fish and fish habitat) were not considered further. The potential for reduced marine mammal foraging efficiency as a result of underwater noise is addressed under the assessment of residual effects of sensory disturbance, presented below.

Potential Effects of Increased Contaminants

Potential residual effects of Project-related marine vessel traffic on marine water and sediment quality are discussed in Section 4.3.2 above and are not addressed further in this subsection.

Potential effects associated with any accidental release from vessels are addressed in Sections 4.3.13 (for bilge water containing fuels, oils and/or lubricants) and 5.0 (for oil spills).

Potential Effects of Atmospheric Noise

Pinnipeds on land may be sensitive to human disturbance. Behavioural responses by Steller sea lions onshore have been documented for both natural and anthropogenic disturbances, though the degree and type of response may vary (*e.g.,* agitating head, vocalizing, fleeing into the water) and depend on location (Kucey 2005, Kucey and Trites 2006). Repeated disturbance of rookeries or haulouts by construction, aircraft, boats or fishing activities may result in temporary or even permanent abandonment of these areas (Kucey 2005, Lewis 1987). Displacement from rookeries during the pupping season is of primary concern as this may result in pup mortality (*i.e.,* from being trampled, drowned, or separated from their mothers) or increased energetic costs to both mothers and pups should feeding or nursing opportunities be interrupted (DFO 2010a). Since there are no rookeries within or in close proximity to the Marine RSA, these effects are not considered further.

Displacement into the water from haulouts may slightly increase energetic costs or the risk of predation from transient killer whales; however, the DFO Management Plan for the Steller Sea Lion (2010a) states that Steller sea lions "often habituate to chronic disturbances" and notes that there are currently haulout sites in "high traffic areas close to major urban centres such as Vancouver and Victoria". The closest approach of the marine shipping lanes to a Steller sea lion haulout is 1 km, at Trial Islands. However, current shipping activity passes at this distance and Steller sea lions continue to use this haulout location. This is not predicted to change as a result of the increase in Project-related atmospheric vessel noise. As such, the potential effect of atmospheric noise on marine mammals is not discussed further. The increase in atmospheric sound levels in the Marine RSA was assessed for human receptors in Section 4.3.5 above.

4.3.7.4.2 Identified Potential Effects

The identified potential effects on marine mammals associated with the increase in Project-related marine vessel traffic include auditory injury and sensory disturbance.

Loud underwater noise has the potential to result in temporary or permanent auditory injury (*i.e.,* temporary or permanent threshold shifts [TTS or PTS]) to marine mammals in close proximity to the sound source (Richardson *et al.* 1995). To determine potential effects of Project-related vessel-based underwater noise on marine mammals, sound source levels from tankers and tugs (based on literature values and acoustic modelling) were contrasted with threshold sound levels that have been predicted to cause temporary and permanent auditory injury in marine mammals.

The production of loud underwater noise could also cause sensory disturbance to marine mammals (sometimes referred to in the literature as behavioural disruption or disturbance). Sensory disturbance may result in behavioural responses such as habitat avoidance, changes in activity state (*e.g.,* feeding, resting, or travelling) and/or interference with communication and perception of sounds (*i.e.,* masking; Richardson *et al.* 1995). The extent of sensory disturbance depends on a number of factors, including: the source level; frequency and duration of the underwater noise; the context (*i.e.,* the animal's activity state at the time); and the species in question. Results of the acoustic modelling were contrasted with threshold sound levels that have been predicted to induce behavioural disturbance. Below these thresholds, marine mammals may still be able to detect Project-related noise, and this may interfere with their communication or ability to perceive other important acoustic signals in their environment (*i.e.,* masking). While no thresholds exist for quantifying the potential for such effects, or their importance at the population level, the spatial extent over which Project-related sounds will be detectable by marine mammals is discussed.

4.3.7.4.3 Injury Criteria and Disturbance Thresholds

Noise-induced PTS, TTS, and sensory disturbance may compromise marine mammal feeding efficiency, predator detection, and/or migratory success, and can lead to reduced health and possibly death (Richardson *et al.* 1995). DFO does not have any formal guidance or thresholds for assessing the potential effects of underwater noise on marine mammals (with the exception of seismic surveys, for which it has a statement of Canadian practice) (DFO 2013g).

Different thresholds are typically used for impulsive noise (single or multiple pulses; *e.g.,* explosions or pile driving) versus non-pulse sound sources (*e.g.,* shipping). Since increased Project-related marine vessel traffic will introduce only non-pulse sounds to the marine environment, thresholds which relate only to pulse-type noise are not provided or discussed further in this assessment. Further details on effects and thresholds related to pulse-type noise are presented in Section 7.6.11 of Volume 5A.

In the absence of Canadian legislation or guidelines for non-pulse sound sources, the ESA considered two alternative sets of commonly-applied thresholds.

The first set of thresholds, developed by Southall *et al.* (2007; hereafter referred to as the Southall *et al.* thresholds), is used primarily to evaluate the potential for permanent injury (*i.e.,* PTS). Sound levels capable of inducing injury in marine mammals are not well established. PTS has not been observed in any marine mammal and TTS has only been observed in a few species of pinnipeds and small toothed whales (Southall *et al.* 2007). Estimates of sound levels capable of inducing auditory injury are therefore developed by extrapolating from known or predicted marine mammal auditory thresholds (Richardson *et al.* 1995, Southall *et al.* 2007). The injury criteria proposed by Southall *et al.* in 2007 are the most recent generalized estimates of PTS-inducing SELs, and are based on a comprehensive analysis of existing research. Southall *et al.*'s proposed injury criteria for SELs are summarized in Table 4.3.7.2. Different thresholds are proposed for cetaceans (*i.e.,* whales, dolphins, and porpoises) and pinnipeds (*i.e.,* seals and sea lions).

The second set of thresholds is that currently used by NOAA in the US to issue *Marine Mammal Protection Act* (*MMPA*) permits and conduct *Endangered Species Act* Section 7 consultations (NOAA Fisheries 2013). These are considered interim conservative thresholds to be used until formal guidance is available. The NOAA criteria are frequently used to evaluate sensory disturbance because Southall *et al*. did not recommend specific numeric criteria for the onset of sensory disturbance for non-pulse sound sources. The NOAA criteria also set thresholds for SPLs deemed capable of potentially causing PTS, but only for impulsive sounds. The NOAA criteria are summarized alongside Southall *et al.*'s in Table 4.3.7.2. Both metrics are considered in this assessment. While NOAA is currently revising its criteria, with specific reference to different sound sources (*e.g.,* explosives; Finneran and Jenkins 2012), criteria specific to shipping noise are not yet available.

TABLE 4.3.7.2

MARINE MAMMAL INJURY CRITERIA AND SENSORY DISTURBANCE THRESHOLDS USED IN THE ESA

Species Group	Southall *et al.* Injury Criteria (PTS-onset)[1,2]	Southall *et al.* TTS-onset Thresholds	NOAA 'Behavioural Disruption' Thresholds[3]
	SEL[4] (dB re: 1 µPa^2-s)[5]	SEL[4] (dB re: 1 µPa^2-s)[5]	RMS SPL[6] (dB re: 1 µPa)
Pinnipeds	203	183	120
Cetaceans	215	195	120

Notes:

1 Shipping is an example of a non-pulse noise. Thresholds for pulse noises such as impact pile driving are not presented above.

2 The term "auditory injury" as used by NOAA or Southall *et al.* is intended to refer strictly to permanent auditory damage (*i.e.*, PTS) and the column of injury criteria above thus reflects only the onset levels for PTS (not TTS). However, the terms 'permanent auditory injury' and 'temporary auditory injury' are used in this ESA interchangeably with the terms PTS and TTS, respectively (*i.e.*, this assessment considers TTS to be a form of injury, even if only temporary in nature).

3 The term "behavioural disruption" is used by NOAA, and the term "behavioural disturbance" is used by Southall *et al.* 2007. For the purposes of this ESA, both of these terms and associated thresholds are encapsulated under the effect of "sensory disturbance".

4 Values taken from Southall *et al.* 2007.

5 Decibels re: 1 µPa are the accepted unit for measuring underwater sound as it relates to marine mammals (Richardson *et al.* 1995, Southall *et al.* 2007); however, there are different metrics (*i.e.*, peak vs RMS) for measuring and reporting decibels (all SPL values used in this ESA are RMS). SELs are a measure of received sound energy (the dB level of the time integral of the squared-instantaneous sound pressure normalized to a 1-s period) and values presented in Table 4.3.7.2 were developed to reflect M-weighted SELs by functional hearing group (see Southall *et al.* 2007). Functional hearing groups and M-weighted SELs reflect the fact that different species hear best at different frequency ranges. Only unweighted SELs (*i.e.*, SELs that do not account for species-specific hearing ranges) are modelled and used in this assessment. Comparison of unweighted source levels and M-weighted thresholds is expected to give a conservative estimate of the Southall PTS and TTS onset distances, since unweighted levels are always higher than M-weighted values.

6 Values taken from NOAA Fisheries 2013.

7 RMS SPL = Root Mean Square Sound Pressure Level (SPLs values presented in this report are all RMS unless otherwise noted; units in dB re: 1 µPa); SEL = Sound Exposure Level (always referenced in this ESA in units of dB re: 1 µPa2-s); PTS = Permanent Threshold Shift; TTS = Temporary Threshold Shift.

4.3.7.4.4 Summary of Acoustic Modelling Results

Sound Pressure Level (SPL) Modelling Scenarios and Results

Project-related marine vessel traffic will increase by approximately 30 Aframax tanker calls to the Westridge Marine Terminal per month (*i.e.,* an additional 720 tanker transits through the Marine RSA each year). This number is expected to be a maximum, and the actual number of tanker calls will fluctuate monthly. A potential concern associated with the proposed expansion is that increased levels of underwater noise from vessel traffic may negatively affect marine mammals such as the *SARA*-listed southern resident killer whale and humpback whale. As part of the ESA, JASCO Applied Sciences Ltd. (JASCO) performed an underwater acoustic modelling study to predict underwater sound levels generated by vessel traffic associated with the Project. Detailed results and discussion are presented in Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1). Summary tables of some of these results are provided below and are used in the following sections to assess potential acoustic effects of increased vessel traffic on marine mammals.

The JASCO study modelled the acoustic footprint (in RMS SPLs) produced during a single pass of an outbound tanker and accompanying tug at four representative locations along the shipping lanes in the Marine RSA.

- **Scenario 1** - Strait of Georgia – An Aframax tanker, plus one un-tethered accompanying tug at 500 m from the tanker's stern, both travelling at a normal transiting speed of 13 knots.
- **Scenario 2** - Haro Strait – An Aframax tanker, plus one accompanying tug tethered to the tanker's stern at 50 m, both travelling at a normal transiting speed of 10 knots.
- **Scenario 3** - Juan de Fuca Strait – An Aframax tanker, plus one un-tethered accompanying tug at 500 m from the tanker's stern, both travelling at a normal transiting speed of 15 knots.
- **Scenario 4** - North of Cape Flattery – A solo Aframax tanker transiting at a normal transiting speed of 15 knots

Locations of each modelling scenario are shown on Figure 4.3.1. The different speeds were chosen to reflect predicted maximum speeds in each area, which vary based on local restrictions and requirements for escort tug accompaniment (tethered or un-tethered). When the underwater noise modeling program was initiated, tugs were not expected to accompany outbound tankers to the west of Scenario 3. Since completion of acoustic modelling, Trans Mountain has proposed to add an additional un-tethered tug, to travel in the vicinity of outbound laden tankers between Race Rocks and the 12 nautical mile limit and be available to assist if the tanker encounters navigational problems. Expected speeds for the tanker and tug in this area will be in the range of 10 to 12 knots (while 15 knots was modelled to be conservative, as increased speed generally causes increased underwater noise). The additional tug will contribute additional underwater noise above what was modelled for Scenario 4; however, the reduced speeds from 15 knots to 10 or 12 knots for both tanker and tug are likely to partially offset the effects of the additional vessel. Changes to this scenario are, in the professional judgment of the assessment team, not expected to alter the conclusions presented in the ESA. Revised acoustic modelling will be undertaken and filed as supplemental information in Q1 2014 to confirm these predictions (see Section 4.5).

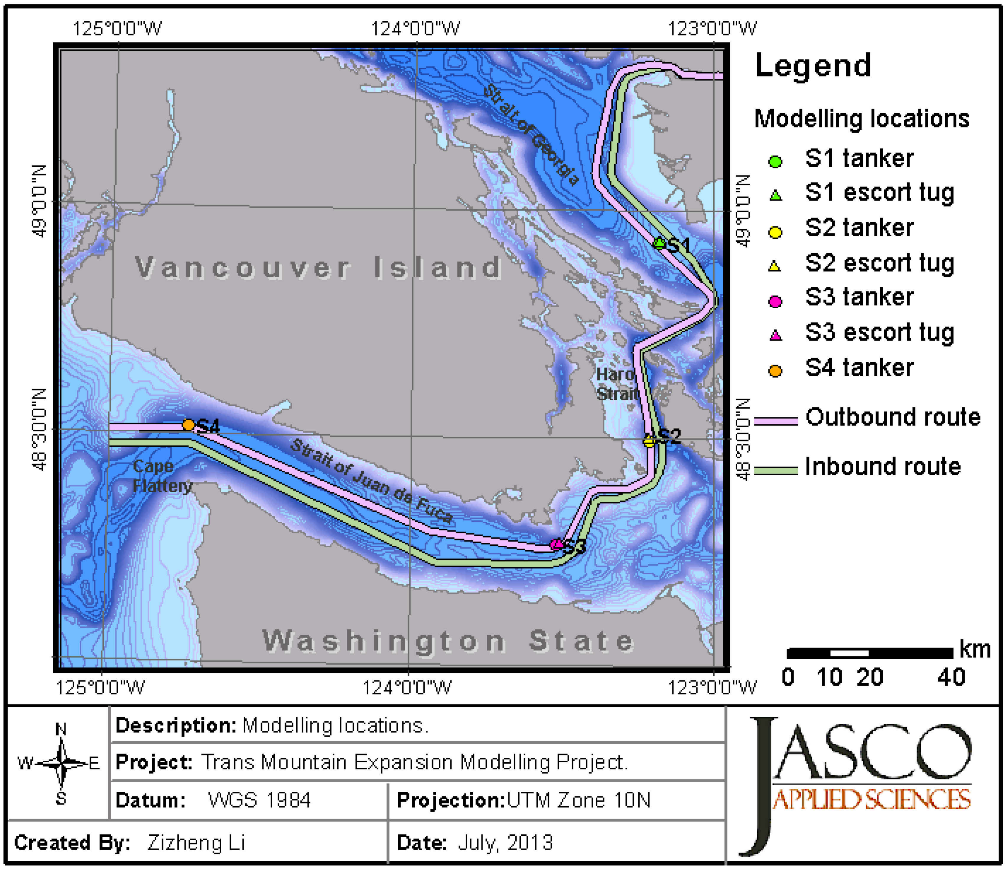

Figure 4.3.1 Map of Marine Acoustic Modeling Study Area, Showing Inbound and Outbound Shipping Lanes and Four Modeled Source Locations

The acoustic source levels used in the modeling study to represent tankers and tugs associated with the Project were derived from measurements of similar vessels obtained from the available literature. Table 4.3.7.3 shows the radii (in km) to the SPL contours for each of the four scenarios described above.

TABLE 4.3.7.3

RADII OF UNDERWATER SOUND PRESSURE LEVEL CONTOURS FOR SCENARIOS 1 TO 4

RMS SPL[1] (dB re: 1 μPa)[2]	Scenario 1 (13 knots, un-tethered tug)		Scenario 2 (10 knots, tethered tug)		Scenario 3 (15 knots, un-tethered tug)		Scenario 4 (15 knots, no tug)	
	R_{max} (km)[3]	$R_{95\%}$ (km)[4]	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
120	5.28	4.79	5.44	3.64	8.1	7.13	8.55	6.52
130	1.56	1.42	0.82	0.73	2.96	2.65	1.27	1.18
140	0.54	0.49	0.18	0.17	0.79	0.7	0.22	0.21

Notes:

1 SPL = Sound Pressure Level.

2 Results taken from Table 8 in Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1). Only radii for SPL values up to 140 dB re: 1 μPa (where calculated R95% distances drop to 500 m or less) are summarized here. Radii for SPLs up to 190 dB re: 1 μPa are presented in Table 8 as referenced above. At resolutions of less than a few hundred metres, the model assumes that all noise originates from the propeller of the loudest vessel (*i.e.*, the tug in all but Scenario 4).

3 Rmax is the maximum distance (in km) from the source to the given noise threshold in any direction (equivalent to R100%). For cases where the ensonification to a specific level is discontinuous and small pockets of higher received levels occur far beyond the main ensonified volume (*e.g.*, due to convergence of sound rays), Rmax would be much larger than R95% and, therefore, could be misleading if not given alongside R95%.

4 R95% is the radius of a circle that encompasses 95% of the grid points whose value is equal to or greater than the threshold value. For a given threshold level, this radius always provides a range beyond which no more than 5% of a uniformly distributed population would be exposed to sound at or above that level, regardless of the geometrical shape of the noise footprint. Distances to various SPL thresholds discussed in this assessment will always refer to the R95% values.

Table 4.3.7.4 presents predicted exposure times for a stationary marine mammal in close proximity to the shipping lane at each scenario location, during a single transit of Project-related marine vessels. This translates to potential daily exposure of an individual marine mammal to sensory disturbance from Project-related marine vessels for approximately 4 per cent of the day (based on the worst case scenario [*i.e.,* Scenario 3] and assuming a single exposure to both Project-related marine vessel transits in a 24-hour period). Actual exposure times would be less for animals swimming away from the vessel (either by chance or as part of a negative behavioural response), but could be more for animals swimming alongside or ahead of the vessel (either also by chance, as a result of attraction to the vessel, or as a negative behavioural response if it occurs within confined channels). Fast-moving and highly mobile species such as killer whales may also be exposed to the same vessel more than once over the course of a single transit through the Marine RSA.

TABLE 4.3.7.4

LENGTH OF EXPOSURE TO SOUND LEVELS CAPABLE OF CAUSING SENSORY DISTURBANCE TO A STATIONARY MARINE MAMMAL FOR SCENARIOS 1 TO 4

	Scenario 1 (13 knots)	Scenario 2 (10 knots)	Scenario 3 (15 knots)	Scenario 4 (15 knots, no tug)
Length of Exposure (in minutes) of a Stationary Marine Mammal to SPLs[1] Exceeding Sensory Disturbance Thresholds (*i.e.,* > 120 dB re: 1 µPa)[2]	24	24	31	28

Notes: 1 SPL = Sound Pressure Level.

2 Calculated based on values presented in Table 4.3.7.3, assuming a single transit of Project-related marine vessels, passing a stationary marine mammal in close proximity to the shipping lane, and exposed to SPLs > 120 dB re: 1 µPa both before and after the passing of the vessel (*i.e.*, two times the R95% distance).

Audiograms

The potential for anthropogenic noise to affect a marine mammal depends not just on the sound level (in decibels) or type of sound (impulse or non-pulse), but also on how well the animal can hear the noise. Noises at frequencies that animals cannot hear well are less likely to disturb them. Audiograms are species-specific sensitivity curves that represent an animal's auditory detection threshold (*i.e.,* the point at which they are able to first hear a sound) as a function of frequency (Erbe 2002). Different species of marine mammals can be classed into different functional hearing groups based on their hearing sensitivity at different frequencies. Southall *et al.* (2007) identified four functional hearing groups for marine mammal exposure to underwater noise:

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

The acoustic modelling study calculated audiogram-weighted levels (*i.e.,* noise levels above hearing threshold, expressed in units of dB re: hearing threshold (dB re: HT) for the three marine mammal indicators, each of which represents a separate functional hearing group. Audiogram-weighted levels were also calculated for harbour porpoises, and these were found to be appropriately represented by the killer whale indicator (as the representative odontocete and mid to high-frequency hearing specialist; acoustic modeling results specific to harbour porpoises are available in Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1). Therefore, the southern resident killer whale is considered to be an appropriate indicator for assessing effects of underwater noise on other toothed whales, including porpoises and dolphins.

Sound levels less than 0 dB re: HT are below the typical hearing threshold for a species and, therefore, are expected to be inaudible. Because of this, audiogram-weighted contour maps can be used to predict the extent to which a noise will be audible to a particular species.

Ambient Noise

In addition to an individual species' ability to hear sounds at different frequencies, the ambient background noise of the environment will also affect the zone within which a particular sound is detectable. Ambient noise is the composite noise from all sources in a given environment, from both natural and anthropogenic sources, and it varies with time and location (Bradley 1996). Natural sources of ambient noise include wind and waves, precipitation, biological sources, and tidal currents. Wind and waves are a main source of naturally occurring noise for frequencies from <1 Hz to at least 50 kHz. The interactions between precipitation and ocean surface can be an important component across frequencies from several hundred hertz to greater than 20 kHz. Marine mammals, and some fish and shrimp, are biological sources for ambient noise, covering a frequency band from <10 Hz to >200 kHz. Anthropogenic sources of ambient noise in BC include ship and boat traffic, aircraft, dredging and construction, sonars, explosions, and ocean acoustic studies. Commercial shipping noise is the major contributor to ambient noise for frequencies from 5–500 Hz, and this source of chronic low frequency noise has been increasing steadily alongside the shipping industry's growth in vessel number, size, and power (Andrew *et al.* 2002, NRC 2003a, Tyack 2008, Wenz 1962).

Current levels of ambient background noise in the Marine RSA limit the zone of detectability of noise originating specifically from Project-related marine vessels, although the background itself may be made up of audible noise from numerous other vessels. Ambient noise levels were estimated for the modelling study based on a review of available published ambient measurements for the area. Results of this review show that marine traffic is the dominant source of underwater noise in the Marine RSA, and primary noise sources identified include (in no particular order): bulk carriers, container ships, cruise ships, barges, tugs, tankers, coast guard vessels, ferries, fishing vessels, whale watching boats, recreational boats, sea planes, and wind and wave noise. The variability of ambient noise in the Marine RSA stems primarily from fluctuations in volume of vessel traffic. Other noise sources (*e.g.,* wind, waves, rain, distant shipping, etc.) are likely to dominate when it is relatively quiet. Table 4.3.7.5 presents the estimated range of average ambient noise in the Marine RSA weighted by different marine mammal species audiograms. Values differ between species as a result of the different frequency ranges within which each functional hearing group hears best (*i.e.,* results have been audiogram-weighted for each species). The upper limit reflects ambient noise as heard by the individual species under 'loud' baseline conditions (*e.g.,* during periods of dense vessel traffic). Lower limits reflect audiogram-weighted ambient noise under 'quiet' background conditions.

TABLE 4.3.7.5

ESTIMATED RANGE OF AVERAGE AMBIENT AUDIOGRAM-WEIGHTED NOISE IN THE MARINE RSA

Ambient Noise	Audiogram-weighted ambient noise SPL (dB re: HT)[1,2,3]			
	Humpback Whale	Killer Whale	Harbour Porpoise	Steller Sea Lion
Upper Limit	75	64	57	37
Lower Limit	52	45	38	14

Notes:
1 Table 9 in Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1).
2 HT = hearing threshold.
3 The range of ambient noise SPLs presented represents the predicted range of background conditions under both ‘loud’ (*i.e.*, lower limit) and ‘quiet’ (*i.e.*, upper limit) conditions in the Marine RSA, within the species-specific hearing range, and in the absence of Project-related marine vessels.

Table 4.3.7.6 shows the estimated distance that underwater noise from Project-related marine vessels is predicted to be detectable by various marine mammal species after accounting for both species-specific hearing abilities and predicted ambient underwater noise levels (*i.e.,* the distance at which Project-related noise becomes audible over background levels). Minimum distances reflect the extent to which Project-specific sounds will be distinguishable from the background under ‘loud’ baseline conditions. Maximum distances reflect the extent to which Project-specific sounds are distinguishable under ‘quiet’ background conditions. Beyond these distances, current levels of background noise in the Marine RSA are expected to mask the ability of marine mammals to detect Project-related marine vessels. Note that these distances are those at which incremental Project-specific underwater noise is predicted to be detectable and do not represent the distances at which sensory disturbance is expected to occur.

TABLE 4.3.7.6

ESTIMATED MINIMUM AND MAXIMUM ZONE OF DETECTABILITY ($R_{95\%}$) ABOVE AMBIENT NOISE, FOR SCENARIOS 1 TO 4

Marine mammal species[1]	Scenario (13 knots)		Scenario 2 (10 knots)		Scenario 3 (15 knots)		Scenario 4 (15 knots, no tug)	
	Min. km (loud background)[2]	Max. km (quiet background)	Min. km (loud background)	Max. km (quiet background)	Min. km (loud background)	Max. km (quiet background)	Min. km (loud background)	Max. km (quiet background)
Killer whale	12.1	79.7	2.6	43.2	14.4	88.9	14.1	89.9
Harbour porpoise	12.1	84.5	2.6	47.4	14.3	93.6[3]	14.3	107.3[3]
Humpback whale	12.1	87.3	7.8	47.2	14.8	93.8[3]	15.0	107.3[3]
Steller sea lion	12.1	84.7	2.6	47.5	14.3	93.7[3]	14.3	107.3[3]

Notes:
1 Data from Table 15 in Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1).
2 Minimum and maximum distances correspond to the upper and lower limits of ambient noise, respectively.
3 Maximum extent restricted by modelling boundary.

4.3.7.4.5 Assessment of Potential for Residual Effects of Auditory Injury

Cumulative Sound Exposure Level Modelling and Results

To estimate distances to Southall *et al.*'s PTS- and TTS-onset thresholds, a different acoustic modelling approach was taken. At each of the four modelling scenario locations, cumulative broadband SELs for Project-related marine vessels were modelled along the shipping lanes. Modelled cumulative SELs reflect the total acoustic energy emitted by Project-related marine vessels in the Marine RSA over 24 hours. The calculations were based on the number of Project-related tankers and tugs assumed to transit both the inbound and outbound shipping lanes over this 24 hour period (*i.e.,* assuming a monthly average of 30 partly-loaded Aframax-sized tanker calls [60 transits]). Further details on the modelling and assumptions related to escort tug transits are provided in Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1). Cumulative SELs were computed for a static receiver (*i.e.,* a stationary marine mammal) passed by a transiting tanker and escort tug at a range of distances (*i.e.,* 10 to 500 m). To measure the cumulative SEL radius at this scale of resolution (*i.e.,* to within 10 m), the model assumes that all noise originates from the propeller of the loudest vessel (*i.e.,* the tug in all but Scenario 4, which has no tug). Estimated distances to Southall *et al.*'s TTS-onset thresholds for both cetaceans and pinnipeds are shown in Table 4.3.7.7. The model showed that sound levels were insufficient for PTS-onset at any distance from the Project-related marine vessels.

TABLE 4.3.7.7

ESTIMATED DISTANCES TO TEMPORARY THRESHOLD SHIFT-ONSET THRESHOLDS FOR SCENARIOS 1 TO 4

TTS[1]-onset threshold (dB re: 1 μPa^2-s)[2,3]	Scenario 1 (13 knots)	Scenario 2 (10 knots)	Scenario 3 (15 knots)	Scenario 4 (15 knots, no tug)
195 (cetaceans)	< 10 m	< 10 m	13 m	< 10 m
183 (pinnipeds)	25 m	17 m	29 m	10 m

Notes:
1 TTS = temporary threshold shift.
2 Values taken from Southall *et al*. 2007.
3 SELs are a measure of received sound energy (the dB level of the time integral of the squared-instantaneous sound pressure normalized to a 1-s period) and values presented in Table 4.3.7.7 were developed to reflect M-weighted SELs by functional hearing group (see Southall *et al*. 2007). Only unweighted SELs (not the M-weighted SELs) are modelled and used in this assessment. Comparison of unweighted source levels and M-weighted thresholds is expected to give a conservative estimate of the Southall TTS onset distances, since unweighted levels are always higher than M-weighted values.

Permanent Auditory Injury (PTS)

Under the Southall *et al.* criteria, cumulative broadband SELs are not predicted to exceed PTS-onset thresholds for cetaceans or pinnipeds under any of the four modelled scenarios (see Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1). Based on these results, no permanent auditory injury to marine mammals is expected as the result of the increase in Project-related marine vessel transit through the Marine RSA, and the potential for residual effects of PTS is not discussed further.

Temporary Auditory Injury (TTS)

Under the Southall *et al.* criteria, cumulative SELs are only predicted to exceed TTS thresholds for pinnipeds at distances of less than 30 m from the vessel's propellers, and for cetaceans at less than 15 m from the vessel's propellers (see Table 4.3.7.7). To measure the SPL radius at this scale of resolution, the model assumes that all noise originates from the propeller of the loudest vessel (*i.e.,* the tug in all but Scenario 4). As such, marine mammals would need to approach within 30 m of the vessel propellers to be exposed to sound levels potentially capable of causing TTS. It is unlikely that a marine mammal would approach this close to the vessels' operating propellers, and exposure to cumulative SELs capable of causing TTS is considered similarly unlikely. Based on these results, no temporary auditory injury to marine mammals is expected as the result of vessel transit through the Marine RSA, and the potential for residual effects of TTS is not discussed further.

4.3.7.4.6 Mitigation Measures

While Trans Mountain can actively enforce restrictions on tankers docked at the Westridge Marine Terminal to comply with Trans Mountain operating practices and standards, once the tanker departs from the terminal, Trans Mountain has little direct control over the operating practices of the tankers or tugs as Project-related marine vessels are owned and operated by a third party. Marine transportation in Canadian waters is authorized and regulated through the *Canada Shipping Act, 2001* and related legislation, and regulations are administered by Transport Canada and the CCG. As such, no direct mitigation has been proposed by Trans Mountain for effects associated with increased Project-related marine transportation.

However, PMV is in the midst of developing a program to look at the current levels of underwater noise in the Strait of Georgia and surrounding waters and to consider options for reducing potential environmental effects of noise from marine traffic on marine mammals. This program will be a collaborative effort, led by PMV, and supported by TC, DFO, and the CCG. It will involve the Chamber of Shipping and the PPA as key stakeholders, as well as other major marine shipping industry representatives. The program will involve the deployment of a network of hydrophones in the Strait of Georgia and Haro Strait that will be used to measure the acoustic signatures of vessels and to monitor the activities of southern resident killer whales and other cetaceans. Data collected through the program will contribute to the development of mitigation measures aimed at reducing acoustic disturbance to marine mammals. PMV is expected to release more details on the program in early 2014.

Trans Mountain is strongly supportive of this regionally-based collaborative industry-government approach to developing viable solutions that could be applied to the marine transportation industry as a whole. Trans Mountain met with PMV in late 2013 and expressed its interest in contributing in a meaningful capacity to the development and implementation of the proposed program. Trans Mountain is also willing to support the outcomes (*i.e.*, research findings and recommended mitigations) that result from the PMV program or a similar government-industry effort. Trans Mountain will be furthering conversation with PMV in early 2014 to establish how to best support and participate in current and future endeavours on this topic.

Table 4.3.7.8 shows the identified potential effects and residual effects associated with Project-related marine vessel traffic on marine mammal indicators. The identification of these effects are based on the results of literature reviews, desktop analyses, acoustic modeling, engagement with government agencies and other stakeholders (Section 3.0), and the professional experience of the assessment team.

TABLE 4.3.7.8

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE MAMMALS

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1. Marine Mammals Indicator – Southern Resident Killer Whale			
1.1 Auditory injury or sensory disturbance	RSA	• Project-related marine vessels are owned and operated by a third party. Marine transportation in Canadian waters is authorized and regulated through the *Canada Shipping Act* and related legislation and regulations are administered by Transport Canada and the CCG. • Trans Mountain would be interested in supporting and participating in a joint industry-government advisory group that would be charged with determining and/or developing effective mitigation measures to reduce potential effects of underwater noise on marine mammals in the region.	• Sensory disturbance due to underwater noise from vessels (may include temporary displacement, startle response, increased energy expenditure, reduced foraging efficiency, communication masking, change in activity state, and/or increased stress).
2. Marine Mammals Indicator – Humpback Whale			
2.1 Auditory injury or sensory disturbance	RSA	• Project-related marine vessels are owned and operated by a third party Marine transportation in Canadian waters is authorized and regulated through the *Canada Shipping Act* and related legislation and regulations are administered by Transport Canada and the CCG. • Trans Mountain would be interested in supporting and participating in a joint industry-government advisory group that would be charged with determining and/or developing effective mitigation measures to reduce potential effects of underwater noise on marine mammals in the region.	• Sensory disturbance due to underwater noise from vessels (may include temporary displacement, startle response, increased energy expenditure, reduced foraging efficiency, communication masking, change in activity state, and/or increased stress).
3. Fish and Mammals Indicator – Steller Sea Lion			
3.1 Auditory injury or sensory disturbance	RSA	• Project-related marine vessels are owned and operated by a third party Marine transportation in Canadian waters is authorized and regulated through the *Canada Shipping Act* and related legislation and regulations are administered by Transport Canada and the CCG. • Trans Mountain would be interested in supporting and participating in a joint industry-government advisory group that would be charged with determining and/or developing effective mitigation measures to reduce potential effects of underwater noise on marine mammals in the region.	• Sensory disturbance due to underwater noise from vessels (may include temporary displacement, startle response, increased energy expenditure, reduced foraging efficiency, communication masking, change in activity state, and/or increased stress).

Note: 1 RSA = Marine RSA

4.3.7.5 Potential Residual Effects

The potential residual environmental effect on marine mammals indicators associated with increased Project-related marine vessel traffic is sensory disturbance due to underwater noise from vessels (may include temporary displacement, startle response, increased energy expenditure, reduced foraging efficiency, communication masking, change in activity state, and/or increased stress) (Table 4.3.7.8).

4.3.7.5.1 Sensory Disturbance

Marine mammals rely on sound for nearly all aspects of their life functions including navigation, mate selection, predator avoidance, prey detection, communication, and generally sensing their environment (Payne and Webb 1971, Tyack and Clark 2000). Underwater sound levels produced during marine transportation activities that are below PTS or TTS levels of concern may therefore still elicit behavioural responses that affect marine mammal populations (Nowacek *et al.* 2007, Richardson *et al.* 1995, Southall *et al.* 2007). DFO's *Recovery Strategy for Northern and Southern Resident Killer* identified underwater noise and associated sensory disturbances as one of several threats to this population, while acknowledging the uncertainty around potential long-term effects of this disturbance (DFO 2011a).

The degree of sensory disturbance experienced by a marine mammal depends on numerous factors, including the source level, frequency, and attenuation rate of the underwater sound, as well as the species, proximity, activity state, and individual in question (Richardson *et al.* 1995, Southall *et al.* 2007). Sensory disturbance may also vary widely in form, ranging from non-observable physiological responses (such as increases in stress hormones [Rolland *et al.* 2012]), or decreases in ability to detect other sounds in the environment (*i.e.,* masking or reductions in communication space [Clark *et al.* 2009]), to overt physical reactions such as startle responses, changed activity budgets, and reduced time spent feeding (Williams *et al.* 2006, Lusseau *et al.* 2009). Habitat avoidance may exclude animals from important foraging or breeding areas (Morton and Symonds 2002). While current science cannot predict the potential population consequences of increased underwater noise (Wartzok *et al.* 2005), repeated disturbance from whale-watching has, over the long term, affected population-level parameters (Bejder *et al.* 2006, Lusseau and Bejder 2007).

Southall *et al.*'s proposed criteria do not provide quantitative thresholds for sensory disturbance. As such, only the NOAA behavioural disruption criteria (*i.e.,* 120 dB re: 1 μPa for both cetaceans and pinnipeds) are used in the quantitative comparison with predicted Project-related SPLs for the Marine RSA. Based on results of the acoustic modelling study, noise levels associated with increased Project-related marine vessel traffic within the Marine RSA are expected to exceed the NOAA threshold for behavioural disruption. SPLs above this threshold are predicted to extend for 4 to 7 km (R95%) from the Project vessels in the absence of other noise (*i.e.,* not accounting for current ambient acoustic conditions; see first row of Table 4.3.7.3). While this assessment considers potential effects across the entire Marine RSA, effects of sensory disturbance from underwater noise will be centered on the shipping lanes within a roughly 14 km wide corridor (*i.e.,* 4 to 7 km on either side of the vessel). As noted earlier, Project-related marine vessels and other large vessels are required to remain within designated shipping lanes during inbound and outbound transits.

Distance from the shipping lane to shore exceeds this value (7.13 km) along 33 per cent of the inbound shipping lanes and along 49 per cent of the outbound shipping lanes in the Marine RSA. For example, the distance between the outbound shipping lane and the Canadian shoreline at Carmanah Point in Juan de Fuca Strait is 9 km, whereas the zone of sensory disturbance (*i.e.,* 95 per cent radius to 120 dB re: 1 μPa) is predicted to extend roughly 6.5 km from the shipping lane at this location (see Scenario 4, Table 4.3.7.3). This means that there are portions of the Marine RSA that marine mammals could access that are beyond the zone of sensory disturbance directly attributable to Project-related marine vessels. Although vessels will be moving continuously along the shipping lane, and noise associated with Project-related marine vessels will therefore be transient at any one particular location, potential effects are most likely for marine mammals that are in the vicinity at the time of vessel transit through 'pinch point' locations. At these locations, the influence of sensory disturbance would extend to the nearest shoreline and all animals within these constricted waterways would be exposed. For example, at Race Rocks Ecological Reserve, the distance to the outbound shipping lane is 4.7 km, while the zone of sensory disturbance is predicted to extend 7.1 km (in both directions) from the shipping lane at this location (see Scenario 3, Table 4.3.7.3).

While areas of the Marine RSA further than 7 km away from the shipping lanes will not be exposed to Project-related SPLs predicted to cause sensory disturbance, marine mammals will nonetheless be able to detect Project-related marine vessel traffic noise over much longer distances. SPLs below NOAAs behavioural disruption threshold may still affect an animal's communication space (*i.e.,* the predicted area over which they can communicate) (Clark *et al.* 2009) or cause physiological stress responses (Rolland *et al.* 2012). Based on the broad range of ambient conditions in the Marine RSA reported in the literature (*i.e.,* from quiet to loud), Project-related marine vessel traffic will be discernible above ambient conditions for distances ranging from 2 km (loud noise conditions) to over 100 km (quiet noise conditions; see Table 4.3.7.6). Most ambient noise variability in the Marine RSA is the result of vessel traffic types, movement patterns and site-specific physical conditions (Bassett *et al.* 2012). The large range in distances of detectability primarily reflects the large difference in ambient conditions (*i.e.,* roughly 20 to 30 dB) between quiet periods and periods of high marine traffic volume (see acoustic modelling study for further details on ambient noise conditions and modelling).

It is not possible to quantify how much time an individual or population of marine mammals may be exposed to noise resulting specifically from increased Project-related marine vessels, as both the vessels and marine mammals are in a near constant state of motion, and at any one time, their occurrence may or may not overlap. However, some general temporal exposure predictions can be made. It will take Project-related tankers and accompanying escort tugs approximately 12 hours (based on an average speed of 13 knots across 296 km of shipping lanes) to complete one transit of the Marine RSA, and on average, there will be two transits every 24 hours. Therefore, on average, the Project will result in the presence of a Project-related tanker (with potential escort tug depending on location and whether the tanker is empty or full), at some location in the Marine RSA at all times for the life of the Project. Under a hypothetical scenario, a stationary marine mammal in proximity to the shipping lane during a single Project-related marine vessel pass could be exposed to sensory disturbance for 24 to 31 minutes (approximately 2 per cent of each day for each passage; see Table 4.3.7.4), depending on the speed of the vessel and site-specific physical conditions. However, since some species such as killer whales are highly mobile, there is potential for an individual to interact with the same Project-related marine vessel more than once during a single day (*e.g.,* for marine mammals circling an island and re-encountering the vessel further along the shipping lanes). Overall, it is expected that exposure of any particular individual to Project-based sensory disturbance is unlikely to exceed much more than 0.5 to 2 hours a day (*i.e.,* 2 per cent to 8 per cent of each day assuming up to two exposures per transit for each of the two Project-related marine vessel transits in a 24-hour period).

While exposure of a stationary marine mammal in the Marine RSA to a Project-related marine vessel will be intermittent (*i.e.,* two vessel transits per day), this daily exposure will occur throughout the life of the Project. Most studies report that marine mammal behaviour returns to normal after sound production ceases (Richardson *et al.* 1995, Southall *et al.* 2007). In consideration of only routine effects associated with the Project, it is therefore expected that the time between vessel transits would allow marine mammals to recover from the sensory disturbance before the next transit of a Project-related marine vessel transit, were it not for the current existence of other vessel traffic in the Marine RSA.

While marine mammals may not encounter another Project-related marine vessel for the remainder of the day, they are very likely to encounter other marine vessels (*e.g.,* other tankers, container ships, cruise ships, ferries, fishing vessels, tourism vessels, tugs, barges and recreational vessels) within minutes to hours of the passing of the Project-related marine vessel. Assuming that similar potential sensory disturbance exposure times and extents may result from other marine traffic in the area, over the life of a marine mammal whose home range or critical habitat overlaps the Marine RSA, exposure to underwater noise from vessel traffic for any individual is likely much more frequent, and could conceivably approach near-continuous sensory disturbance.

Shipping is not a novel activity in the Marine RSA, and many species that use this area regularly are likely to have become ‘habituated’ to sounds associated with marine transportation activities. However, while habituation is likely to reduce the occurrence of high energy startle responses, which are considered more likely in response to a novel or acute sound source, there may be other costs associated with habituation and continued use of this environment (*e.g.,* need to increase communication signal duration [Miller *et al.* 2000] or amplitude [Holt 2008]). Holt (2008) found that for every 1 dB increase in underwater noise, killer whales will attempt to compensate by increasing their vocalizations by 1 dB.

Marine mammals continue to use these waters and there has been no observed long-term avoidance of this area. This fact alone; however, is not evidence that current ambient noise levels are not causing some degree of disturbance. Much of the habitat in the Marine RSA has been recognized as important for marine mammals, and has been designated as critical for two species (southern resident killer whale and humpback whale). As distribution of many marine mammal species is often highly correlated to the distribution of their prey, the importance of accessing key foraging grounds may to some degree outweigh other negative aspects (*e.g.,* loud ambient conditions) associated with that habitat.

4.3.7.6 Significance Evaluation of Potential Residual Effects

The measurement endpoints for marine mammals include both quantitative and qualitative measurement of potential Project effects. Predicted underwater noise from the increase in Project-related marine vessel traffic was estimated using methods established in previous acoustic studies (see detailed report in Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1). There is a lack of Canadian regulatory thresholds, standards, or guidelines for evaluating potential residual effects of underwater noise from vessel traffic (or other sources) on marine mammals. Therefore, this assessment considers thresholds used for other Canadian projects and in other parts of the world (*e.g.,* in the US). The importance of marine mammal habitat affected by the Project was evaluated qualitatively based on a review of available research literature. Overall findings were based primarily on the professional judgment of the assessment team.

Table 4.3.7.9 provides a summary of the significance evaluation of the potential residual environmental effects of Project-related increases in vessel traffic on marine mammal indicators. The rationale used to evaluate the significance of each of the residual environmental effects is first provided below for each indicator.

TABLE 4.3.7.9

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE MAMMALS

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
1 Marine Mammals Indicator – Southern Resident Killer Whale									
1(a) Sensory disturbance due to underwater noise.	Negative	RSA	Long-term	Periodic	Immediate	High	High	Low	Significant
2 Marine Mammals Indicator – Humpback Whale									
2(a) Sensory disturbance due to underwater noise.	Negative	RSA	Long-term	Periodic	Immediate	Medium	High	Low	Not Significant
3 Marine Mammals Indicator – Steller Sea Lion									
3(a) Sensory disturbance due to underwater noise.	Negative	RSA	Long-term	Periodic	Immediate	Low	High	High	Not Significant
4 Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Mammals									
4(a) Combined effects of increased Project-related marine vessel traffic on the marine mammals indicators (1[a], 2[a] and 3[a]).	Negative	RSA	Long-term	Periodic	Immediate	High	High	Low	Not Significant to Significant

Notes:
1 RSA: Marine RSA
2 **Significant Residual Environmental Effect:** A high probability of occurrence of a permanent or long-term residual effect of high magnitude that cannot be technically or economically mitigated.
3 Refer to the discussion on Southern Resident Killer Whales below for the rationale for the evaluation.

4.3.7.6.1 Marine Mammals Indicator - Southern Resident Killer Whale

The following subsection provides the evaluation of significance of the potential residual effect on the southern resident killer whale indicator.

Sensory Disturbance of Southern Resident Killer Whales Due to Underwater Noise

Southern resident killer whales are listed as Endangered under Schedule 1 of *SARA*. This is due in large part to their small population size of only 82 individuals (*i.e.,* J Pod = 26, K Pod = 19 and L Pod = 37 as of July 1, 2013) (Center for Whale Research 2013). A large portion of the Marine RSA has been designated as critical habitat under *SARA*; this includes the following transboundary waters of BC and Washington State: Juan de Fuca Strait, Haro Strait, Boundary Pass, the Southern Gulf Islands, and the southern portion of the Strait of Georgia (DFO 2009b, 2011) (see Figure 4.2.22). One hundred percent of the designated southern resident killer whale critical habitat that has been identified in Canadian waters falls inside the boundaries of the Marine RSA. The portion of this transboundary area that falls under US jurisdiction was designated as critical habitat under the US *Endangered Species Act* in 2006 (National Marine Fisheries Service [NMFS] 2006a,b).

Federal designation of the importance of this habitat is based on consistent and prolonged seasonal occupancy of southern resident killer whales in this area (DFO 2011a) (see Figure 4.2.23). On average, J Pod (representing a third of the entire population) spends some of its time in the Marine RSA during every month of the year, and appears to seldom leave this region (Ford *et al.* 2000, Osborne 1999, Osborne *et al.* 2001). K and L pods are more common in the western portion of the Marine RSA, particularly from late spring through fall (DFO 2011a, The Whale Museum 2011). On certain occasions, all whales are seen together in the same area – an event referred to as a 'superpod'.

According to DFO's *Recovery Strategy for Northern and Southern Resident Killer Whale* (DFO 2011a) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) *Assessment and Update Status Report on the Killer Whale* (COSEWIC 2008), key threats to the southern resident killer whale population include: chemical and biological contaminants; reductions in the availability or quality of prey (primarily Chinook and chum salmon); and physical and acoustic disturbance. DFO has included the environment's acoustic attributes in their designation of critical habitat for southern resident killer whales, and sources of acoustic disturbance are noted as including both high-intensity sounds (such as those produced by seismic surveys) and "chronic sources such as vessel traffic" (DFO 2011a). At this time, DFO has not identified any standards or thresholds that describe what ambient sound levels might provide appropriate acoustic habitat for killer whales or other marine mammals (within critical habitat areas or elsewhere). As noted below, these threats are inter-related.

An acoustic modelling study by MacGillivray *et al.* (2012) predicted two audiogram-weighted behavioural thresholds for killer whales, based on behavioural disturbance responses by northern resident killer whales reported in the literature (*i.e.,* Williams *et al.* 2002a,b). The study determined that at received sound levels of approximately 64 dB re: HT, killer whales overtly avoided a whale-watching boat, while at received SPLs of approximately 57 dB re: HT, they exhibited subtle avoidance responses. Based on the predicted values presented in Table 4.3.7.5, current background noise levels under the loudest conditions in the Marine RSA already exceed the values calculated by MacGillivray *et al.* (2012) as being capable of causing subtle behavioural responses in killer whales, and are equal to levels capable of causing overt behavioural responses. This comparison is based on current ambient conditions, before the introduction of noise associated with increased Project-related marine vessel traffic.

The Marine RSA encompasses a busy marine intersection of a wide range of vessel traffic travelling to and from the urban ports of Vancouver, Victoria, and Seattle, as well as locally around each of these centres and the Gulf and San Juan islands. While current ambient underwater noise conditions may already exceed levels predicted to cause sensory disturbance, not all of this noise is associated with commercial shipping activities (*i.e.,* tankers, tugs, cargo containers, and bulk carriers). This area also contains high levels of vessel traffic associated with passenger lines (*i.e.,* ferries and cruise ships), commercial and recreational fishing vessels, and both commercial tourism and general recreational vessels. Commercial whale-watching has been recognized as a potential stressor for many marine mammal populations around the world (Baker and Herman 1989, Corkeron 2004, Lusseau and Bejder 2007). In an acoustic modelling study of whale-watching vessels operating around southern resident killer whales in this region, Erbe (2002) predicted that noise from fast-moving whale-watching boats was audible to killer whales for distances over 16 km, was able to mask killer whale calls for over 14 km, might elicit behavioural responses over 200 m, and could even cause TTS of 5 dB over distances of 450 m. While Canadian and US agencies have collaborated to develop whale-watching guidelines (Be Whale Wise 2013, DFO 2013p), southern resident killer whales are in the presence of whale-watching boats (both commercial and pleasure boat-based) for 12 hours a day during summer months (Lusseau *et al.* 2009) as well as most of the daylight hours during the late spring and early fall periods.

Increases in sensory disturbance may also act additively with other stressors in the environment. One of the primary concerns associated with the effects of acoustic disturbance is that it can reduce the amount of time spent feeding. A study by Williams *et al.* (2006) examined the effects of disturbance from boat traffic in Johnstone Strait, BC, on the population of northern resident killer whales. The researchers found that in the presence of boats, killer whales spent a statistically-significant less amount of time feeding. The potential energetic cost associated with this loss in feeding opportunity may have resulted in an estimated 18 per cent decrease in energy intake (Williams *et al.* 2006). The vessels in Williams *et al.*'s 2006 study were primarily commercial fishing traffic, which would have been transiting the area tangentially to the killer whales. Similar results were observed by Lusseau *et al.* (2009), who measured a statistically significant negative effect on foraging for southern resident killer whales in the presence (*i.e.,* within 100 m and 400 m) of vessel traffic. Whales were statistically significantly less likely to be foraging (and significantly statistically more likely to be traveling) when boats were nearby (within 100 m) (Lusseau *et al.* 2009). The long-term consequences of reduced foraging in the presence of vessels could be exacerbated for populations that are already prey-limited, as may be the case for southern resident killer whales (Lusseau *et al.* 2009, DFO 2011a, Williams *et al.* 2011).

While sensory disturbance may lead to observable responses such as changes in activity state, the efficiency of foraging may also be affected if ambient noise levels interfere with an animal's ability to communicate. A recent study by Williams *et al.* (2013) looked at ambient noise conditions at 12 locations in BC, and assessed how the current acoustic environment might be affecting marine mammal communication space. Haro Strait and the waters off southeastern Vancouver Island are the main concentration area for southern resident killer whales in the Marine RSA (Ford *et al.* 2000). Williams *et al.* (2013) found that the long-term spectral averages in Haro Strait were dominated by broadband noise, characteristic of ship engines and high noise levels from vessel traffic were found to be nearly continuous over 24 hours. In the frequency bands that killer whales use for social communication, median noise levels in Haro Strait were high enough to reduce killer whale communication space by up to 62 per cent under typical conditions, and by up to 97 per cent under the noisiest conditions (calculated over an 8 km range and relative to the median quietest "normal noise conditions" recorded at any of the 12 sites; Williams *et al.* 2013). Previous research has also shown that boat noise can mask killer whale echolocation ability (Bain and Dahlheim 1994). Underwater noise from marine vessels, including Project-related marine vessels could result in an unknown degree of communication masking, which could reduce southern resident killer whales' ability to navigate, detect or capture prey, or detect and communicate with conspecifics. The magnitude or population-scale implications of such effects are unknown.

DFO's *Recovery Strategy for Northern and Southern Resident Killer Whale* states that: "Both physical and acoustic disturbance from human activities may be key factors causing depletion or preventing recovery of resident killer whale populations" (DFO 2011a). Based on available scientific knowledge, it is concluded that past and current activities (including all forms of mortality, high contaminant loads, reduced prey, and sensory and physical disturbance) have resulted in significant adverse cumulative effects to the southern resident killer whale population. The recent historical decline of the southern resident killer whale population and its current status (*i.e.,* endangered) support this conclusion. However, given the current state of knowledge, and the ability of threats to interact with one another, it is not possible to completely partition how each threat may be affecting the population.

While the endangered status of southern resident killer whale is assumed to represent a currently-existing significant adverse cumulative effect, there are currently no quantitative Canadian thresholds with respect to assessing sensory disturbance for marine mammals associated with underwater noise, nor are there recommended Canadian standards or guidelines with respect to what would be appropriate ambient SPLs or SELs for southern resident killer whale critical habitat. Trans Mountain has little influence over the operating practices of the tankers or tugs as Project-related marine vessels are owned and operated by a third party; however, Trans Mountain expects that through its tanker acceptance process the calling vessels are maintained and operated to high industry standards. These vessels and other marine transportation in Canadian waters is authorized and regulated through the *Canada Shipping Act, 2001.* Related legislation and regulations are administered by Transport Canada and the CCG. The increase in Project-related marine vessel traffic is also expected to be proportionately small relative to overall current marine transportation activities in the Marine RSA. Despite operating legally, the Project will contribute additional underwater noise that could affect the southern resident killer whale population. As such, even though the Project contribution to overall sensory disturbance effects is small, the potential effects of increased Project-related marine vessel traffic are determined to be significant for southern resident killer whales.

A summary of the rationale for all of the significance criteria is provided below (Table 4.3.7.9, point 1[a]).

- **Spatial Boundary** - Marine RSA – residual effects of sensory disturbance on southern resident killer whales will be concentrated along the shipping lanes in the Marine RSA and will decrease with distance from the sound source (*i.e.*, tankers and tugs).
- **Duration** - long-term – tanker transits and the associated production of underwater noise along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.
- **Frequency** - periodic – Project-related marine vessel traffic will increase by approximately 30 Aframax tanker calls to the Westridge Marine Terminal per month (*i.e.*, an additional 720 tanker transits each year). It will take Project-related marine vessels approximately 12 hours to complete one transit of the Marine RSA, and on average, there will be two transits every 24 hours. Southern resident killer whales are highly mobile; however, on average exposure to a single transit will likely be limited to a maximum of two exposures per day (*i.e.*, periodic).
- **Reversibility** - immediate – southern resident killer whales would likely recover from the direct effects of a single event causing sensory disturbance (*i.e.*, single passing of a Project-related tanker/tug) immediately (*i.e.*, in less than two days).
- **Magnitude** - high – Project-related underwater noise within the Marine RSA will exceed NOAA's regulatory standards for sensory disturbance. While there are no Canadian regulatory standards with respect to this effect, the NOAA thresholds are used as commonly-applied environmental standards. Southern resident killer whales within 4 to 7 km of the shipping lanes are expected to be

disturbed by vessel traffic and this effect will occur throughout the Canadian designated critical habitat for this endangered population.

- **Probability** - high – underwater noise produced by Project-related marine vessels is expected to exceed the current NOAA standards for sensory disturbance within 4 to 7 km of the transiting vessels. As such, there is a high probability that southern resident killer whales in the Marine RSA will experience some degree of sensory disturbance as a result of increased Project-related marine vessel traffic.
- **Confidence** - low – there is no precedent (*e.g.*, environmental assessments for other projects) for attempting to assess significance of the effects of sensory disturbance from underwater noise associated with marine shipping on southern resident killer whales. What is known with certainty concerning this population is its small size, recent population trends, endangered status, and relative importance of this area (*i.e.*, critical habitat). Recent ambient noise measurement studies have been conducted in the Marine RSA and results are available in the literature (Williams *et al.* 2013; see also Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1). Project-related marine vessel source levels were not directly measured but surrogate vessels from the literature are deemed appropriate and acoustic modeling followed standard practices. Disturbance from vessels and underwater noise have been shown through numerous studies to alter behaviour, cause compensatory responses, and interfere with normal activity patterns, but the greatest source of uncertainty is the linkage of sensory disturbance effects to population-level consequences and the degree to which such effects can be attributed to underwater noise from Project-related marine vessels and other ships and boats.

Other toothed whales that may be observed in the Marine RSA include Dall's porpoises, harbour porpoises, Pacific white-sided dolphins and the other ecotypes of killer whales (*i.e.,* northern residents, transients and offshores). While many of these other species of toothed whale are common in the area, no critical habitat has been identified within the Marine RSA for any species of toothed whale other than southern resident killer whales (designated) and transient killer whales (potential). DFO Important Areas for harbour porpoise have also been identified in the Marine RSA. Most of these species belong to the same functional hearing group, with the exception of harbour porpoises. While species such as harbour porpoises may be somewhat more sensitive than southern resident killer whales to high frequency sounds, and may show more pronounced responses to disturbance, acoustic modelling of harbour porpoises suggest that the extent of sensory disturbance is expected to be generally comparable across all toothed whale species found within the Marine RSA. As such, effects of sensory disturbance to the southern resident killer whale indicator are expected to be conservative with respect to potential effects to all toothed whales.

The increase in Project-related marine vessel traffic will contribute additional underwater noise to the existing adverse acoustic conditions in the Marine RSA. Based on results of acoustic modelling, this noise will be detectable by toothed whales over large distances and may cause sensory disturbance within 4 to 7 km of the shipping lanes. However, Project-specific effects are expected to contribute a proportionately small component of the overall marine transportation sources for underwater noise. For southern resident killer whales, it was determined that the current status of that population meant that any residual effect beyond current levels was undesirable, and furthermore, the entire population spends much of its time in the Marine RSA. For that reason, effects on southern resident killer whales were determined to be significant. In contrast, residual effects of the Project will affect only localized portions of the overall North Pacific (or Canadian) populations of toothed whales in the Marine RSA. As such, and in consideration of the notable differences between population status, abundance, and occurrence of southern resident killer whales versus the various other species of toothed whales in the Marine RSA, effects of increased Project-related marine vessel traffic on toothed whales (other than southern resident killer whales) are deemed to have a negative impact balance, but are not significant.

These comparisons are in no way meant to diminish the importance of maintaining functional acoustic habitats for all marine mammal species. Instead, they only serve to highlight that the specific and unique biology and circumstances of southern resident killer whales do not apply equally to any other species of toothed whale in the Marine RSA.

4.3.7.6.2 Marine Mammals Indicator - Humpback Whale

The following section provides the evaluation of significance of the potential residual effect on the humpback whale indicator.

Sensory Disturbance of Humpback Whales Due to Underwater Noise

Humpback whales are listed as Threatened under Schedule 1 of *SARA*. They appear to be present in most of the Marine RSA in a comparatively lower density than some other areas of BC (DFO 2013h) and are present in the area, particularly south of Victoria and around Cape Flattery, primarily during summer and fall (see Figure 4.2.24). DFO has designated humpback whale critical habitat for four areas in BC, including an area off southwest Vancouver Island that overlaps slightly with the western-most portion of the Marine RSA (DFO 2013h) (see Figure 4.2.22). Critical habitat that overlaps the Marine RSA is based primarily on summer observations of concentrations of humpback whales in the area east of Barkley Canyon and between La Pérouse Bank and Nitinat Canyon, and on the shelf edge near the southern portion of Juan de Fuca Canyon (Ford *et al.* 2010), though most of these large concentrations are just outside the Marine RSA.

Activities identified by the *DFO Humpback Whale Recovery Strategy* as “likely to destroy or degrade critical habitat” include vessel traffic, toxic spills, overfishing, seismic exploration, sonar and pile driving (DFO 2013h). The COSEWIC *Assessment and Update Status Report on the Humpback W*hale also includes noise disturbance amongst its list of key threats (COSEWIC 2011).

Baleen whales, such as the humpback whale, lack the high-frequency echolocation systems of odontocetes, and are instead believed to be more sensitive to the low to medium underwater noise frequencies in which they sing and vocalize (Au *et al.* 2006, Richardson *et al.* 1995). Therefore, they are generally more likely than toothed whales to be able to hear sound levels in the frequency range of commercial shipping. This difference between functional hearing groups is noted in Table 4.3.7.5, where current background noise levels under the loudest conditions in the Marine RSA are predicted to be higher for humpback whales than for killer whales or harbour porpoises (*i.e.,* relative to each species’ different hearing thresholds).

Humpback whales produce a wide variety of vocalizations, and use sounds to contact one another, during mating displays and long-distance migrations, and to coordinate feeding behaviours (Cerchio and Dahlheim 2001, Payne and McVay 1971, Sharpe 2001). Most existing studies specific to behavioural reactions of humpback whales in response to underwater noise relate to impulsive sounds such as seismic airguns or explosives (McCauley *et al.* 2000, Todd *et al.* 1996); those that involve non-pulse sounds often relate to whale-watching (Corkeron 1995). Baker and Herman (1989) reported on the responses of humpback whales in Alaska during opportunistic passing of medium and large vessels at distances greater than 400 m. Whales exhibited behavioural changes such as decreased respiration rates and increased dive times when vessels were within 4,000 m. Overall, the study documented short-term behavioural changes in response to vessels and the authors suggested that high vessel traffic volumes could displace whales from preferred feeding habitat (Baker and Herman 1989).

NOAA's behavioural disruption threshold is not species-specific (*i.e.,* it has not been audiogram-weighted or developed to reflect different functional hearing groups); however, it remains the most commonly applied regulatory threshold for assessing sensory disturbance. Based on this metric, sensory disturbance is possible for all marine mammals within 4 to 7 km of Project-related marine vessels (not accounting for current ambient acoustic conditions; see first row of Table 4.3.7.3). Unlike for killer whales, there are currently no quantitative sensory disturbance thresholds relative to humpback whale hearing thresholds (*i.e.,* in dB re: HT). Although it is possible to estimate how far Project-related marine vessel traffic might be discernible to humpback whales above ambient conditions (*i.e.,* from 8 km to over 100 km based on the broad range of ambient conditions in the Marine RSA reported in the literature; see Table 4.3.7.6), based on the available data, there is no species-specific way to determine at what point within this distance humpback whales might exhibit sensory disturbance or any implications of such disturbance.

At this time, no scientific study has established a causal link between increased vessel noise and population-level effects on humpback whales (Wartzok *et al.* 2005), though potential mechanisms have been observed in other cetacean populations (Lusseau and Bejder 2007). As noted for killer whales, Williams *et al.* (2013) found indications that humpback whales in the noisiest regions in BC may be losing communication space. In the frequency bands that humpback whales use for communication, median ambient noise levels in Haro Strait were determined to be high enough to reduce humpback whale communication space by up to 52 per cent under typical conditions, and by up to 94 per cent under the noisiest conditions (calculated over a 32 km range and relative to the median quietest "normal noise conditions" recorded at any of 12 sites in BC) (Williams *et al.* 2013).

The increase in Project-related marine vessel traffic will contribute additional underwater noise to the Marine RSA. Based on results of acoustic modelling, this noise will be detectable by humpback whales over large distances and may cause sensory disturbance within 4 to 7 km of the shipping lanes. While the acoustic environment in many areas of the humpback whale's range may currently exceed environmental standards for sensory disturbance, the North Pacific population is not only stable, but has been growing at an annual rate of approximately 4.9 per cent since 1993 (Cascadia Research 2008). Unlike for southern resident killer whales, DFO has identified critical habitat for humpback whales in other areas of BC, and humpback whales in Canada belong to a much larger population (*i.e.,* 2008 estimate of 18,302 individuals in the North Pacific) (Cascadia Research 2008). Based on photo-identification studies (from 1992 to 2006) and a minimum number alive (MNA) estimate of the 2006 BC humpback whale population size (1,620 individuals), 208 humpback whales have been identified in the southwest Vancouver Island critical habitat area; this represents approximately 13 per cent of the BC coast-wide MNA (DFO 2010b).

These comparisons are in no way meant to diminish the importance of maintaining functional acoustic habitats for humpback whales or any marine mammal species. Instead, they only serve to highlight that the specific and unique biology and circumstances of southern resident killer whales (*i.e.,* small population size with no external recruitment potential, 100 per cent Marine RSA overlap with entire known Canadian critical habitat, etc.) do not apply equally to North Pacific humpback whales, or any other species of baleen whale in the Marine RSA.

Underwater noise associated with increased Project-related marine vessel traffic will add to the existing background noise in the Marine RSA. However, Project-specific effects are expected to contribute a proportionately small component of the overall marine transportation sources for underwater noise. These residual effects of the Project will affect a relatively small, localized component of the overall North Pacific (or Canadian) humpback whale population, and only during periods of the year when they are present in the Marine RSA. As such, effects of increased Project-related marine vessel traffic on humpback whales are deemed to have a negative impact balance, but are not significant.

A summary of the rationale for all of the significance criteria is provided below (Table 4.3.7.9, point 2[a]).

- **Spatial Boundary -** Marine RSA – residual effects of sensory disturbance on humpback whales will be concentrated along the shipping lanes in the Marine RSA and will decrease with distance from the sound source (*i.e.,* tankers and tugs).
- **Duration** - long-term – tanker transits and the associated production of underwater noise along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.
- **Frequency** - periodic – Project-related marine vessel traffic will increase by approximately 30 Aframax tanker calls to the Westridge Marine Terminal per month (*i.e.,* an additional 720 tanker transits each year). It will take Project-related marine vessels approximately 12 hours to complete one transit of the Marine RSA, and on average, there will be two transits every 24 hours.
- **Reversibility** - immediate – humpback whales would likely recover from the direct effects of a single event causing sensory disturbance (*i.e.,* single passing of a Project-related tanker/tug) immediately (*i.e.,* in less than two days).
- **Magnitude** - medium – Project-related underwater noise within the Marine RSA will exceed NOAA's regulatory standards for sensory disturbance. While there are no Canadian regulatory standards with respect to this effect, the NOAA thresholds are used as commonly-applied environmental standards. Humpback whales within 4 to 7 km of the shipping lanes are expected to be disturbed by vessel traffic. The Marine RSA overlaps a small portion of the identified Canadian critical habitat for this species and only a small proportion of the much larger North Pacific population of humpback whales occurs seasonally in the Marine RSA. For these population status reasons, the magnitude is rated as medium.
- **Probability** - high – underwater noise produced by Project-related marine vessels is expected to exceed the current NOAA standards for sensory disturbance within 4 to 7 km of the transiting vessels. As such, there is a high

probability that humpback whales will experience some degree of Project-related sensory disturbance while in the Marine RSA.

- **Confidence** - low – Recent ambient noise measurement studies have been conducted in the Marine RSA and results are available in the literature (Williams *et al.* 2013; see also Appendix A of the Marine Resources - Marine Transportation Technical Report (Volume 8B, TR 8B-1). Project-related marine vessel source levels were not directly measured but surrogate vessels from the literature are deemed appropriate and acoustic modeling followed standard practices. Disturbance from vessels and underwater noise have been shown through numerous studies to alter behaviour, cause compensatory responses, and interfere with normal activity patterns, but the greatest source of uncertainty is the linkage of sensory disturbance effects to population-level consequences and the degree to which such effects can be attributed to underwater noise from Project-related marine vessels and other ships and boats. The primary rationale for the difference in significance determination between humpback whales and southern resident killer whales is the marked difference in status, population size, distribution, and relative use and importance of the Marine RSA.

Other baleen whales that frequent the Marine RSA on occasion include fin whales, grey whales, and minke whales. While these other species of baleen whale are not altogether uncommon in the area, neither is any considered particularly abundant. No critical habitat or DFO Important Areas have been identified within the Marine RSA for any species of baleen whale other than humpback whales. All baleen whales belong to the same functional hearing group, and while species such as fin whales may be somewhat more sensitive than humpback whales to low frequency sounds associated with shipping, effects of sensory disturbance to the humpback whale indicator are expected to be generally comparable to effects on all baleen whale species found within the Marine RSA. Furthermore, based on its distribution and abundance in the Marine RSA, the humpback whale is deemed more likely to be exposed to effects associated with the increase in Project-related marine vessel traffic, and some of these effects will occur within humpback whale critical habitat. As such, effects of sensory disturbance to the humpback whale indicator are expected to adequately address potential effects to all baleen whales, and residual effects to baleen whales as a result of the increase in Project-related marine vessel traffic are determined to be not significant.

4.3.7.6.3 Marine Mammals Indicator - Steller Sea Lion

The following section provides the evaluation of significance of the potential residual effect on the Steller sea lion indicator.

Sensory Disturbance of Steller Sea Lions Due to Underwater Noise

Steller sea lions are listed as Special Concern under Schedule 1 of *SARA*. While there are no designated critical habitats or rookeries (*i.e.,* breeding areas) within the Marine RSA, a Marine Protected Area (MPA) at Race Rocks protects an important winter haulout site (COSEWIC 2003c). In addition to several other major winter haulouts and one year-round haulout at Carmanah Point, there are several minor haulouts located in the Marine RSA and both male and female Steller sea lions are present here year-round (see Figure 4.2.25).

The DFO Steller Sea Lion Management Plan list the following as threats of moderate concern for Steller sea lions: prey reduction (from either fisheries competition, or environmental change and variability); environmental contaminants; physical disturbance when on terrestrial habitat (pups on rookeries); and toxic spills (DFO 2010a). There are no current threats of high concern listed and acoustic disturbance when in aquatic habitat is listed as low concern.

Pinnipeds vocalize both in air and underwater but generally over a lower, more restricted bandwidth than most other marine mammals (*i.e.,* between 100 Hz and several tens of kHz) (Southall *et al.* 2007). Likewise, their hearing capabilities differ above and below water (Kastak and Schusterman 1998, Schusterman 1981), though they may be disturbed by introduced noise in either media. Southall *et al.* (2007) developed their noise exposure criteria without reference to any behavioural measures of hearing for Steller sea lions, either atmospheric or underwater. They instead estimated an auditory bandwidth for all pinnipeds of 75 Hz to 30 kHz in air, and 75 Hz to 75 kHz underwater, based on studies involving other species (Southall *et al.* 2007). Since then, there have been a few studies specific to hearing in Steller sea lions.

California sea lions are best adapted to hearing in air, with greatest sensitivity from 2 to 8 kHz (Kastak and Schusterman 1998). Recent research suggests that the closely-related Steller sea lion has similar high frequency atmospheric hearing limits, with sensitivity that increases with frequency up to 10 kHz, and then decreases towards 20 to 32 kHz (*i.e.,* they have good atmospheric hearing from 1 to 20 kHz) (Mulsow *et al.* 2011). Steller and California sea lion hearing sensitivity have also been found to be essentially the same in air and underwater, except in the highest frequencies of their hearing range (Hemilä *et al.* 2006, Mulsow and Reichmuth 2010). Kastelein *et al.* (2005) found that the female Steller sea lion showed highest underwater hearing sensitivity from 16 to 25 kHz, while the male was most sensitive to underwater frequencies of 1 to 16 kHz. As such, the thresholds proposed by Southall *et al.* conservatively capture the bandwidths of greatest hearing sensitivity for Steller sea lions, both in air and underwater.

Pinnipeds in the water have typically been shown to tolerate close vessel approaches, even congregating around fishing vessels (California sea lions) (Richardson *et al.* 1995). Most marine acoustic energy of vessel sounds is concentrated in the 50 to 500 Hz range (NRC 2003a, Ross 1976). Since Steller sea lions have poor underwater hearing sensitivity below 1,000 Hz (Kastelein *et al.* 2005), most of the acoustic energy of Project-related marine vessels in the Marine RSA will not be audible to Steller sea lions. Based on the results presented in Table 4.3.7.5, the estimated average ambient noise in the Marine RSA above Steller sea lion audiograms ranges from 14 to 37 dB re: HT. Based on the audiogram-weighted sound contour maps produced during acoustic modelling, noise produced by Project-related marine vessels will for the most part fall below 35 dB re: HT, except within a few km of the vessels (see Figures 26 to 29 and Table 13 in Appendix A of the Marine Resources – Marine Transportation Technical Report (Volume 8B, TR 8B-1). Therefore, noise produced by the increase in Project-related marine vessels will primarily be within the predicted range of current ambient conditions in the Marine RSA; Project-specific vessel traffic will be most detectable directly along the shipping lane during a vessel transit. Effects of increased Project-related marine vessel traffic on Steller sea lions are therefore determined to be not significant.

A summary of the rationale for all of the significance criteria is provided below (Table 4.3.7.9, point 3[a]).

- **Spatial Boundary** - Marine RSA – residual effects of sensory disturbance on Steller sea lions will be concentrated along the shipping lanes in the Marine RSA and will decrease with distance from the sound source (*i.e.*, tankers and tugs).

- **Duration** - long-term – tanker transits and the associated production of underwater noise along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.
- **Frequency** - periodic – Project-related marine vessel traffic will increase by approximately 30 Aframax tanker calls to the Westridge Marine Terminal per month (*i.e.*, an additional 720 tanker transits each year). It will take Project-related marine vessels approximately 12 hours to complete one transit of the Marine RSA, and on average, there will be two transits every 24 hours.
- **Reversibility** - immediate – Steller sea lions in the Marine RSA are expected for the most part to be habituated to regular traffic movements along the shipping lanes and a large part of the acoustic energy produced by Project-related (and other large commercial vessels) is expected to be inaudible. The addition of underwater noise associated with the increase in Project-related traffic that is audible to Steller sea lions is expected to be within the range of current ambient conditions. While individuals in the water are expected to move away from vessels, large-scale disturbance around the haulouts is not expected, and individuals are likely to recover from the direct effects of sensory disturbance immediately.
- **Magnitude** - low – there are no rookeries, critical habitat or DFO Important Areas for Steller sea lions in the Marine RSA, and introduced noise from Project-vessels (relative to Steller sea lion hearing) will mostly be within the range of current ambient conditions. Little if any detectable effects are predicted as a result of the increase in current traffic, which will be concentrated along the shipping lanes.
- **Probability** - high – underwater noise produced by Project-related marine vessels is expected to exceed the current NOAA standards for sensory disturbance within 4 to 7 km of the transiting vessels. However, these thresholds do not factor in species-specific hearing abilities, and based on audiogram-weighted analyses, Project-related marine vessels will for the most part be undetectable to Steller sea lions outside of current ambient conditions. There is a high probability that Steller sea lions will experience some degree of Project-related sensory disturbance while in the Marine RSA.
- **Confidence** - high – pinnipeds in water and away from rookeries are known to be fairly tolerant of even close vessel approaches and the Marine RSA does not include any rookeries, critical habitat, DFO Important Areas or other habitat identified as being key to Steller sea lions.

Other pinnipeds that frequent the Marine RSA include harbour seals and California sea lions, as well as less common sightings of elephant seals and northern fur seals. While harbour seals do breed in the Marine RSA, they do not have specific breeding rookeries as do Steller sea lions and breeding occurs throughout BC. DFO Important Areas for harbour seals in the Marine RSA are shown in Figure 4.2.22. No critical habitat has been identified for any species of pinniped within the Marine RSA. All pinnipeds belong to the same functional hearing group, and effects of sensory disturbance to the Steller sea lion indicator are expected to be comparable to effects on all pinniped species found within the Marine RSA. As such, effects to pinnipeds as a result of the increase in Project-related marine vessel traffic are determined to be not significant.

4.3.7.6.4 Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Mammals

The evaluation of the combined effects of increased Project-related marine vessel traffic on marine mammals considers collectively the assessment of the likely potential residual effects on the following indicators: southern resident killer whale, humpback whale, and Steller sea lion. The assessment of these indicator species for the selected effects is considered to adequately represent potential Project effects on all marine mammals within the Marine RSA.

A summary of the assessment conclusions for combined effects is provided below and presented in Table 4.3.7.9 (point 4[a]). Where two indicators had different criterion conclusions, the more conservative assessment was carried forward to the combined effects assessment.

- **Spatial Boundary** - Marine RSA – concentrated along the shipping lanes and will decrease with distance from the sound source (*i.e.*, tankers and tugs).
- **Duration** - long-term – tanker transits and the associated production of underwater noise along the shipping lanes will be initiated during operations and extending through the life of the Project.
- **Frequency** - periodic – Project-related marine vessel traffic increase by approximately 30 Aframax tanker calls to the Westridge Marine Terminal per month (*i.e.*, an additional 720 tanker transits each year). It will take Project-related marine vessels approximately 12 hours to complete one transit of the Marine RSA, and on average, there will be two transits every 24 hours.
- **Reversibility** - immediate – marine mammal species would likely recover from the direct effects of a single event causing sensory disturbance (*i.e.*, single passing of a Project-related tanker/tug) immediately (*i.e.*, in less than two days).
- **Magnitude** - high – Project-related underwater noise within the Marine RSA will exceed NOAA's regulatory standards for sensory disturbance. While there are no Canadian regulatory standards with respect to this effect, the NOAA thresholds are used as commonly-applied environmental standards. Southern resident killer whales within 4 to 7 km of the shipping lanes are expected to be disturbed by vessel traffic and this effect will occur throughout the Canadian designated critical habitat for this endangered population.
- **Probability** - high – underwater noise produced by Project-related marine vessels is expected to exceed the current NOAA standards for sensory disturbance within 4 to 7 km of the transiting vessels. As such, there is a high probability that marine mammal species will experience some degree of Project-related sensory disturbance while in the Marine RSA.
- **Confidence** - low - disturbance from vessels and underwater noise have been shown through numerous studies to alter behaviour, cause compensatory responses, and interfere with normal activity patterns, but the greatest source of uncertainty is the linkage of sensory disturbance effects to population-level consequences and the degree to which such effects can be attributed to underwater noise from Project-related marine vessels and other ships and boats.

Given that past and current activities are considered to have caused significant adverse effects on the southern resident killer whale population, the residual effects associated with the increase in Project-related marine vessel activity on this species was considered to be significant. Project-related effects on humpback whale and Steller sea lion populations in the Marine RSA are considered to be not significant.

4.3.7.7 Potential United States Effects

As there are no Canadian regulatory standards with respect to sensory disturbance due to the increase in Project-related underwater noise, the US regulatory standards for sensory disturbance (*i.e.*, NOAA's) were used in the above assessment as commonly-applied environmental standards. No differences in the indicators or acoustic conditions in the US and Canadian portions of the Marine RSA were identified that would change the nature of the effects assessment. Therefore, the effects are expected to be similar in Canadian and US waters.

4.3.7.8 Summary

As identified in Table 4.3.7.9, given the current Endangered status of the southern resident killer whale population, residual effects associated with increased Project-related marine vessel traffic on marine mammals are considered to be significant.

4.3.8 Marine Birds

This subsection of the ESA considers the potential effects of the increased project-related marine vessel traffic on marine birds. Key issues for marine birds were identified through discussions with provincial and federal government agencies, including EC, and the professional judgment of the assessment team based on extensive experience working on marine terminal and transportation projects in BC. The increased Project-related marine vessel traffic and associated potential visual, acoustic and physical disturbances from large vessels may cause marine birds to flush from and avoid important open water or nearshore feeding and rearing habitats. Individuals that become disoriented can subsequently strike or collide with vessels, particularly at night when vessels have work area and operating lights, or during fog or inclement weather conditions of low visibility. Project-related issues are identified as:

- sensory disturbance and subsequent behavioural alterations resulting from visual presence, wake waves, atmospheric and underwater noise from Project-related marine vessels; and
- potential injury or mortality from strikes or collisions with Project-related marine vessels.

The assessment of potential effects to marine birds from Project-related marine vessel traffic has particular objectives which include, but are not limited to, ensuring there is:

- compliance with the BC *Wildlife Act*, the *CEA Act, 2012*, and the *Migratory Birds Convention Act* (MBCA) with respect to harassment, harm or mortality of birds or bird nesting areas;
- protection for marine bird species at risk, consistent with the objectives of the federal *SARA*, the NEB Filing Manual (2013c), and provincial and local policies related to biodiversity and wildlife habitat conservation (*e.g.*, provincial best management practices);

- management of marine bird species in the context of associated ecological values within the shipping lanes and Marine RSA; and
- special attention to species of importance to the culture and traditional harvest of Aboriginal communities whose traditional territories overlap with the shipping lanes.

4.3.8.1 Assessment Indicators and Measurement Endpoints

It is important to consider potential Project-related effects on all marine bird species within the study area; however, it is impractical to assess every species present. Therefore, a suite of marine bird indicator species, each representing a group of birds with a similar ecological niche, has been selected to represent the effects to a broad range of marine bird species consistent with standard environmental practice (Lindenmayer *et al.* 2000, Mallory *et al.* 2010). The process for selecting indicators for the assessment of effects to marine birds began with a review of existing marine habitats and associated bird species known to be present seasonally within the Marine Birds LSA for marine transportation (see Section 4.3.8.2) that could be affected by Project-related marine vessel traffic. Potential effects from the increased Project-related marine vessel traffic are represented by five selected indicator species: surf scoter; fork-tailed storm-petrel; pelagic cormorant; glaucous-winged gull; and Cassin's auklet. These five species each represent a subset of the diverse assemblage of resident and migrant marine birds that use distinct niches within the matrix of marine and coastal habitats of the Marine Birds LSA. Indicators were selected to fit all or most of the following criteria:

- they are resident in, or seasonally utilize, habitats within the Marine Birds LSA for foraging and/or breeding;
- they have life requisites shared by a broad group of other marine bird species;
- they are a species of conservation concern, are considered restricted in range, or are associated with a confined or sensitive ecological community;
- there is an established baseline to describe their biology, population abundance and distribution;
- they have been documented as a species susceptible to anthropogenic disturbances;
- they are a species whose extirpation could alter or disrupt the function of the ecosystem;
- they have been identified as important to one or more coastal Aboriginal communities; and
- they have previously been useful indicators in regional effects-based assessments and, therefore, have been the focus of academic and/or regulatory studies within the Marine Birds LSA.

The selection of a suite of marine bird indicators was discussed with senior representatives of government agencies, including EC. The final selection took into consideration feedback from regulators, Aboriginal communities and stakeholders, and the professional judgment of the assessment team. All of the indicator species are highly mobile and are, at times, widely distributed throughout the Marine RSA. The final selection of indicators focused on marine birds that are:

- of conservation or regional importance;
- have an established baseline of information available and, therefore, are likely to be present seasonally within the Marine Birds LSA and Marine RSA;
- resident, migrant breeders or overwintering species; and/or
- a species belonging to an ecological guild not otherwise well-represented (*e.g.*, pelagic foragers, represented by fork-tailed storm-petrel).

Fork-tailed storm-petrels may be affected by sensory disturbance from increased Project-related marine vessel traffic, and has minimal potential to be subjected to injury or mortality as a result of collisions with vessel structures. This species is abundant and widespread using offshore areas and the continental shelf break for up to eight months during the non-breeding season. In the breeding season, it feeds close to colonies in nearshore waters along the shipping lanes and in small groups on the continental shelf. Following ships during the day, it is also attracted by boat lights at night which can cause disorientation. Lights from ocean going vessels attract individuals that often collide with them becoming momentarily dazed and incapable of flying away (USFWS 2006). The fork-tailed storm-petrel has similar requirements to other pelagic bird species that occasionally use the open waters of the Marine RSA, such as short-tailed albatross. It has been known to be sensitive to marine environmental disturbances.

Cassin's auklets are a breeding resident species of conservation concern (provincial list status – Blue). Cassin's auklets may be affected by sensory disturbance from increased Project-related marine vessel traffic, and the consequent avoidance of nearshore foraging habitat. Breeding primarily occurs along the coast of BC. It spends its life, resting and feeding, on the open sea and only comes ashore to colonies after dark during the breeding season and leaves before dawn. This behaviour makes auklets vulnerable to injury or mortality from bird strikes or collisions with Project related marine vessels during inclement weather or from night-lighting on vessels. During the non-breeding season, it is most abundant in waters over the continental shelf. Direct threats to local populations include human and sensory disturbance, fisheries-related mortality, mammal predation at colonies and food supply limitations. It has similar habitat requirements to other sensitive alcid species (Hentze 2006, USFWS 2006), such as murrelets and murres, that rely on the open water and nearshore areas for foraging on fish and crustaceans.

Surf scoters are a seasonally resident seabird species of conservation concern (provincial list status – Blue) widely distributed along the BC coastline, especially during spring and fall migration periods. The Marine RSA provides staging and overwintering habitat for multi-aged aggregations of a few hundred to several thousand individuals that forage on benthic invertebrates within 1 km of shore. Surf scoters may be affected by sensory disturbances from Project-related marine vessels, particularly in narrow channels and passages, and consequently flush and avoid important nearshore and intertidal foraging habitat. Southward migration from inland breeding areas is usually at night (Butler and Savard 1985), therefore, it may be vulnerable to disorientation from night-lighting and potential injury or mortality as a result of collisions with vessel infrastructure. Non-breeding habitat includes sheltered freshwater and marine bays, harbours and lagoons. It has similar requirements to other resident and seasonally present seabirds that feed on nearshore invertebrates, and to waterfowl species using shoreline habitats.

Pelagic cormorants are a resident and locally breeding species of conservation concern (provincial list status – Red). Pelagic cormorants may be affected by sensory disturbance during vessel operations particularly within narrow channels, and potential injury or mortality as a result of collisions with vessel infrastructure during inclement weather events. Active breeding colonies are present on rocky cliffs of islands or headlands within the narrow passage of Haro Strait. The number of pelagic cormorant nests within the Strait of Georgia had declined by approximately 54 per cent between 1987 and 2000 (Chatwin *et al.* 2002) potentially from the effects of nearshore fisheries and gillnet mortalities (USFWS 2006); however, in recent years populations have been stable (Crewe *et al.* 2012). The species is traditionally important to coastal Aboriginal communities as a harvest species (USFWS 2006). The species is sensitive to disturbance, especially near nesting sites and in areas experiencing increased recreational boating activity. Pelagic cormorants dive in the littoral-benthic zone for solitary fish and invertebrates. It has similar foraging and breeding requirements to other piscivorous birds within the Marine RSA, such as common merganser.

Glaucous-winged gulls are an abundant resident and locally breeding species eating fish, small birds, eggs, small mammals, invertebrates and refuse. Glaucous-winged gulls may be affected by sensory disturbances during vessel operations, and have a marginal potential for injury or mortality from collisions with vessel infrastructure during weather events or from disorientation as a result of vessel operating or night=time work lights. The gull is an abundant resident and locally breeding species eating fish, small birds, eggs, small mammals, invertebrates and refuse. It has been traditionally harvested by south coast Aboriginal communities (individuals and eggs) (Fediuk and Thom 2003, First Nations Health Council 2011b). Although generally an inshore species, it does venture from the coast where it is often seen around fishing vessels at sea. The gull may feed pelagically as far as the continental shelf (approximately 100 km from shore). The gull has similar requirements to other marine bird species as a generalist in the current context of the both natural and disturbed marine environments, and to other adaptive species in disturbed environs, such as northwestern crow.

Rationale for the selection of each of the indicators is summarized in Table 4.3.8.1.

The increased Project-related marine vessel traffic has the potential to affect marine birds through direct changes in habitat availability from wake effect, sensory disturbance and consequent avoidance in important habitats, and the risk of injury or mortality from Project–related marine vessels. Qualitative measurement endpoints associated with these effects have been identified for each indicator (Table 4.3.8.1). Sensory disturbance was qualitatively assessed for each indicator species based on potential flushing or disturbance threshold, and behaviour alterations or habitat avoidance that might result from marine vessel noise and activity. The likelihood of injury or mortality was qualitatively assessed for each of the indicators based on the potential for strikes or collisions with project-related marine vessels. The predicted degree of change in these parameters was used to characterize, and determine the significance of, potential direct and cumulative environmental effects from the Project.

TABLE 4.3.8.1

ASSESSMENT INDICATORS AND MEASUREMENT ENDPOINTS FOR MARINE BIRDS

Marine Bird Indicator	Measurement Endpoints	Rationale for Indicator Selection
Fork-tailed storm-petrel	• Qualitative measure of the likelihood of sensory disturbance from the visual presence of vessels, wake waves and atmospheric or underwater noise • Qualitative measure of the potential for injury or mortality of marine birds from vessel strikes	• Resident breeder • Documented as sensitive to light disturbance from vessels at night • Established baseline of bird biology, population abundance and distribution • Sensitive to anthropogenic disturbances • Similar requirement to rare and sensitive pelagic seabirds, such as albatross, jaegers, shearwaters and other petrel species
Cassin's auklet		• Resident breeder • Species of conservation concern • Sensitive to anthropogenic disturbances • Known effects from marine vessels including fisheries-related mortalities • Congregates in mixed species alcid flocks • Established baseline of bird biology, population abundance and distribution • Represents other alcid species
Surf scoter		• Winter resident and spring/fall migrant • Species of conservation concern • Congregates in large flocks during migration and overwintering periods • Established baseline of bird biology, population abundance and distribution • Sensitive to anthropogenic disturbances • Similar requirements to other seabirds and waterfowl using nearshore and intertidal zones, such as goldeneyes and harlequin ducks
Pelagic cormorant		• Breeding resident • Species of conservation concern • Declining in population abundance • Established baseline of bird biology, population abundance and distribution • Traditionally important to Aboriginal communities as a harvest species • Sensitive to vessel and other anthropogenic disturbances • Similar requirement to other littoral zone and deep foraging piscivores such as grebes, loons and other cormorant species
Glaucous-winged gull		• Breeding resident • Abundant population as a generalist in natural and disturbed environments • Established baseline of bird biology, population abundance and distribution • Known attraction to vessels as an opportunistic feeder • Traditionally important to Aboriginal communities as a harvest species • Similar requirements to a wide range of marine birds including other gulls, jaegers and terns

4.3.8.2 Spatial Boundaries

Spatial boundaries for the assessment of marine birds include the geographic extent within which the potential effects of the Project are expected to be measurable. The regional setting includes species of conservation concern, breeding sites and marine habitats of particular importance to marine birds, including substantial and internationally important breeding colonies, areas of known seasonal congregations and staging areas, IBAs and other marine conservation areas. The spatial boundaries have been identified as the Marine Birds LSA and the Marine RSA.

- **Marine Birds LSA** - includes the inbound and outbound marine shipping lanes, the area between the shipping lanes where it exists and a 1 km buffer extending from the outermost edge of each shipping lane. The shipping lanes extend from the Westridge Marine Terminal in Burnaby, through Burrard Inlet, south through southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, then westward past Victoria and though Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea.
- **Marine RSA** - comprised of a large portion of the Salish Sea, including the inland marine waters of the southern Strait of Georgia and Juan de Fuca Strait and their connecting channels, passes and straits. The Marine RSA is generally centred on the marine shipping lanes, which extend from the Westridge Marine Terminal through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, westward past Victoria and through Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea. The western boundary of the Marine RSA extends further out to sea than the western boundary of the Salish Sea and the northern boundary of the Marine RSA is limited to the southern portion of the Strait of Georgia. Puget Sound is excluded from the Marine RSA.

The marine birds study areas also follow guidance indicated by the NEB in the letter titled Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Increased Marine Shipping Activities (NEB 2013b), received by Trans Mountain on September 10, 2013. The letter indicates that the marine transportation assessment should take place out to the 12 nautical mile limit of Canada's territorial seas.

Study area boundaries for marine birds are shown in Figure 4.2.2.

4.3.8.3 Marine Bird Context

The Marine RSA falls within the Strait of Georgia, Haro Strait and Juan de Fuca Strait, all of which are within the Salish Sea, an inland area of ocean that extends from Olympia, Washington northward to Campbell River, BC. To the east it is bounded by the mainland coasts of BC and Washington State, and the Fraser River Delta, which drains into the Strait of Georgia. The Olympic Peninsula of Washington State is to the southwest. Numerous islands and islets belonging to either the Gulf Islands or the San Juan Islands form an archipelago of diverse marine habitats with associated dependent marine life.

The shipping lanes are an established route for all types of vessels and are among the busiest shipping lanes on the Pacific coast. Marine vessels including cargo ships, cruise ships and oil tankers are required to use these distinct shipping lanes for navigational and safety purposes (BC MCA 2010, CCG 2013b, Volume 8C, TERMPOL Studies). Most commercial vessels use the Strait of Georgia to access the 23 major marine terminals in Burrard Inlet, two automobile terminals, and a cargo and container terminal along the Fraser River and the Deltaport at Roberts Bank. In 2012, tug and barge transits made up approximately 49 per cent of the total sailed nautical miles, with cargo and ferry traffic making up a further 18 per cent and 15 per cent, respectively (Volume 8C, TERMPOL Studies). Tanker and cargo traffic from Vancouver uses Haro Strait to access international waters via the Juan de Fuca Strait. In 2012, passenger ferries made up approximately 38 per cent of the total sailed nautical miles in Haro Strait, with cargo traffic making up a further 21 per cent (Volume 8C, TERMPOL Studies).

Marine and coastal ecosystems are subject to dramatic large-scale changes and fluctuations in productivity. El Niño events result in elevated water temperatures and decreased abundance of prey species, which can lead to reduced reproductive output and survival rates for marine birds. Human activities and disturbances exacerbate these natural pressures. Much of the marine shoreline within the Marine RSA is developed for industrial or residential use, with the exception of some federally and provincially-designated conservation areas including MPAs, RCAs, WMAs, Ecological Reserves, Provincial Parks and State Parks. There are 20 IBAs present within the Marine RSA, which range in size from 140 ha to 153,717 ha (see Marine Birds – Marine Transportation Technical Report, Volume 8B, TR 8B-2). Marine areas that are adversely affected by recreation, commercial fishing, human developments, and vessel operations reduce habitats available for marine birds.

Marine birds require marine and coastal habitats during all or a part of their life cycle (Croxall *et al.* 2012). The Salish Sea supports diverse populations of seasonally present bird species using important foraging areas, such as marine upwellings, shallow open water and the continental shelf. The Marine RSA encompasses many large breeding and staging areas that are in close proximity to the shipping lanes. Breeding colonies of double-crested cormorants, pelagic cormorants, black oystercatchers, rhinoceros auklets, Cassin's auklets, tufted puffins, pigeon guillemots, great blue herons, fork-tailed storm petrels, Leach's storm-petrels, and glaucous-winged gulls are documented within the Salish Sea (Chatwin *et al.* 2002, Elliot *et al.* 2005, Vermeer 1983, Wahl *et al.* 1981). Extensive nest sites are located on Protection Island, Tatoosh Island, Smith and Minor Islands, Mandarte Island, and Race Rocks (Wahl *et al.* 1981) (Figure 4.2.26). Multiple non-colonial species also breed in these areas (Burton 2010, Wahl *et al*. 1981).

An estimated 124 marine bird species (Campbell *et al.* 1990, Stevens 1995) in the Marine RSA use coastal terrestrial habitats (above high-water mark); foreshore (high-water to low-water tide mark); nearshore (low-water mark to water extending 10 m seaward); and offshore areas (nearshore to the continental shelf). Species of conservation concern reported within the Marine RSA include short-tailed albatross, Brandt's cormorant, double-crested cormorant, western grebe, great blue heron, Cassin's auklet, common murre, tufted puffin, horned puffin, marbled murrelet, surf scoter, red knot, long-billed curlew and peregrine falcon (Badzinski *et al.* 2008, BC CDC 2013).

4.3.8.4 Potential Effects and Mitigation Measures

4.3.8.4.1 Effects Considerations

The potential for effects from Project-related marine vessel traffic is considered in the context of the volume and activity of existing traffic in the established in-bound and out-bound shipping lanes. The lanes are confined for a small portion of the entire route out to sea, primarily within Burrard Inlet east of First Narrows, and within Haro Strait where the vessels pass a complex of small islets and channels. Average channel width in the Strait of Georgia and Juan de Fuca

Strait is approximately 22 to 28 km (Thompson 1981); therefore, the greatest proportion of the Marine Birds LSA surrounding the shipping lanes is open water habitat.

A thorough review of potential issues to include in the assessment of potential Project effects on marine birds was based on the assessment team's experience and relevant scientific literature. Additional issues were raised through consultation with Aboriginal communities, government agencies and other stakeholders; however, some were eventually scoped out by the assessment team based on past experience with similar projects. These included recommendations to assess other indicator species such as black oystercatcher, great blue heron and western grebe. Oystercatchers and herons use shoreline habitats within the Marine RSA, and effects to these species from routine operations would be associated with wake effects. As indicated in the detailed assessment of wake effects in Section 4.3.6.6 for Marine Fish and Fish Habitat, only 5 per cent of the total length of shoreline in the Canadian portion of the Marine RSA is located within 2 km of the shipping lanes. These areas include shoreline in Burrard Inlet, Haro Strait and the area around Victoria on Vancouver Island. Wake waves from Project-related marine vessel traffic are expected to be well within the range of natural wave conditions. Wave height would dissipate rapidly at increasing distances from the vessels. Any temporary disturbance to intertidal habitat due to vessel wake would not normally be detectable from existing conditions and, therefore, marine birds are unlikely to be disturbed to any substantial extent by wave heights from Project-related marine vessels. As such, there is no anticipated potential effect of vessel wake on marine birds and it is not discussed further.

Western grebes are of conservation concern and seasonally present within the Marine RSA in small groups. Although an important species of concern, western grebes are represented in the assessment of effects to various foraging guilds by selected indicator species, primarily the pelagic cormorant, due to its conservation status, similar foraging strategy, importance as a resident breeder and its abundant local population.

4.3.8.4.2 Identified Potential Effects

The potential for environmental effects on marine birds is assessed by first identifying the ecology and habitat requirements of species using the study area and then considering these with respect to the increased Project-related marine vessel traffic. The potential effects associated with marine shipping were based on the results of a literature review, desktop analyses, TMRU studies, and expertise of the assessment team. Consultation with senior representatives of government agencies (primarily EC) and other relevant stakeholders provided additional information on potential effects and recommendations for mitigation. The increased Project-related marine vessel traffic has potential to adversely affect marine birds through sensory disturbances from the visual presence of vessels and/or atmospheric and underwater noise, which then may result in behaviour alterations. Injury or mortality could result from bird disorientation from night-lighting during vessel operations, and consequent bird strikes or collisions with vessels.

Behaviour Alterations or Sensory Disturbance

Physiological responses of animals to visual disturbance may include increased heart rate and respiration, increased blood flow to skeletal muscle, increased body temperature, elevations of blood sugar and reduced blood flow to the skin and digestive organs, a "fight or flight" response (Knight and Gutzwiller 1995), which is key to improving their chances of survival under adverse conditions. Non-lethal disturbance stimuli caused by humans can create a response in birds analogous to predation risk (Frid and Dill 2002). Noise disturbances can cause increased energy expenditure in seabirds especially during breeding periods (Jungius and Hirsch 1979).

Repeated disturbance events over time decreases the time and energy spent in fitness-enhancing activities such as feeding, parental care or mating and results in lowered fitness levels. The bird's level of perceived risk depends on the particular species, the environmental variables present and factors related to natural predation risk. These energetic trade-offs can indirectly affect population survival and reproduction.

Marine birds have been documented as particularly sensitive to various human-related disturbances (Birdlife International 2012b, Carney and Sydeman 1999, Ruddock and Whitfield 2007, Smith 2000), the degree of which is dependent on the species. BC MOE (2004) identifies disturbance by vessel traffic in at-sea foraging sites as a threat to marine birds, with some species more sensitive to approaching vessels than others (Schwemmer *et al.* 2011). Studies have shown that atmospheric noise and visual disturbances can cause a flight or panic response near colonies that can result in avoidance of important habitats or abandonment of nests (DND 1994, Dufour 1980). Marbled murrelets and pelagic cormorants have exhibited a strong flushing response when recreational vessels are within 70 m and 150 m, respectively. Some species may even react before the possibility of visual detection by a boat-based observer. In a study of cormorants by Hentze (2006), over 60 per cent of cormorants reacted at 150 m. Some species or individuals chose to fly and leave the feeding area completely, others dove and resurfaced a short distance away from the boat (Bellefleur *et al.* 2009, Hentze 2006). Kittlitz's murrelets foraging at nearshore areas have had temporarily suppressed feeding by passing vessels, although normal behaviour resumed within the same day (Agness *et al.* 2008). Variables such as season, sea state, hour, bird group size, vessel speed, approach distance, approach angle, average bird density, location, and average prey density all combine to influence marine bird flushing distances (Hentze 2006).

Anthropogenic noise sources can mask communication, displace animals from preferred foraging or breeding habitat, disrupt predator-prey interactions and in extreme cases, cause hearing loss. The atmospheric sound levels required to cause disturbance or damage to hearing in birds are believed to be high (>90 dB re 20 uPa), and generally of high intensity or long duration (DND 1994). There is evidence that some sea birds are markedly disturbed (if not injured) by impulse sound levels in air, in the 120 dB re 20 uPa range (Black 2005). Marine birds located near transiting vessels may respond to atmospheric noise by panic, flushing and moving away for the duration of the disturbance.

There is little information in the literature to evaluate marine bird response to disturbance from underwater noise. Underwater dB-levels are represented differently from atmospheric dB-levels and may be adjusted by adding 25.5 dB to the airborne dB-level to get a comparable underwater dB-level. Furthermore, as a result of the much higher acoustic impedance of water compared to air, another 36 dB correction is required, making an airborne sound pressure level of, for example, 90 dB re 20 uPa comparable to an underwater 151.5 dB re 1 uPa (Slabbekoorn *et al.* 2010). Underwater vessel noise varies as a function of vessel size, speed and design. In general, large vessels create louder and lower frequency sounds than smaller vessels (Richardson *et al.* 1995). Noise is produced by propeller cavitation and the broadband source levels from a VLCC can exceed 205 dB re 1 uPa at source (Richardson *et al.* 1995). Other tankers are reported as typically emitting underwater sound between 169 and 200 dB re1 uPa at source. Black-footed penguins (*Spheniscus demersus*) have been documented as sensitive to frequencies within the range of 100 Hz to 15 kHz (Wever *et al.* 1969). The underwater call playback of a chase-boat engine noise from 150 m has been used to reduce waterfowl predation pressure on molluscs (Ross *et al.* 2001). Many seabirds spend a substantial portion of their lives under the water and most likely have sensory adaptations to facilitate aquatic life history. Although there is substantial variation among species (*e.g.*, species-specific disturbance thresholds, scale of displacement, recovery times or resilience) and under differing conditions, previous research indicates that birds may habituate to low noise levels that are continuous or predictable (Gladwin *et al.* 1988). Hearing effects in birds are well documented on land but effects from underwater noise depends on how often and deeply seabird species dive, their tendency to be disturbed by noise, and their ability to adapt to excess noise (Dooling 1978). With few data or measurements of underwater hearing abilities in birds, and a paucity of literature on the effects of underwater noise on bird behaviour, it is difficult to directly assess potential effects of underwater noise on marine birds found in the Marine RSA. Potential effects of underwater noise are considered as part of the assessment of potential general sensory disturbance.

Speckman *et al.* (2004) found that marbled murrelets in Alaska were reasonably habituated to the physical presence of transiting marine vessels, such that they tended to paddle away, or dive, rather than fly, which is more energetically intensive. Birds tend to habituate to disturbance when it is predictable and not associated with a negative experience such as fright or harm (Steidl and Anthony 2000, Ward and Stehn 1989). Habituation may occur to various degrees in some species, and could continue to occur in the Marine RSA; however, this is difficult to measure without extensive research, and also difficult to separate from the disturbances caused by other human or vessel activities along the shipping lanes.

Sensory disturbances in the Marine Birds LSA could result in the alteration of their normal movement patterns to avoid vessel noises or activities. Atmospheric and underwater noise, and activity during vessel operations, could cause birds to avoid preferred sites within the Marine Birds LSA, and consequently reduce habitat effectiveness (see Figure 4.2.3). Currently, there are abundant populations of marine birds using habitats that overlap areas of high shipping activity, such as Haro Strait, the Fraser River, Burrard Inlet and the Strait of Georgia. However, vessel traffic near seabird colonies in the region is a relatively common occurrence and; therefore, Project-related shipping activity is not expected to present a new environmental effect.

Likelihood of Injury or Mortality

Injury or mortality may occur as a result of marine bird interactions with Project-related marine vessel activities. Major sources of artificial light in the marine environment include vessels, marine terminals, lighthouses, light-induced fisheries and oil/gas platforms. Seabirds are highly visually oriented and known to become disoriented at night, especially during migration, in the presence of artificial light (Bruderer *et al.* 1999, LeCorre *et al.* 2002). Light-induced bird strikes are known to occur when vessels navigate during darkness (Merkel and Johansen 2011) and the likelihood of injury or mortality increases when visibility is reduced by fog and extreme weather conditions (Birdlife International 2003, Greer *et al.* 2010). Variables that can combine to influence the likelihood of strikes include weather conditions, season and lunar phase, and the species and age of birds. (Montevecchi 2006). In a few cases, mass collisions of hundreds or thousands of seabirds have been documented during storm events (Black 2005). Some species groups, such as alcids (Merkel and Johansen 2011, Stumpf *et al.* 2011), are more responsive or confused and, therefore, more susceptible to night-lights and the potential for collisions with vessel infrastructure. In a study off the coast of Greenland by Merkel and Johansen (2011), all reported bird strikes occurred during the night or in twilight, from 4 pm to 5 am, and with a higher frequency during the dark mid-winter period. In 26 of the 42 cases, visibility was reduced due to snow or rain. These types of events have also been documented at various shipping areas around the world (Black 2005, Merkel and Johansen 2011, Montevecchi 2006). This information is lacking for the Marine RSA; however, and no specific thresholds for evaluating the effect have been identified.

Potential effects associated with the increased Project-related marine vessel traffic on marine bird indicators are listed in Table 4.3.8.2. The summary of recommended mitigation measures provided in Table 4.3.8.2 was principally developed in accordance with provincial regulatory guidelines including Develop with Care 2012 (BC MFLNRO 2012).

TABLE 4.3.8.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE BIRDS

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1. Marine Birds Indicators – Fork-tailed Storm-petrel, Cassin's Auklet, Surf Scoter, Pelagic Cormorant, Glaucous-winged Gull			
1.1 Behavioural alteration or sensory disturbance	RSA	• No mitigation is recommended since Project-related marine vessels will be operated by third-party subcontracting corporations acting under relevant shipping and piloting authorities. Marine transportation in Canadian territorial waters is regulated through the *Canada Shipping Act* administered by Transport Canada and the CCG.	• Sensory disturbance, stress, behavioural changes or avoidance of important habitats.
1.2 Likelihood of injury or mortality	LSA	• No mitigation is recommended since Project-related marine vessels will be operated by third-party subcontracting corporations acting under relevant shipping and piloting authorities. Marine transportation in Canadian territorial waters is regulated through the *Canada Shipping Act* administered by Transport Canada and the CCG.	• Injury or mortality events.

Note: 1 LSA = Marine Birds LSA; RSA = Marine RSA

The objectives of the Project are to ensure that industry-accepted practices are implemented to avoid, or limit, any potential adverse effects from activities related to vessel operations as well as implement acceptable and effective mitigation measures and environmental management procedures. Through a background of ecological knowledge of the surrounding local and regional marine areas, and the implementation of appropriate management practices and measures, it is predicted that the Project can meet the objectives for protection of marine bird species, species at risk and regulatory compliance, and traditional and regional biodiversity values through reductions in the potential for sensory disturbances, injury or mortality.

4.3.8.5 Potential Residual Effects

Residual effects are those that are predicted to remain after mitigation measures have been applied. The potential residual environmental effects on the marine birds indicators associated with the increased Project-related marine vessel traffic (Table 4.3.8.2) are as follows:

- sensory disturbance, stress, behavioural changes or avoidance of important habitats; and
- injury or mortality events.

4.3.8.6 Significance Evaluation of Potential Residual Effects

In general, non-significant effects can occur in a population in a localized manner over a short period of time (similar to natural variation) and have no measurable and/or meaningful adverse effect on the integrity of the population as a whole (BC EAO 2013, FEARO 1994c). A residual adverse effect is considered significant when a population of a species is sufficiently affected to cause a change beyond which natural recruitment (*i.e.*, reproduction and immigration from unaffected areas) will not return the regional population to its former level. Significant effects have a high probability of a permanent or long-term and high magnitude effect that cannot be technically mitigated.

The magnitude of effect on most indicators from increased likelihood of mortality and sensory disturbance can be determined qualitatively. This is the most appropriate approach to evaluate the potential residual environmental effects without measurable standards to compare them to. Evaluation of the significance of these potential residual effects relies on the professional judgment of the assessment team that includes members with extensive environmental impact assessment experience in marine environments. Mitigation measures are intended to avoid or reduce the severity of potential effects.

Table 4.3.8.3 provides a summary of the evaluation of significance of residual effects on the marine birds indicators from the increased Project-related marine vessel traffic.

TABLE 4.3.8.3

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE BIRDS

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
1. Marine Birds Indicator – Fork-tailed Storm-petrel									
1(a) Behavioural alteration or sensory disturbance.	Negative	RSA	Long-term	Periodic	Short-term	Low	High	High	Not significant
1(b) Likelihood of injury or mortality.	Negative	LSA	Long-term	Occasional	Medium-term	Low	Low	High	Not significant
2. Marine Birds Indicator – Cassin's Auklet									
2(a) Behavioural alteration or sensory disturbance.	Negative	RSA	Long-term	Periodic	Short-term	Medium	High	High	Not significant
2(b) Likelihood of injury or mortality.	Negative	LSA	Long-term	Occasional	Medium-term	Low	Low	High	Not significant
3. Marine Birds Indicator – Surf Scoter									
3(a) Behavioural alteration or sensory disturbance.	Negative	RSA	Long-term	Periodic	Short-term	Medium	High	High	Not significant
3(b) Likelihood of injury or mortality.	Negative	LSA	Long-term	Occasional	Medium-term	Low	Low	High	Not significant
4. Marine Birds Indicator – Pelagic Cormorant									
4(a) Behavioural alteration or sensory disturbance.	Negative	LSA	Long-term	Periodic	Short-term	Medium	High	High	Not significant
4(b) Likelihood of injury or mortality.	Negative	LSA	Long-term	Occasional	Medium-term	Low	Low	High	Not significant

TABLE 4.3.8.3

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE BIRDS (continued)

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
5. Marine Birds Indicator – Glaucous-winged Gull									
5(a) Behavioural alteration or sensory disturbance.	Negative	LSA	Long-term	Periodic	Short-term	Low	High	High	Not significant
5(b) Likelihood of injury or mortality.	Negative	LSA	Long-term	Occasional	Medium-term	Low	Low	High	Not significant
6. Combined Effects of Increased Project-related Marine Vessel Traffic on Marine Birds									
6(a) Combined effects of increased Project-related marine vessel traffic on the marine birds indicators (1[a], 2[a], 3[a], 4[a] and 5[a]).	Negative	RSA	Long-term	Periodic	Short-term	Medium	High	High	Not significant

Notes: 1 LSA = Marine Birds LSA; RSA = Marine RSA

2 **Significant Residual Environmental Effect:** A high probability of occurrence of a permanent or long-term residual effect of high magnitude that cannot be technically or economically mitigated.

4.3.8.6.1 Marine Birds Indicator - Fork-tailed Storm-petrel

The following subsections provide the evaluation of significance of the potential residual effects on the fork-tailed storm-petrel indicator.

Sensory Disturbance, Stress, Behavioural Changes or Avoidance of Important Habitats

The fork-tailed storm-petrel moves offshore during the non-breeding season and is most associated with the continental shelf and shelf break (Shuford and Gardali 2008). The fork-tailed storm-petrel rarely lands, fluttering low over offshore waves, sometimes in flocks, hovering over the ocean to capture fish and zooplankton from the surface of the water. This will reduce the potential for the extent of sensory disturbances that might affect surface or diving foragers. The increase in large vessel traffic introduced by the Project is unlikely to have long-term effects that are detectable within the regional population of fork-tailed storm-petrel considering the context of the existing high volume large vessel traffic within the Marine RSA, and the highly pelagic nature of this species. The physical presence of vessels and noise is anticipated to result in localized, regular, and short-term sensory disturbance (*i.e.*, the avoidance of preferred or important habitats) that is considered to have a negative impact balance. Observations within the Marine RSA during the fall are most likely to occur near Race Rocks as indicated by previously documented observations (Bird Studies Canada 2013b) and somewhat distant from marine vessels, so the probability of substantial disturbance events is low. Flushing and noise disturbances may happen in close range of the vessel, depending on the vessel activity and existing sea conditions but is expected to have a lower probability of affecting this species compared to other indicators. Fork-tailed storm-petrels may be partially habituated to the presence and activity of marine traffic, since they commonly forage by following ships during the day to take advantage of discarded food. The magnitude of the residual effects on fork tailed storm-petrel associated with sensory disturbance caused by the increased Project-related marine vessel traffic is considered to be low (Table 4.3.8.3, point 1[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – effects may extend beyond the Marine Birds LSA under certain at-sea conditions considering the pelagic, wide-ranging and agile flight pattern of storm-petrels.
- **Duration** - long-term – the event causing sensory disturbance to fork-tailed storm-petrels is the operation of Project-related marine vessels which occurs for the life of the Project.
- **Frequency** - periodic – the event causing sensory disturbance to fork-tailed storm-petrels is the passage of Project-related marine vessels which will occur intermittently, but repeatedly, with regular vessel transits at the potential rate of twice per day, for the life of the Project.
- **Reversibility** - short-term – recovery from the effects of sensory disturbance may be interrupted by subsequent vessels or other marine activities and, therefore, may not be reversible in immediately but in some period greater than 2 days but less than one year.
- **Magnitude** - low – the effects will be detectable at the individual level but marginal to negligible on the population level with consideration for the context of high volume large vessel traffic currently within the study area, and the tendency for storm-petrels to follow ships opportunistically.
- **Probability** - high – the Project is likely to cause sensory disturbance to fork-tailed storm-petrel.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the study area.

Injury or Mortality Events

Fork tailed storm-petrels are attracted by night-lighting on marine vessels which can result in harmful or fatal collisions with ship infrastructure (USFWS 2006), although these events have been uncommon (Black 2005, Le Corre *et al.* 2002). The residual effect of injury or mortality associated with the increased Project-related marine vessel traffic is considered to have a negative impact balance. Accounting for the low abundance of individuals likely to be present seasonally, the probability of a fork-tailed storm-petrel being hit by, or colliding with, Project-related marine vessels is anticipated to be low (Table 4.3.8.3, point 1[b]). With consideration for the presence of navigational and work lights, and associated light effects from many vessels within the shipping lanes at night, it would be difficult to isolate the effects of additional lighting associated directly with the increase in vessels from the Project. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine Birds LSA – effects are confined to the vicinity of the shipping lanes for Project-related marine vessels.

- **Duration** - long-term – the event causing injury or mortality effects on fork-tailed storm-petrel is the operation of the increased Project-related marine vessel traffic, which will continue for the life of the Project.
- **Frequency** - occasional – the event leading to a potential injury or mortality will occur intermittently and sporadically for the life of the Project.
- **Reversibility** - medium-term – the effect of an event of mortality will be restored in one generation of recruitment and maturity for individuals of that species.
- **Magnitude** - low – the effects will not be detectable at regional population levels.
- **Probability** - low – injury and mortality are possible but unlikely to occur as a result of the Project.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the coastal region.

4.3.8.6.2 Marine Bird Indicator - Cassin's Auklet

The following subsections provide the evaluation of significance of the potential residual effects on the Cassin's auklet indicator.

Sensory Disturbance, Stress, Behavioural Changes or Avoidance of Important Habitats

Cassin's auklets breed in colonies at established sites within the western portion of Marine RSA near Juan de Fuca Strait. During the non-breeding season, they spend most of the time at sea in upwellings, with southern populations likely moving north (Ainley *et al.* 2011) and northern ones moving south to the continental shelf. Cassin's auklets forage during both day and night, usually in small groups, and occasionally in large flocks. During the non-breeding season, larger flocks are vulnerable to disturbance. There is unlikely to be more than a low level of habituation to an increase in the presence and activity of marine vessel traffic, as indicated by scientific literature that documents the sensitivities of these and other alcid species to various sources of disturbance (Hentze 2006). Considering the existing relatively high volume of vessel traffic within the Marine Birds LSA and Marine RSA, the increase in large vessel traffic introduced by the Project is likely to have short-term effects on individuals and small groups; however, it is unlikely that these residual effects will be detectable in the regional population of Cassin's auklet. This effect is considered to have a negative impact balance. The physical presence of vessels and noise is anticipated to result in localized, regular sensory disturbances to Cassin's auklet considered to be of medium magnitude (Table 4.3.8.3, point 2[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – effects may extend beyond the Marine Birds LSA depending on at-sea conditions, the known sensitivity of the species, season (*e.g.*, breeding), and age of individuals.
- **Duration** - long-term – the event causing sensory disturbance to Cassin's auklet will be initiated during operations and occur for the life of the Project.

- **Frequency** - periodic – sensory disturbance to Cassin's auklet will occur intermittently, but repeatedly, with regular transits potentially twice per day, for the life of the.

- **Reversibility** - short-term – recovery from the effect of sensory disturbance may be interrupted by subsequent vessels or other marine activities and, therefore, may not be reversible immediately but in some period greater than 2 days but less than one year.

- **Magnitude** - medium – the effects will be detectable at the individual level, but low to moderate on the population level considering the context of high volume large vessel traffic conditions currently within the study area, the regularity of Project-related marine vessel transits twice per day, and the known sensitivity of alcid species to disturbance.

- **Probability** - high – the Project is likely to cause sensory disturbance to Cassin's auklet.

- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the coastal region.

Injury or Mortality Events

Cassin's auklets are among the group of marine birds, the alcids, documented as vulnerable to night lighting on marine vessels, due to their tendency to fly long distances at night to and from the nesting colony, sometimes resulting in harmful or fatal collisions with ship infrastructure. The potential effect from Project-related marine vessel traffic resulting in injury or mortality is considered to have a negative impact balance, especially during the breeding season. Bird strikes or vessel collisions are expected to be uncommon and sporadic; however, considering the presence of navigational and work lights, and the associated light effects from all vessels using these same the shipping lanes at night, it would be difficult to isolate the direct effects of additional lighting associated with the Project. Therefore, the residual effect on Cassin's auklet is considered to be of low magnitude (Table 4.3.8.3, point 2[b]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine Birds LSA – effects are confined to the vicinity of the shipping lanes for Project-related marine vessels.

- **Duration** - long-term – the event causing potential injury or mortality effects on Cassin's auklet is the operation of the Project-related marine vessel traffic, which will continue for the life of the Project.

- **Frequency** - occasional – the event leading to a potential injury or mortality effect may occur intermittently and sporadically for the life of the Project.

- **Reversibility** - medium-term – the effect of an event of mortality will be restored in one generation of recruitment and maturity for individuals of that species.

- **Magnitude** - low – the effects are not expected to be detectable at regional population levels.

- **Probability** - low – injury and mortality is possible but unlikely to occur as a result of the Project.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the coastal region.

4.3.8.6.3 Marine Bird Indicator - Surf Scoter

The following subsections provide the evaluation of significance of the potential residual effects on the surf scoter indicator.

Sensory Disturbance, Stress, Behavioural Changes or Avoidance of Important Habitats

Surf scoters are seasonally migrant and not known to breed in the Marine RSA. Effects from sensory disturbance would be limited to the wintering, migrating and moulting periods (late summer to late spring when large rafts of foraging birds are present, primarily in nearshore areas with abundant benthic resources. A smaller proportion of the non-breeding population is found in open waters during this time. The vessel activity and noise is anticipated to result in localized, regular, short-term disturbances primarily in narrower portions of the shipping lanes, such as in Haro Strait. Depending on the time of year, large aggregations of surf scoters (*e.g.*, thousands in spring foraging on Pacific herring spawn) could be vulnerable to effects; however, groups of birds are expected to move away from vessels. If the disturbance is not substantial, normal behaviors and activities should resume within a relatively short time–frame, depending on whether the recovery period is interrupted by subsequent marine activities. The impact balance of residual sensory disturbance to surf scoter is considered to be negative. The change in large vessel traffic introduced by the Project will be long term; however, it is unlikely that adverse effects would be detectable within the relatively large regional population of surf scoters considering the context of high volume vessel traffic within the Marine RSA (Table 4.3.8.3 point 3[a]). Surf scoters may be somewhat habituated to the presence and activity of marine vessel traffic, although this has not been assessed in the region, and is somewhat less likely in birds that are present seasonally and not resident. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – effects may extend beyond the Marine Birds LSA depending on at-sea conditions, the bird activity and season (*e.g.*, breeding), group size and age of individual surf scoters.
- **Duration** - long-term – the event causing the potential sensory disturbance to surf scoter will be initiated during operations and occur for the life of the Project.
- **Frequency** - periodic – sensory disturbance to surf scoter will occur intermittently, but repeatedly, due to regular transits potentially twice per day, for the life of the Project .
- **Reversibility** - short-term – recovery from the effects of sensory disturbance may be interrupted by subsequent vessels or other marine activities and, therefore, may not be reversible immediately but in some period greater than 2 days but less than one year.

- **Magnitude** - medium – the effects will be detectable at the individual level, marginal to seasonally moderate on the population level considering the high volume large vessel traffic conditions currently within the study area and the potential for large aggregations of birds during overwintering in channels and nearshore habitats.
- **Probability** - high – the Project is likely to cause sensory disturbances to surf scoters.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the Project area.

Injury or Mortality Events

Surf scoters migrate from inland breeding areas in fall, usually flying at night. They are, therefore, considered potentially vulnerable to night-lighting on marine vessels, during migration, and to disorientation during inclement weather, fog and low visibility. Bad weather events can result in harmful or fatal collisions with vessel infrastructure, although these events are not often documented in this species (Savard *et al.* 1998). Consequently, although potential adverse effects are considered to have a negative impact balance, bird strikes or collisions are expected to be uncommon. And it would be difficult to isolate the direct effects of lighting associated with the increase in vessels from the Project from those effects of navigational and work lights present on other vessels in the shipping lanes. The magnitude of the residual effect on surf scoter is considered to be of low magnitude (Table 4.3.8.3, point 3[b]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine Birds LSA – effects are confined to the vicinity of the shipping lanes for Project-related marine vessels.
- **Duration** - long-term – the event causing potential injury or mortality effects on surf scoter is the operation of Project-related marine vessel traffic, which will continue for the life of the Project.
- **Frequency** - occasional – the event leading to a potential injury or mortality effect may occur intermittently and sporadically for the life of the Project.
- **Reversibility** - medium-term – the effect of an event of mortality will be restored in one generation of recruitment and maturity for individuals of that species.
- **Magnitude** - low – the effects will potentially occur to individuals but will not likely be detectable at regional population levels.
- **Probability** - low – injury and mortality is possible; however, is unlikely to occur as a result of the Project.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the coastal region.

4.3.8.6.4 Marine Bird Indicator - Pelagic Cormorant

The following subsections provide the evaluation of significance of the potential residual effects on the pelagic cormorant indicator.

Sensory Disturbance, Stress, Behavioural Changes or Avoidance of Important Habitats

The regional population of pelagic cormorants is abundant year-round and habitat use is primarily focused in nearshore areas for fishing. This species is known to have one of the largest flushing distances among marine birds, depending on age, season and sea conditions. Any disturbance effects would be considered to have a negative impact balance and would primarily be expected to occur in the narrow portions of the shipping lanes used for feeding, such as in Haro Strait. Although the sensitivity of pelagic cormorants to human disturbances is well documented, they have also been known to use developed sites for foraging, and commercial structures and vessels for perching and resting. While the change in large vessel traffic introduced by the Project is likely to have long-term adverse effects, it is unlikely that these effects would be detectable at the regional population level for pelagic cormorants considering their likely familiarity with the high volume of vessel traffic present within the study area. A level of habituation to the presence and activity of marine traffic in some areas might be assumed with their tendency to utilize man-made structures, although habituation has not previously been assessed in the Marine RSA. Consequently, the residual effect of sensory disturbance on pelagic cormorants associated with the increased Project-related marine vessel traffic is considered to be of medium magnitude (Table 4.3.8.3, point 4[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine Birds LSA – effects are likely to be limited to the Marine Birds LSA in a ZOI specific to the site-specific sensitivity of the pelagic cormorant (approximately 500 m), depending on weather conditions, bird age and activity, and season.
- **Duration** - long-term – the event causing potential sensory disturbance to pelagic cormorant will be initiated during operations and occur for the life of the Project.
- **Frequency** - periodic – the event causing a potential sensory disturbance will occur intermittently but repeatedly, with potential regular transits twice per day, for the life of the Project.
- **Reversibility** - short term – recovery from the effects of sensory disturbance may be interrupted by subsequent vessels or other marine activities and, therefore, may not be reversible immediately but in some period greater than 2 days but less than one year.
- **Magnitude** - medium – the effects will be detectable at the individual level but marginal to moderate on the population level considering the high volume large vessel traffic conditions currently within the study area and the potential sensitivity of pelagic cormorants to underwater and surface disturbances within narrow channels.
- **Probability** - high – the Project is likely to cause sensory disturbance to pelagic cormorants.

- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the coastal region.

Injury or Mortality Events

Cormorants have previously been documented (ConocoPhilips Alaska 2011) as vulnerable to lighting effects from marine vessels, especially at night and can become disoriented during periods of low visibility or inclement weather. The potential for events resulting in harmful or fatal collisions with vessel infrastructure are not expected due to their familiarity with and use of artificial structures to perch, and their affinity for nearshore areas. Residual effects will have a negative impact balance, although, bird strikes or vessel collisions are expected to be uncommon. Considering the presence of navigational lights and light effects from all vessels within the shipping lanes, it might be difficult to attribute strike events directly to the increase in lighting from Project-related vessels. The residual effect on pelagic cormorant is considered to be of low magnitude (Table 4.3.8.3, point 4[b]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine Birds LSA – effects are confined to the vicinity of the shipping lanes for Project-related marine vessels.
- **Duration** - long-term – the event causing potential injury or mortality effects on pelagic cormorant will be initiated during operations and continue for the life of the Project.
- **Frequency** - occasional – the event leading to potential injury or mortality may occur intermittently and sporadically for the life of the Project.
- **Reversibility** - medium-term – the effect of an event of mortality will be restored in one generation of recruitment and maturity for individuals of that species.
- **Magnitude** - low – there may be effects to individuals but effects will not be detectable at regional population levels.
- **Probability** - low – injury and mortality is possible; however, is unlikely to occur as a result of the Project.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the coastal region.

4.3.8.6.5 Marine Bird Indicator - Glaucous-winged Gull

The following subsections provide the evaluation of significance of the potential residual effects on the glaucous-winged gull indicator.

Sensory Disturbance, Stress, Behavioural Changes or Avoidance of Important Habitats

Glaucous-winged gulls are ubiquitous within the Marine RSA and breed at many locations near the shipping lanes. Although generally an inshore species, it does venture out to sea following fishing vessels for discarded catch and foraging for fish and other foods as far as the continental shelf. The impact balance of potential residual effects on glaucous-winged gulls arising from sensory disturbance associated with the increased Project-related marine vessel traffic is considered to be negative. Because of their strong association with existing vessel traffic, including commercial and recreational fishing, within the study area, this species has a low likelihood of adverse effects. The change in large vessel traffic introduced by the Project is likely to be long-term, but unlikely to be detectable in the high-density population of glaucous-winged gulls within the region. There is likely to be habituation to the presence and activity of marine traffic, as is evident from their predominance and adaptability to anthropogenically altered habitats. Consequently, the magnitude of potential residual effects on glaucous-winged gull from sensory disturbance is considered to be of low magnitude (Table 4.3.8.3, point 5[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine Birds LSA – effects of sensory disturbance are unlikely to extend beyond the Marine Birds LSA due to the smaller ZOI for the adaptable glaucous-winged gull compared to other marine bird indicators.
- **Duration** - long-term – the event causing potential sensory disturbance to glaucous-winged gull will be initiated during operations and occur for the life of the Project.
- **Frequency** - periodic – the event leading to potential injury or mortality may occur intermittently; however, repeatedly during regular vessel transits for the life of the Project.
- **Reversibility** - short-term – recovery from the effects of sensory disturbance may be interrupted by subsequent vessels or other marine activities and, therefore, may not be reversible immediately but in some period greater than 2 days but less than one year.
- **Magnitude** - low – the effects will be detectable at the individual level negligible on the population level considering the high volume of vessel traffic present within the Marine RSA and the tendency for gulls to become associated with human-influenced environments, follow fishing vessels, and their opportunistic use of habitats.
- **Probability** - high – the Project is likely to have an effect on glaucous-winged gulls.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the Project area.

Injury or Mortality Events

Glaucous-winged gulls have been documented (ConocoPhilips Alaska 2011) as striking marine vessels and structures during relatively extreme weather, periods of low visibility or disorientation. Gulls tend to roost on or near the shoreline at night and, therefore, night-lighting from vessels in the shipping lanes are unlikely to adversely affect them except under abnormal circumstances. These mortality events associated with vessels have harmful or fatal results, although are uncommon in this species. Potential effects are expected to have a negative impact balance, although, events of injury or mortality is expected to be rare. The residual effect on glaucous-winged gull is considered to be of low magnitude (Table 4.3.8.3, point 5[b]).

A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine Birds LSA – effects are confined to the shipping lanes for Project-related marine vessels.
- **Duration** - long-term – the event causing potential injury or mortality effects on glaucous-winged gull will be initiated during operations and continue for the life of the Project.
- **Frequency** - occasional – the effect will occur rarely to intermittently and sporadically for the life of the Project.
- **Reversibility** - medium-term – the effect of an event of mortality will be restored in one generation of recruitment and maturity for individuals of that species.
- **Magnitude** - low – the effects will not be detectable at regional population levels.
- **Probability** - low – injury and mortality is possible; however, is unlikely to occur as a result of the Project.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds and data pertinent to the area.

4.3.8.6.6 Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Birds

The evaluation of the combined effects of increased Project-related marine vessel traffic on the marine bird indicators considers, collectively, the likelihood of potential residual effects on the following indicators: fork-tailed storm-petrel; Cassin's auklet; surf scoter; pelagic cormorant; and glaucous-winged gull. Given that the likelihood of injury to or mortality of any indicators is low, the potential residual effects associated with sensory disturbance represents the combined effects of increased Project-related marine vessel traffic on marine birds (Table 4.3.8.3, point 6[a]).

The Strait of Georgia is one of the busiest waterways on the Pacific Coast of North America (Parks Canada 2013) and the assessment of combined effects has been considered in this context. Effects are assessed within an existing setting of high volume vessel activity within the Marine RSA and with the standards set by the existing regulatory framework. The results of the marine birds assessment does not contradict any management objectives of established regional marine conservation plans.

Marine birds are likely to be affected by sensory disturbances from marine shipping activities that may cause the flushing of birds from preferred habitats in the Marine Birds LSA and Marine RSA on a repeated basis through regular transits of Project-related marine vessels in the shipping lanes twice per day. Depending on the species, this may generate indirect behavioural alterations and increased energetic costs to individuals, especially during the breeding season. Marine birds are present in the shipping lanes throughout the year, with various species using these habitats seasonally for migration and staging, overwintering, moulting and foraging. The adverse effects of sensory disturbances will be localized and short-term with each passing of a vessel. The number of injuries or events of mortality are expected to be low throughout the life of the Project within the Marine Birds LSA or Marine RSA. Individual encounters will be relatively brief and are not expected to be detrimental to the viability, stability and overall wellbeing of the diverse populations of marine birds.

Residual effects from the increased Project-related marine vessel traffic have a high probability of occurrence for the long-term but with a low to medium magnitude. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – effects are primarily confined to the Marine Birds LSA because sensory disturbances will dissipate with increasing distance from the vessel and the threshold of disturbance for birds is conservatively accommodated in the Marine Birds LSA extent; however, considering the wide-ranging activity of some pelagic species, and the particular vulnerability of other species to disturbances, it may extend to the Marine RSA in certain seasons and under particular at-sea conditions.
- **Duration** - long-term – the event causing potential injury or mortality effects on marine birds will be initiated during operations and continue for the life of the Project.
- **Frequency** - periodic – disturbance events may occur intermittently but repeatedly for the life of Project-related marine vessel operations.
- **Reversibility** - short-term - the recovery from the effects of sensory disturbance from each vessel interaction, including the potential for associated behavioural alterations, may not be immediate due to the possibility of subsequent interruption by other vessels and/or marine activities and, therefore, reversibility may take longer than 2 days but should be less than one year.
- **Magnitude** - medium – the effects will be detectable at the individual level, and may have marginal effects on the populations of some sensitive colonial breeding species in narrow channels areas, but will generally be low to medium with consideration for the context of high volume vessel traffic that currently exists within the Marine RSA.
- **Probability** - high – the Project is likely to cause adverse effects to varying degrees and under some conditions on marine birds.
- **Confidence** - high – based on a good understanding by the assessment team on pathways of effect between the increased Project-related marine vessel activities and marine birds, and with baseline data relevant to the coastal region.

4.3.8.7 Potential United States Effects

During the breeding season, seabirds cross terrestrial/marine ecological and political boundaries on a regular basis to forage. Even relatively ‘local’ species cross multiple jurisdictions within a day (*e.g.*, state lands and waters, and federal waters) while pelagic species may transit through international waters on a daily, weekly, or monthly time-frame. Seabird life-histories expose individuals and populations to environmental conditions affecting both terrestrial and marine habitats (Jodice and Suryan 2010). No differences in open water or intertidal habitats, vessel activity or natural wave conditions in the US and Canadian portions of the Marine RSA were identified that would change the nature of the effects assessment.

The same types of effects from shipping assessed in Canadian waters are expected to be present in US waters where the marine bird species compositions and the volume of large marine vessel traffic is similar or greater in US waters. However, federal and state management policies may be slightly different than provincial policies. Since the jurisdiction of agencies does not cross the land-sea boundary in the same manner as the seabirds they are managing, these management efforts are often facilitated by multi-agency communication and collaboration. Therefore, the effects from marine vessel traffic are expected to be similar in Canadian and US waters.

4.3.8.8 Summary

As identified in Table 4.3.8.3, there are no situations where there is a high probability of occurrence of a permanent or long-term residual environmental effect of high magnitude on marine birds. Consequently, it is concluded that the residual environmental effects on marine birds from operational activities associated with the increased Project-related marine vessel traffic will be not significant.

4.3.9 Marine Species at Risk

For the purpose of the assessment, marine species at risk are considered to include all federally and provincially-listed marine species of conservation concern, as follows:

- any marine species listed as Endangered, Threatened, or Special Concern under *SARA* (Government of Canada 2013a);
- any marine species recommended for SARA-listing by COSEWIC (Government of Canada 2013b); and
- any marine species identified on the BC Conservation Data Centre’s (BC CDC) Red or Blue lists (BC CDC 2013).

Table 4.2.9.1 of Section 4.2.9 lists the marine species at risk that have been identified as likely to occur within the Marine RSA. This list includes 20 marine fish and invertebrate species, 11 marine mammal species (or ecotypes) and 19 marine bird species. Potential effects of the increased Project-related marine vessel traffic on these species are assessed through the use of indicators in Section 4.3.6, Section 4.3.7 and Section 4.3.8.

In selecting the indicators for marine fish, marine birds and marine mammals, preference was often given to species at risk. For example, Pacific salmon were selected as an indicator for marine fish and fish habitat, in part, to represent the two salmon populations known to occur within the Marine RSA that are listed under COSEWIC (*i.e.*, Interior Fraser coho – Endangered and Cultus sockeye – Endangered). Likewise, the pelagic cormorant (BC CDC – Red list) was selected as an indicator for marine birds as well as the Steller sea lion (*SARA* – Special Concern), humpback whale (*SARA* – Threatened) and southern resident killer whale (*SARA* – Endangered) were selected as indicators for marine mammals.

While prioritizing the selection of indicator species with conservation status, indicators were also required to reasonably represent a suite of species with similar habitat requirements, life history characteristics and most importantly, potential sensitivities to Project effects. An important consideration in selecting indicators was whether or not the indicator can be linked to a probable pathway of effect. For example, Pacific salmon were determined to be an appropriate choice for assessing the potential effects of vessel wake, since juvenile salmon are known to use shoreline habitats within the Marine RSA for foraging and migration. In contrast, although the yelloweye rockfish is listed as a species of Special Concern under *SARA*, this deep-water species is unlikely to ever interact with vessel wake. As such, it was not selected as an appropriate indicator, since there are no probable pathways of effect between potential Project impacts and yelloweye rockfish.

In cases where two or more species at risk with similar habitat requirements and life history characteristics were identified as potentially suitable indicators, the assessment considered: priority of conservation concern; the likelihood of the species to occur within the Marine RSA; and the degree to which the species is considered to be sensitive to potential Project effects. For example, in the selection of a marine mammal indicator representative of odontocetes (toothed whales), both the harbour porpoise and the southern resident killer whale were considered. The southern resident killer whale was ultimately selected, since its designated critical habitat overlaps almost entirely with the Marine RSA and since it is considered to be of greater conservation concern (*i.e.*, it is listed as Endangered under *SARA*, while the harbour porpoise is listed as Special Concern).

While acknowledged differences remain between species represented underneath the indicators (*e.g.*, seasonal timing in the area, preferred habitat, prey etc.), the most important consideration remains that the similarities or differences in how the potential impacts of the Project manifest for a specific organism, and whether these are adequately captured by the assessment of the indicator. In cases where subtle differences in potential effects for non-indicator species at risk may not be entirely covered by the indicator species, such considerations are noted under the assessment of the indicator. For example, given the known sensitivities of harbour porpoise to underwater noise, a brief discussion of harbour porpoises is included within the consideration of killer whales as the representative toothed whale. Most importantly, while determinations of significance focus on the individual indicator species, industry best management practices were described in consideration of the broader taxonomic group or ecological guild, and will be applied to equally benefit all species at risk, not only the assessment indicators.

In summary, although not all marine species at risk are discussed explicitly under each indicator, potential Project effects were assessed in consideration of all species at risk. The indicators used to represent marine fish, marine birds and marine mammals were carefully selected to ensure that the full range of potential Project effects on species at risk was addressed and mitigations to reduce these effects will apply to all species at risk, not just the indicators. Refer to Section 4.3.6, Section 4.3.7 and Section 4.3.8 for the significance rationale for applicable indicator species. No significant adverse effect on marine species at risk has been identified as a result of the increased Project-related marine vessel traffic, with the exception of the potential effect of sensory disturbance on southern resident killer whale, which was identified as significant.

4.3.10 Traditional Marine Resource Use

This subsection considers the potential effects of increased Project-related marine vessel traffic associated with the expansion of the Westridge Marine Terminal in Burnaby, BC on TMRU of the coastal waters of southwest BC and US waters that are covered by the spatial boundaries of the Marine RSA.

Coastal Aboriginal community's connection to the marine environment is profound. Traditional use of the marine environment includes the subsistence practices of hunting, fishing and plant gathering, movement by travelways, and cultural traditions and customs practiced at gathering places and sacred areas. The potential residual effects discussed in this subsection apply to traditional marine resource users in both Canadian and US waters within the Marine RSA.

Issues associated with the current volume of tanker traffic, total marine vessel traffic in the study areas, and future increases in vessel traffic associated with general population growth are not assessed. Project-specific effects of the construction and operation of the proposed expansion of the Westridge Marine Terminal are addressed separately in Volume 5B. The Traditional Marine Resource Use - Marine Transportation Technical Report (Volume 8B, TR 8B-5) provides further information on existing conditions related to use of Canadian and US coastal waters, including potential issues and interactions with the TMRU of potentially affected Aboriginal communities.

4.3.10.1 Assessment Indicators and Measurement Endpoints

For the purposes of this assessment, TMRU is described in terms of:

- subsistence activities and sites; and
- cultural sites.
- Table 4.3.10.1 summarises the assessment indicators, measurement endpoints and the rationale for their selection. The indicators selected represent components of the marine environment that are of particular value or interest to Aboriginal communities. The indicators have been selected based on initial feedback from Aboriginal communities and government agencies and were refined based on this feedback to reflect the components valued by traditional resource users, which are often holistic in nature and span both the biophysical and social disciplines. Potential Project-related effects on TMRU are linked to the biophysical elements (*e.g.,* marine fish, marine mammals and marine birds) and this assessment of TMRU relies in part on the results of the assessment of the relevant biophysical elements.

The measurement endpoints used to assess Project-related effects of increased marine vessel traffic on the indicators include quantitative and qualitative parameters, chosen based on available biophysical and socio-economic information, and a review of other assessments of similar projects.

TABLE 4.3.10.1

ASSESSMENT INDICATORS AND MEASUREMENT ENDPOINTS FOR TRADITIONAL MARINE RESOURCE USE

Traditional Marine Resource Use Indicators	Measurement Endpoints	Rationale for Indicator Selection
Subsistence activities and sites	• Hunting • Fishing • Plant gathering • Travelways	The selection of indicators and measurement endpoints reflect the NEB Filing Manual (2013c) requirements for traditional land and resource use in Table A-3 and considered key issues and interests identified during Aboriginal and stakeholder engagement. They also considered feedback from participants in the North Vancouver and Victoria ESA Workshops.
Cultural sites	• Gathering places • Sacred areas	

4.3.10.2 Spatial Boundaries

Spatial boundaries used for the assessment of potential effects of Project-related marine vessel traffic on TMRU are defined as follows.

- **Marine LSA** - The Marine LSA for TMRU incorporates the primary ZOI likely to be affected by marine vessel wake, atmospheric and underwater noise generated by transiting tankers. The area has been allocated as the in-bound and outbound shipping lanes plus a buffer that encompasses the LSA boundaries of marine fish and fish habitat, marine mammals and marine birds since TMRU is dependent on these resources (Table 4.3.10.2). There is no separately defined LSA for marine mammals since potential effects are assessed within the Marine RSA (below). This includes the inbound and outbound marine shipping lanes, the area between the shipping lanes, where it exists, and a 2 km buffer extending from the outermost edge of each shipping lane. The shipping lanes extend from the Westridge Marine Terminal in Burnaby, through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, then westward past Victoria and through the Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea, corresponding to the line of longitude of Buoy J.
- **Marine RSA** - The Marine RSA is the area where the direct and indirect influence of other marine activities could overlap with Project-specific marine transportation effects, potentially resulting in residual or cumulative effects on TMRU. This area encompasses a large portion of the Salish Sea and it generally extends from the western to eastern boundaries of the Salish Sea; however, it confines the northern and southern extents to exclude the central and northern Strait of Georgia and Puget Sound, respectively. Major waterways in the Marine RSA that overlap with the marine shipping lanes extending from the Westridge Marine Terminal through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, westward past Victoria and Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea.

TABLE 4.3.10.2

INPUTS TO TRADITIONAL MARINE RESOURCE USE LSA BOUNDARIES

Resource Component	Local Study Area	ESA Reference
Marine Fish and Fish Habitat	Includes the inbound and outbound marine shipping lanes, the area between the shipping lanes where it exists, and a 2 km buffer extending from the outermost edge of each shipping lane. The shipping lanes extend from the Westridge Marine Terminal in Burnaby, through Burrard Inlet, south through southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, then westward past Victoria and though Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea.	Marine Fish and Fish Habitat, Section 4.3.6
Marine Birds	Includes the inbound and outbound marine shipping lanes, the area between the shipping lanes where it exists, and a 1 km buffer extending from the outermost edge of each shipping lane. The shipping lanes extend from the Westridge Marine Terminal in Burnaby, through Burrard Inlet, south through southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, then westward past Victoria and though Juan de Fuca Strait out to the 12 Nautical Mile limit of Canada's territorial sea.	Marine Birds, Section 4.3.8

The TMRU spatial boundaries have evolved based on feedback during Aboriginal and stakeholder engagement. Stakeholder feedback resulted in the extension of the Marine LSA and Marine RSA beyond the Burrard Inlet to out to the 12 nautical mile limit of Canada's territorial sea. The TMRU study area evolved to include the areas of the Marine LSA and Marine RSA that extend into US waters. In addition, the TMRU study areas follow guidance provided by the NEB in the letter titled Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Increased Marine Shipping Activities (NEB 2013b), received by Trans Mountain on September 10, 2013. The letter indicates the marine transportation assessment should take place out to the 12 nautical mile limit of Canada's territorial seas.

Maps of the spatial study boundaries for TMRU are provided in Section 4.2.

4.3.10.3 Traditional Marine Resource Use Context

Of the 27 marine and inlet Aboriginal communities engaged on the Project with Trans Mountain, the following 21 communities have been identified as having an interest in the Project or having interests potentially affected by the increased Project-related marine vessel traffic:

- Esquimalt Nation;
- Cowichan Tribes;
- Halalt First Nation;
- Hwlitsum First Nation;
- Pacheedaht First Nation;
- Penelakut First Nation;
- Semiahmoo First Nation;
- Stz'uminus First Nation (Chemainus);

- Lyackson First Nation;
- Malahat First Nation;
- Pauquachin First Nation;
- Scia'new Indian Band (Beecher Bay);
- Tsartlip First Nation;
- Tsawout First Nation;
- Tsawwassen First Nation;
- Tseycum First Nation;
- Katzie First Nation;
- Kwikwetlem First Nation;
- Musqueam Indian Band;
- Squamish Nation; and
- Tsleil-Waututh Nation.

Traditional marine resource use studies (TMRU studies) were initiated for the Project in 2012 and are ongoing (Section 4.2.10.2). Participation in the TMRU studies, either as TERA-facilitated or community directed using a third-party consultant, was discussed with Aboriginal communities based on an indicated interest in participating in these studies. The Traditional Marine Resource Use – Marine Transportation Technical Report (Volume 8B, TR 8B-5) prepared by TERA incorporates the results of the preliminary interests identified by participating Aboriginal communities as received by Trans Mountain to date.

Esquimalt Nation conducted a TERA-facilitated TMRU study that included a map review and community interviews focusing on the Crown lands and waters within the asserted traditional territory of Esquimalt Nation crossed by the Marine RSA. Each phase of the TERA-facilitated TMRU study is described in further detail in the Traditional Marine Resource Use - Marine Transportation Technical Report (Volume 8B, TR 8B-5).

To date, preliminary interests were identified to Trans Mountain by Esquimalt Nation, Semiahmoo First Nation, Hwlitsum First Nation and by Cowichan Nation Alliance on behalf of Penelakut First Nation, Halalt First Nation, Hwlitsum First Nation, Stz'uminus First Nation and Cowichan Tribes. Table 4.3.10.3 provides the results to date of the the Esquimalt Nation TMRU study for the Project, as well as the preliminary interests identified by participating Aboriginal communities that may be affected by increased Project-related marine vessel traffic. Further details regarding the progress of each participating community's TMRU study and the preliminary interests received at the time of application filing can be found in the Traditional Marine Resource Use – Marine Transportation Technical Report (Volume 8B, TR 8B-5).

TABLE 4.3.10.3

TRADITIONAL MARINE RESOURCE USE IDENTIFIED TO DATE BY PARTICIPATING ABORIGINAL COMMUNITIES WITHIN OR IN PROXIMITY TO THE MARINE RSA

Location	Activity/Site Type	Description	Location Relative to Shipping Lanes	Location Relative to Marine RSA	Shipping Lanes Crossed to Access Activity/Site?
Esquimalt Nation					
Bear Mountain	Hunting	Ducks in the past	14 km northwest	Northwest of RSA	No
Sooke Inlet	Hunting	Ducks in the past	8 km north	Within RSA	No
East Sooke Park	Hunting	Ducks and deer in the past	10 km north	North of RSA	No
Albert head	Fishing	Ling Cod	4 km west	Within RSA	No
Beacon Hill	Fishing	Sea Urchins	2 km north	North of RSA	No
Ross Bay	Fishing	Sea Urchins	2 km north	Within RSA	No
Dallas Road	Fishing	Salmon in the past	2 km off coast at Dallas Road	Within RSA	No
Brother Island	Fishing	Scrooge Rocks, which are used to collect ling cod eggs	3 km north	Within RSA	No
Race Rocks	Fishing	Ling cod	3 km north	Within RSA	No
Salish Sea	Fishing	Halibut	Encompasses portions of the outbound shipping lane	Within RSA	Yes
Sidney Channel	Fishing	Salmon year round	10 km west	Within RSA	No
Port Hardy	Fishing	Clam digging from Esquimalt to Port Hardy in the past.	3 km west	From Vancouver Island to within RSA	No
Goldstream	Hunting Fishing Plant gathering	Deer and elk in the past. Chum, coho, during low tides it is good for sole harvesting. Site shared by many bands. Clam digging. Salmon berry harvest	25 km north	North of RSA	No
Discovery Island	Fishing	Crabbing in the past	1 km west	Within RSA	No
Catham Island	Fishing	Crabbing in the past	1 km west	Within RSA	No
Saanich	Fishing	Clam digging at very low tide	11 km west	West of RSA	No
Inskip Island	Fishing	Clam digging and rock sticker digging at very low tide	6 km north	Within RSA	No

TABLE 4.3.10.3

TRADITIONAL MARINE RESOURCE USE IDENTIFIED TO DATE BY PARTICIPATING ABORIGINAL COMMUNITIES WITHIN OR IN PROXIMITY TO THE MARINE RSA (continued)

Location	Activity/Site Type	Description	Location Relative to Shipping Lanes	Location Relative to Marine RSA	Shipping Lanes Crossed to Access Activity/Site?
Beecher Bay	Fishing	Crabbing, clam digging, and octopus harvest, salmon, halibut, ling cod	5 km north	Within RSA	No
Esquimalt Lagoon	Hunting Fishing	Ducks in the past. Clam digging and crabbing at Cooper's Cove in the past	7.5 km northwest	Northwest of RSA	No
Orveas Bay	Fishing	Collecting clams, mussels, oysters, and urchins	7.5 km north	Within RSA	No
Sooke Basin	Fishing	Clam digging at every point on basin beaches	10 km north	Within RSA	No
Fisgard Lighthouse	Fishing	Clams and rock stickers in the past	7.5 km northwest	Northwest of RSA	No
Esquimalt Harbour	Fishing	Clams in the past	8 km northwest	Within RSA	No
Victoria Harbour	Gathering place	Historic Village	3 km north	North of the RSA	No
Portage Inlet	Gathering place	Historic Village	6 km northwest	Northwest of the RSA	No
Esquimalt	Gathering place	Current Village	4.5 km northwest	Northwest of the RSA	No
Small Pox Island	Sacred area	Burial site in the past, now a naval base	6.5 km north	North of the RSA	No
Leprosy Island	Sacred area	Burial site, also called D'Arcy Island	3 km west	West of the RSA	No
Beecher Bay	Sacred area	Rock Art site	5 km north	On land, adjacent RSA	No
Large Bedford Island	Sacred area	Rock Art site	5 km north	On land, adjacent RSA	No
Cowichan Tribes					
Salish Sea	Subsistence activities	No details provided	Unknown	Within RSA	Unknown
Unspecified	Cultural sites	No details provided	Unknown	Unknown	Unknown
Halalt First Nation					
Salish Sea	Subsistence activities	No details provided	Unknown	Within RSA	Unknown
Unspecified	Cultural sites	No details provided	Unknown	Unknown	Unknown

TABLE 4.3.10.3

TRADITIONAL MARINE RESOURCE USE IDENTIFIED TO DATE BY PARTICIPATING ABORIGINAL COMMUNITIES WITHIN OR IN PROXIMITY TO THE MARINE RSA (continued)

Location	Activity/Site Type	Description	Location Relative to Shipping Lanes	Location Relative to Marine RSA	Shipping Lanes Crossed to Access Activity/Site?
Hwlitsum First Nation					
Salish Sea	Subsistence activities	No details provided	Unknown	Within RSA	Unknown
Unspecified	Cultural sites	No details provided	Unknown	Unknown	Unknown
Penelakut Tribe					
Salish Sea	Subsistence activities	No details provided	Unknown	Within RSA	Unknown
Unspecified	Cultural sites	No details provided	Unknown	Unknown	Unknown
Semiahmoo First Nation					
Semiahmoo Bay	Subsistence activities and sites	Traditional fishing area	Unknown	Within RSA	Unknown
Boundary Bay	Subsistence activities and sites	Traditional fishing area	Unknown	Within RSA	Unknown
Mud Bay	Subsistence activities and sites	Traditional fishing area	Unknown	Within RSA	Unknown
Strait of Georgia	Subsistence activities and sites	Traditional fishing area	Unknown	Within RSA	Unknown
Unspecified	Subsistence activities and sites	Traditional fishing and shellfish gathering sites	Unknown	Unknown	Unknown
Unspecified	Cultural sites	Traditional practices and culture	Unknown	Unknown	Unknown

Trans Mountain continues to engage with Aboriginal communities and will continue to facilitate TMRU studies with interested communities. The results from ongoing TMRU studies will be provided to the NEB as completed.

Given the similar types of marine environments in Washington State and BC, TMRU is expected to be similar in US and Canadian waters. Where available, descriptions of existing conditions related to TMRU within US waters are provided in Section 4.2.10.3.

4.3.10.4 Potential Effects and Mitigation Measures

The potential effects on TMRU associated with the increased Project-related marine vessel traffic were identified based on the results of the literature review, desktop analysis and TMRU studies, as well as through ongoing engagement with participating Aboriginal communities (see Sections 3.0 and 4.2.10.2).

The results of the literature/desktop review indicate that Aboriginal communities have historically used or presently use the Marine RSA to maintain a traditional lifestyle and continue to use marine resources throughout the Marine RSA for a variety of purposes including fish, shell-fish, mammal and bird harvesting, aquatic plant gathering, and spiritual/cultural pursuits as well as through the use of navigable waters within the Marine RSA to access subsistence resources, neighbouring communities and coastal settlements (Section 4.2.10.3).

The increased marine vessel traffic associated with the proposed expansion and operation of the Westridge Marine Terminal has the potential to directly and indirectly disrupt subsistence hunting and fishing, and plant gathering through changes to local harvesting locales as well as the broader ecological system.

A general increase in marine vessel traffic in the region has the potential to result in changes to the distribution and abundance of subsistence resources due to wake effects on shoreline habitats and sensory disturbance. Similarly, sensory disturbance has the potential to result in disruptions to cultural activities (*e.g.*, gathering places, sacred areas), whereby noise and activity as a result of increased marine vessel traffic may influence the focus and intent of ceremonial activities.

In addition, the navigable waters within the Marine RSA are used to access subsistence resources, neighbouring communities and coastal settlements (Section 4.2.10.3). TMRU activities can occur year round. In addition, the shipping lanes must be traversed to access TMRU sites.

Potential interactions with the TMRU of potentially affected Aboriginal communities already exist. However, the increased Project-related marine vessel traffic raises the likelihood of such interactions. All vessels are required to follow Transport Canada rules in order to avoid conflict when passing and possible collision.

Trans Mountain will require that a tug would accompany the Project-related tankers for the entire transit through the Strait of Georgia and between Race Rocks and the 12 nautical mile to assist with navigation. The tug escort is an enhancement to existing tug requirements. The tug can be tethered for extra navigational assistance if needed (refer to Table 4.3.10.3, Point 1.1 for a list of key mitigation measures with respect to marine safety). Refer to Section 5.3.2 for more detail on the enhanced tug escort as a safety measure.

4.3.10.4.1 Effects Considerations

A range of issues potentially related to TMRU was identified during desktop research and Aboriginal engagement; however, were not included in the assessment. These include:

- the potential effect of increased Project-related marine vessel traffic on coastal habitation sites; and
- the potential effects of increased Project-related marine vessel traffic on inland fisheries.

Concerns about the potential for interactions between Project-related marine vessel traffic and habitation sites and inland fisheries were identified through the desktop review and through ongoing Aboriginal engagement. Both issues are considered outside the scope of this assessment, since normal operation of Project-related marine vessel traffic is not considered to interact with land-based activities. Nonetheless, the Traditional Marine Resource Use – Marine Transportation Technical Report (Volume 8B, TR 8B-5) provides information of the existing conditions related to habitation sites and inland fisheries that may occur within or in proximity to the Marine RSA for consideration of the potential effects of a marine spill on marine users assessed in Section 5.0.

The potential occurrence and associated effects of damage or loss of gear, collisions and other non-spill accidental interactions between Project-related marine vessels and traditional marine resource users are discussed in Section 4.3.11.

The potential effects of credible worst case and smaller marine spills on marine users are discussed in Section 5.0.

4.3.10.4.2 Identified Potential Effects

Potential effects associated with increased Project-related marine vessel traffic on TMRU indicators are listed in Table 4.3.10.3. These interactions are based on the results of the literature review, desktop analysis and engagement with participating Aboriginal communities (see Section 3.0) and the professional experience of the assessment team.

A summary of mitigation measures provided in Table 4.3.10.3 was principally developed in accordance with KMC standards as well as industry best practices related to specific elements such as marine fish and fish habitat, marine mammals and marine birds.

TABLE 4.3.10.3

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON TRADITIONAL MARINE RESOURCE USE

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1. Traditional Marine Resource Use Indicator – Subsistence Activities and Sites			
1.1 Disruption of subsistence hunting activities	RSA	• Refer to Section 4.3.7 Marine Mammals for key recommendations and mitigation relevant to sensory disturbance, wake waves, atmospheric and underwater noise and mammal injury or motility. • Refer to Section 4.3.8 Marine Birds for key recommendations and mitigation relevant to behavior alterations, sensory disturbance, wake waves, atmospheric and underwater noise and bird injury or mortality. • Refer to Section 4.3.3 Marine Air Emissions, Section 4.3.4 Marine GHG Emissions and Section 4.3.5 Marine Acoustic Environment for measures pertaining to nuisance air and noise emissions, respectively. • Project tankers shall utilize the common shipping lanes, already used by all large commercial vessels for passage between the Pacific Ocean and Port Metro Vancouver.	• Disruption of subsistence hunting activities. • Alteration of subsistence resources. Disruption of traditional marine resource user activities from Project-related marine vessel wake (refer to Section 4.3.11).

TABLE 4.3.10.3

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON TRADITIONAL MARINE RESOURCE USE (continued)

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1. Traditional Marine Resource Use Indicator – Subsistence Activities and Sites			
1.1 Disruption of subsistence hunting activities (cont'd)	See above	• Trans Mountain will continue to provide information about Project-related shipping to other marine users. Specifically: - provide regular updated information on Project-related marine vessel traffic to fishing industry organizations, Aboriginal communities, and other affected stakeholders, where possible through the Chamber of Shipping of BC (COSBC); and - initiate a public outreach program prior to Project operations phase. Communicate any applicable information on Project-related timing and scheduling with fishing industry organisations, Aboriginal communities and other affected stakeholders. • Transport Canada requires all vessels, including tankers, to comply with the International Regulations for Preventing Collisions at Sea (with Canadian Modifications) and other major international maritime conventions. • Transport Canada requires compliance by all vessels with the *Canada Shipping Act,* 2001*, Collision Regulations,* the *Navigation Safety Regulations* pursuant to the Act and other applicable regulations and standards, except Government or Military vessels. • The CCG ensures that all large vessels, including Project-related tankers, register with MCTS for communications with port authorities and CCG, and employ Automatic Identification Systems (AIS). • The CCG requires compliance with the CCG fishing vessel advisory notice for commercial ships and fishing vessels using the inside passage waters of British Columbia during the commercial fishing season. This notice refers to all inside marine waters of BC. • The PPA requires compliance with the PPA Compulsory Pilotage Areas (PPA 2013). • PMV ensures compliance with PMV's MRA regulations, including "Clear Narrows" regulations (PMV 2010). • Trans Mountain will require a tug accompanies the Project-related tankers through the Strait of Georgia and between Race Rocks and the 12 nautical mile limit in addition to tug requirements to assist with navigation. The tug can be tethered for extra navigational assistance if needed.	

TABLE 4.3.10.3

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON TRADITIONAL MARINE RESOURCE USE (continued)

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1.2 Disruption of subsistence fishing activities	RSA	• Mitigation measures listed in potential effect 1.1 are applied by the appropriate parties. • Transport Canada and the Transportation Safety Board carry out investigations at the appropriate level in case of a collision between vessels. • Refer to Section 4.3.13 Accidents and Malfunctions. • Tanker owners have third-party insurance coverage in place to address vessel damage, gear loss or injury • Tanker owners have third-party insurance coverage in place to address vessel damage, gear loss or injury. • Transport Canada and the Transportation Safety Board carry out investigations at the appropriate level in case of an incident with high potential for loss like collision between vessels.	• Disruption of subsistence fishing activities. • Alteration of subsistence resources. • Disruption of traditional marine resource user activities from Project-related marine vessel wake (refer to Section 4.3.11).
1.3 Disruption of plant gathering activities	RSA	• Mitigation measures listed in potential effects 1.1 and 1.2 are applied by the appropriate parties.	• Disruption of subsistence plant gathering activities. • Alteration of subsistence resources. • Disruption of traditional marine resource user activities from Project-related marine vessel wake (refer to Section 4.3.11).
1.4 Disruption of use of travelways	RSA	• Mitigation measures in potential effects 1.1 and 1.2 are applied by the appropriate parties. • Trans Mountain will provide regular updated information on Project-related marine vessel traffic to shipping associations, such as Chamber of Shipping.	• Alteration of traditional marine resource users' vessel movement patterns (refer to Section 4.3.11 MCRTU). • Disruption of traditional marine resource user activities from Project-related marine vessel wake (refer to Section 4.3.11)

TABLE 4.3.10.3

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON TRADITIONAL MARINE RESOURCE USE (continued)

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
2. Traditional Marine Resource Use – Cultural Sites			
2.1 Disturbance of gathering places	LSA	• Mitigation measures in potential effects 1.1 and 1.2 will be applied by the appropriate parties. • Trans Mountain will continue to engage affected Aboriginal communities, throughout the operational life of the Project. • Refer to Section 4.3.3 Marine Air Emissions, Section 4.3.4 Marine GHG Emissions and Section 4.3.5 Marine Acoustic Environment for measures pertaining to nuisance air and noise emissions, respectively.	• Increased sensory disturbance for marine users (refer to Section 4.3.11). • Disruption of traditional marine resource user activities from Project-related marine vessel wake (refer to Section 4.3.11)
2.2 Disturbance of sacred sites	LSA	• Mitigation measures in potential effects 1.1 and 1.2 will be applied by the appropriate parties. • Trans Mountain will continue to engage affected Aboriginal communities, throughout the operational life of the Project. • Refer to Section 4.3.3 Marine Air Emissions, Section 4.3.4 Marine GHG Emissions and Section 4.3.5 Marine Acoustic Environment for measures pertaining to nuisance air and noise emissions, respectively.	• Increased sensory disturbance for marine users (refer to Section 4.3.11). • Disruption of traditional marine resource user activities from Project-related marine vessel wake (refer to Section 4.3.11) • Negative user perspectives of increased marine vessel traffic. (refer to Section 4.3.11)

Notes: 1 LSA = Marine LSA; RSA = Marine RSA.

4.3.10.5 Potential Residual Effects

The potential residual socio-economic effects on TMRU indicators associated with increased Project-related marine vessel traffic (Table 4.3.10.3) are:

- disruption of subsistence hunting, fishing and plant gathering activities;
- alteration of subsistence resources;
- alteration of traditional marine resource users' vessel movement patterns;
- disruption of traditional marine resource user activities from Project-related marine vessel wake;
- increased sensory disturbance for marine users; and
- negative user perspectives of increased marine vessel traffic.

As noted by the cross-references appearing in Table 4.3.10.3, all components of the marine environment are understood to support the marine resource base and habitat conditions essential to the practice of traditional activities. As such, many potential residual effects discussed below, though presented with respect to traditional marine resource use, are assessed in consideration of all pertinent biophysical resources known or assumed to be of importance to Aboriginal communities for traditional use.

4.3.10.6 Significance Evaluation of Potential Residual Effects

Where there are no standards, guidelines, objectives or other established and accepted thresholds to define quantitative rating criteria or where quantitative thresholds are not appropriate, the qualitative method that is considered to be the appropriate method. Consequently, a qualitative assessment for TMRU was determined to be the most appropriate method with the evaluation of significance of each of the potential residual effects relying on the professional judgment of the assessment team.

Table 4.3.10.4 provides a summary of the significance evaluation of the potential residual socio-economic effects of increased Project-related marine vessel traffic on TRMU. The rationale used to evaluate the significance of each of the residual socio-economic effects is provided below.

TABLE 4.3.10.4

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON TRADITIONAL MARINE RESOURCE USE

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context: Duration	Temporal Context: Frequency	Temporal Context: Reversibility	Magnitude	Probability	Confidence	Significance[2,3]
1. Traditional Marine Resource Use Indicator - Subsistence Activities and Sites									
1(a) Disruption to subsistence activities.	Negative	RSA	Long-term	Periodic	Long-term	Low	High	Moderate	Not significant
1(b) Alteration of subsistence resources.	Negative	RSA	Long-term	Periodic	Long-term	Low to high	High	Moderate	Significant
1(c) Alteration of traditional marine resource users' vessel movement patterns.	Negative	RSA	Long-term	Periodic	Short- to long-term	Low to medium	High	High	Not significant
1(d) Disruption of traditional marine resource user activities from Project-related marine vessel wake.	Negative	LSA	Long-term	Occasional	Short-term	Low to medium	Low	Moderate	Not significant
1(e) Combined effects on the subsistence activities and sites indicator (1[a] and 1[b]).	Negative	RSA	Long-term	Periodic	Long-term	Low to high	High	Moderate	Significant

TABLE 4.3.10.4

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON TRADITIONAL MARINE RESOURCE USE (continued)

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2,3]
			Duration	Frequency	Reversibility				
2. Traditional Marine Resource Use Indicator – Cultural Sites									
2(a) Increased sensory disturbance for marine users.	Negative	LSA	Long-term	Periodic	Short-term	Low	High	High	Not significant
2(b) Disruption of marine user activities from Project-related marine vessel wake.	Negative	LSA	Long-term	Occasional	Short-term	Low to medium	Low	Moderate	Not significant
2(c) Negative user perspectives of increased Project-related marine vessel traffic.	Negative	RSA	Long-term	Continuous	Long-term	Low	High	Moderate	Not significant
2(d) Combined effects on the cultural sites indicator (2[a] and 2[c]).	Negative	RSA	Long-term	Periodic to continuous	Long-term	Low to medium	High	High	Not significant
3. Combined Effects of Increased Project-Related Marine Vessel Traffic on Traditional Marine Resource Use									
3(a) Combined effects of increased Project-related marine vessel traffic on the traditional marine resource use indicators (1[e] and 2[d]).	Negative	RSA	Long-term	Periodic	Long-term	Low to high	High	High	Significant

Notes:
1 LSA = Marine LSA; RSA = Marine RSA
2 **Significant Residual Socio-Economic Effect:** a residual socio-economic effect is considered significant if the effect is predicted to be:
- high magnitude, high probability, long-term or permanent reversibility, and any spatial boundary that cannot be technically or economically mitigated.

3 Significant effects are only predicted to traditional marine resource use as it relates to southern resident killer whales. See Section 4.3.7 for the determination of significance for marine mammals.

4.3.10.6.1 Traditional Marine Resource Use Indicator – Subsistence Activities and Sites

The following discusses the significance rationale for the potential residual effects identified related to the subsistence activities and sites indicator.

Disruption of Subsistence Hunting, Fishing and Plant Gathering Activities

The disruption of subsistence hunting, fishing and plant gathering activities is a potential residual effect of interactions between traditional resource user vessels and Project-related marine vessel traffic that could occur when Project-related marine vessels are in transit in the shipping lanes.

Resources used and activities associated with TMRU are located within the Marine RSA and situated along or near shipping lanes. Based on the results of the TMRU studies and the desktop analysis, travel corridors are essential for conducting traditional activities and accessing locations for traditional harvesting, and the shipping lanes must be traversed to access TMRU sites. Subsistence harvesting and associated travel can occur within the Marine RSA year round. Key issues and concerns relevant to increase Project-related marine vessel traffic and the disruption of subsistence hunting, fishing and plant gathering activities include potential change in access to the resources and potential for disturbance to the resource harvesters.

The shipping lanes used by the Project are established routes for all types of vessels and are among the busiest shipping lanes in BC (see Volume 8C TERMPOL Study Reports). Transits of Project-related marine vessel traffic through the Marine RSA will increase from once a week to approximately once a day. This could result in a Project-related marine vessel being in the shipping lane at the same time traditional resource user vessels wish to use the shipping lane for traditional harvesting or cross the shipping lane to access harvesting areas. Traditional marine resource user vessels are required to keep the shipping lanes clear, however are permitted to cross the shipping lanes and harvest in and near the lanes when it is considered safe. Project-related marine vessel traffic could restrict access to traditional use areas, particularly if the resource users' travel occurs at the same time and in the same location as the Project vessel's transit. This could result in limiting the ability to harvest in certain areas, missed harvesting opportunities, or an increase in travel time to reach a destination, all which could reduce access to marine resources.

Sensory disturbance from the Project has the potential to result in disruptions to subsistence activities. Noise and visual disturbance as a result of increased marine vessel traffic may deflect resource harvesters from using areas or could influence the focus of the activity, particularly if the Project-related marine traffic occurs at the same time and place as the subsistence activities. This could result in harvesters choosing other locations for their traditional activities, and increased travel time to reach a destination.

In addition, damage or loss to fishing vessels or fishing gear may result from interactions between Project-related marine vessels and traditional marine resource users' fishing vessels. All vessels, including those associated with the Project, are required to follow Transport Canada rules to avoid conflict and possible collision. Although these incidents are rare, they have occurred in the past (refer to Section 4.3.11.6 for a discussion of potential incidents between deep draft vessels and fishing vessels). Lost opportunities for traditional resource harvesting may result if an incident occurs.

The impact balance of this potential residual effect is considered to be negative. The spatial boundary is the Marine RSA, since traditional resource user vessels that are required to cross the shipping lanes may be displaced to other areas in the Marine RSA. The duration of the event causing the disruption of commercial fishing activities is long-term and the reversibility of the residual effect is considered to be long-term, since all effects of Project-related marine vessel traffic would extend for the operational life of the Project.

Since traditional resource user vessels could be encountered by Project-related marine vessels whenever these vessels are transiting through the shipping lanes, the frequency of the event is periodic. The magnitude of the effect is considered to be low, since it is expected that the Project-related disruption would only be temporary, that the frequency of Project-related marine vessels would be once a day, and because disruptions already occur in relation to all large vessels currently using the shipping lanes. Confidence in this evaluation is moderate; although the locations of subsistence activities can be approximated based on known locations of historical harvesting areas (Section 4.2.10.3), the exact movements, timing and frequency of traditional resource user vessel activity cannot be precisely known (Table 4.3.10.4, point 1[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – interactions between Project-related marine vessels and hunting, fishing and plant gathering activities that lead to delays or disruptions in these subsistence activities could occur at any point along the shipping lanes, and may also indirectly affect the distribution of vessels in other areas of the Marine RSA.

- **Duration** - long-term – interactions between Project-related marine vessels and subsistence activities will begin during the operations phase and will extend for the operational life of the Project.
- **Frequency** - periodic – Project-related marine vessels will be present daily in the shipping lanes over the operational life of the Project.
- **Reversibility** - long-term – the potential disruptions to subsistence activities are expected to extend throughout the operations phase of the Project.
- **Magnitude** - low – subsistence activities may be interrupted due to increased Project-related marine vessel traffic; however, are likely to be resumed in most cases once the vessel has passed.
- **Probability** - high – interactions between Project-related marine vessels and traditional resource user vessels that disrupt subsistence activities are considered to have a high likelihood of occurrence.
- **Confidence** - moderate – there is a good understanding of general cause-effect relationships between increased Project-related marine vessels and interactions with subsistence hunting, fishing and plant gathering activities; however, further Aboriginal community engagement will increase confidence and the robustness of the significance evaluation.

Alteration of Subsistence Resources

Based on the results of effects assessments for marine mammals, marine birds and marine fish and fish habitat, alteration of subsistence resources is a potential residual effect of interactions between traditional marine resources and Project-related marine vessel traffic that could occur due to wake effects on shoreline habitats, behavioural alteration or sensory disturbance to subsistence resources when Project-related marine vessels are in transit in the shipping lanes.

Based on the results of the TMRU studies and the desktop analysis, subsistence marine resources harvested are found throughout the Marine RSA, and include marine mammals, fish, shellfish and marine vegetation. Harvesting of these marine resources can occur year round throughout the Marine RSA. Table 4.2.10.1 and Table 4.2.10.2 present the range of marine resources that have been or continue to be harvested. Key issues and concerns relevant to the increase in Project-related marine vessel traffic and the alteration of subsistence resources include potential change in the resources harvested. Changes to the distribution and abundance of resources could in turn result in loss or alteration of harvesting areas, which could result in indirect effects such as harvesters having to spend more time and money to travel further for subsistence activities.

The results of effects assessments for marine mammals, marine birds and marine fish and fish habitat indicate that although there may be residual effects due to the increase in Project-related marine vessel traffic the effects are considered to be not significant, with the exception of southern resident killer whales. It has been determined that there is a currently-existing significant adverse cumulative effect on this population. While the endangered status of the southern resident killer whale prohibits the current hunting of this species, historical data indicates that killer whale populations were once, and may continue to be, a traditionally harvested resource within the Marine RSA (see Section 4.2.10.3) (DFO 2011b).

A review of marine management plans appropriate to the Marine RSA (Section 4.3.1.5) reveals that the plans typically reference the management of marine ecosystems with respect to coastal and marine planning, conservation and management initiatives. The Provincial Marine Protected Areas in British Columbia (Ministry of Sustainable Resource Management 2002) specifically references the importance of killer whale habitat, but does not reference harvesting of killer whales. The remaining plans reviewed listed in Section 4.3.1.5 do not reference killer whales, their habitat, or the harvesting of killer whales.

The impact balance of this residual effect is considered negative. The spatial boundary is the Marine RSA since potential effects of Project-related marine vessel traffic may extend beyond the Marine LSA into the ZOI of site-specific sensitivities of traditionally harvested marine resources. The duration of the event causing the effects to marine resources that support traditional harvesting activities are expected to extend throughout the operations phase of the Project.

While the locations of subsistence activities within the Marine RSA can be approximated based on known locations of historical harvesting areas (Section 4.2.10.3), the extent and current use by traditional resource users of these locations is not precisely known (Table 4.3.10.4, point 1[b]).

Since potential effects on traditionally harvested marine resources are expected whenever Project related vessels transit through the shipping lanes, the frequency of the event is periodic. The magnitude of the effect is considered to range between low and high, and is dependent on each target species' site-specific sensitivities. As described in Section 4.3.7.6, southern resident killer whales within 4 to 7 km of the shipping lanes are expected to be disturbed by vessel traffic and this effect will occur throughout the Canadian designated critical habitat for this endangered population. The assessment of marine mammals has determined the magnitude of this effect on southern resident killer whales is expected to be high; this determination takes into consideration past and current activities resulting in a currently existing significant adverse cumulative effect on this population. Hunting of the southern resident killer whale is currently prohibited, but they have been harvested in the past. Although future harvesting of the southern resident killer whale may be unlikely given the recent historical decline of this population, substantial changes in the availability of a single traditionally harvested resource may also be reflected throughout the broader ecological system and the availability of marine resources overall given the uncertainty associated with cascading marine predator-prey effects. Confidence in this evaluation is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – potential effects may extend beyond the Marine LSA into the ZOI of target marine resources.
- **Duration** - long-term – the event causing effects to traditionally harvested marine resources are expected to extend throughout the operations phase of the Project.
- **Frequency** - periodic – Project-related marine vessels will be present daily in the shipping lanes over the operational life of the Project.

- **Reversibility** - long-term – the effects of disturbance to traditionally harvested marine resources will be dependent on each target species' sensitivities and could extend greater than 10 years when the Project is no longer in operation.
- **Magnitude** - low to high – the effects assessment results for marine fish and fish habitat, marine mammals and marine birds indicates that effects to traditionally harvested marine resources may be detectable and is dependent on each target species' sensitivities, with the exception of the southern resident killer whale population whereby residual effects are beyond environmental and regulatory standards.
- **Probability** - high – the effects of disturbance to traditionally harvested marine resources will also affect subsistence resources.
- **Confidence** - moderate – there is a good understanding of general cause-effect relationships between increased Project-related marine vessels and interactions with traditionally harvested marine resources available for subsistence activities; however, further Aboriginal community engagement will increase confidence and the robustness of the significance evaluation.

Alteration of Traditional Marine Resource Users' Vessel Movement Patterns

The increase in Project-related marine vessel wake traffic may result in alteration of traditional marine resource users' vessel movement patterns (Table 4.3.10.4, point 1[c]). This potential residual effect is assessed under the commercial fisheries and aquaculture indicator in Section 4.3.11. The significance evaluation of this residual effect is provided Table 4.3.11.3, point 1(b). A discussion of this residual effect in Section 4.3.11, which includes all marine resource users, provides an explanation of the rationale of the significance criteria.

Disruption of Traditional Marine Resource User Activities from Project-Related Marine Vessel Wake

Project-related marine vessel wake traffic may result in increased disruption of marine user activities (Table 4.3.10.4, point 1[d]. This residual effect is assessed under the commercial fisheries and aquaculture indicator in Section 4.3.11. The significance evaluation of this residual effect is provided in Table 4.3.11.3, point 1(e). A discussion of this residual effect in Section 4.3.11, which includes all marine resource users, provides an explanation of the rationale of the significance criteria.

Combined Effects of Increased Project-Related Marine Vessel Traffic on Subsistence Activities and Sites

An evaluation of the combined effects considers those residual socio-economic effects that are likely to occur. For the subsistence activities and sites indicator, likely residual socio-economic effects include disruption to subsistence activities and alteration of subsistence resources (Table 4.3.10.4, points 1[a], 1[b] and 1[c]).

The combined effect on the subsistence activities and sites indicator is considered to have a negative net impact balance. The spatial boundary is the Marine RSA. Although the spatial boundary of the interaction is likely to occur within the shipping lanes or Marine LSA, the effects may be felt throughout the Marine RSA. The duration of the event is long-term, over the life of the Project, and the frequency is periodic. Project-related marine vessels will transit daily in the shipping lanes and interactions with traditional resource users are considered to be likely. The magnitude of any interactions is considered to be low to medium, while traditional resource user activity may resume once the vessels have passed, the effects to traditionally harvested marine resources may be detectable and are dependent on each target species' sensitivities, with the exception of the southern resident killer whale population whereby residual effects are beyond environmental and regulatory standards. A summary of the rationale for all of the significance criteria for combined effects on subsistence activities and sites is provided below.

- **Spatial Boundary** - Marine RSA – the combined socio-economic effects on subsistence activities and sites could occur at any point in the Marine RSA.
- **Duration** - long-term – Project-related marine vessel traffic that may cause combined socio-economic effects on subsistence activities and sites will occur for the duration of the operations phase of the Project.
- **Frequency** - periodic – the passage of Project-related marine vessel traffic that could cause combined socio-economic effects on subsistence activities and sites will occur intermittently but repeatedly over the life of the Project.
- **Reversibility** - long-term – overall, the reversibility is long-term as the combined effects may occur for the duration of the operations phase and could extend greater than 10 years when the Project is no longer in operation.
- **Magnitude** - low to high – the combined effects will be detectable by traditional resource users; however, may only be felt while Project-related marine vessels are nearby yet the effects on traditionally harvested marine resources range from negligible to detectable and are dependent on each target species' sensitivities, with the exception of the southern resident killer whale population whereby residual effects are beyond environmental and regulatory standards.
- **Probability** - high – the combined effects are considered to be likely to occur during the life of the Project.
- **Confidence** - moderate – there is a good understanding of general cause-effect relationships between increased Project-related marine vessels and disruptions to subsistence activities and sites; however, further Aboriginal community engagement will increase confidence and the robustness of the significance evaluation.

4.3.10.6.2 Traditional Marine Resource Use Indicator – Cultural Sites

The following discusses the significance rationale for the potential residual effects identified related to the cultural sites indicator.

Increased Sensory Disturbance for Marine Users

The increase in Project-related marine vessel wake traffic may result in increased sensory disturbance for marine users (Table 4.3.10.4, point 2[a]). This potential residual effect is assessed under the marine recreational use indicator in Section 4.3.11. The significance evaluation of this residual effect is provided in Table 4.3.11.3, point 3(g). A discussion of this residual effect in Section 4.3.11, which includes all marine resource users, provides an explanation of the rationale of the significance criteria.

Disruption of Marine User Activities from Project-Related Marine Vessel Wake

Project-related marine vessel wake traffic may result in increased disruption of marine user activities (Table 4.3.10.4, point 2[b]. This residual effect is assessed under the marine recreational use indicator in Section 4.3.11. The significance evaluation of this residual effect is provided in Table 4.3.11.3, point 3(f). A discussion of this residual effect in Section 4.3.11, which includes all marine resource users, provides an explanation of the rationale of the significance criteria.

Negative User Perspectives of Increased Project-Related Marine Vessel Traffic

Increased Project-related marine vessel traffic may result in negative user perspectives for marine users (Table 4.3.10.4, point 2(c)). This residual effect is assessed under the marine recreational use indicator in Section 4.3.11. The significance evaluation of this residual effect is provided in Table 4.3.11.3, point 3(a). A discussion of this residual effect in Section 4.3.11, which includes all marine resource users, provides an explanation of the rationale of the significance criteria.

Combined Effects of Increased Project-Related Marine Vessel Traffic on Cultural Sites

An evaluation of the combined effects considers those residual socio-economic effects that are likely to occur. For the cultural sites use indicator, likely residual socio-economic effects include negative user perspectives of increased Project-related marine vessel traffic and increased sensory disturbance to marine users (Table 4.3.10.4, points 2[a] and 2[c]). The disruption of marine user activities from Project-related marine vessel wake is unlikely to occur and, consequently, was not considered in the evaluation of combined effects on the marine recreational use indicator in Section 4.3.11 MCRTU. The significance of this residual effect is provided in Table 4.3.11-3 (point 3[h]). A detailed assessment of these combined effects in Section 4.3.11, which includes traditional marine resource users, provides an explanation of the rationale of the significance criteria.

Combined Effects of Project-Related Marine Vessel Traffic on Traditional Marine Resource Use

The evaluation of the combined effects of increased Project-related marine vessel traffic on the TMRU indicators considers collectively the assessment of the following indicators: subsistence activities and sites; and cultural sites. The combined residual effects considered to be likely are: disruption of subsistence hunting, fishing and plant gathering activities; alteration of subsistence resources; increased sensory disturbance to marine users; and negative user perspectives of Project-related marine vessel traffic. Where two indicators had different criterion conclusions, the more conservative assessment was carried forward to the combined effects assessment.

Combined effects from increased Project-related marine vessel traffic on TMRU have high probability of occurrence that are long-term and with a low to high magnitude given the predicted residual effects on the southern resident killer whale population (Table 4.3.10.4, point 3[a]). Effects are considered in the context of existing high-volume vessel activity within the Marine RSA and an existing regulatory framework as well as in the context of the availability of a traditionally harvested resource to meet the cultural and subsistence needs of potentially affected Aboriginal peoples. The results of the TMRU assessment do not contradict any management objectives of established regional marine conservation plans or planning documents for marine environments under federal and provincial jurisdiction. A summary of the rationale for all of the significance criteria for combined effects on TMRU is provided below.

- **Spatial Boundary** - Marine RSA – combined socio-economic effects on TMRU could occur at any point in the Marine RSA.
- **Duration** - long-term – the event causing the combined residual effects on TMRU is the transit of Project-related marine vessels which occurs throughout the operational life of the Project.
- **Frequency** - periodic – the event causing the combined residual effects on TMRU is the transit of Project-related marine vessels which occurs intermittently but repeatedly throughout the operational life of the Project.
- **Reversibility** - long-term – the combined residual effects will occur throughout the operational life of the Project and may be reversible when the Project-related marine vessel traffic is no longer in operation.
- **Magnitude** - low to high – the combined residual effects will be detectable by traditional resource users but may only be felt while Project-related marine vessels are nearby. The effects to traditionally harvested marine resources range from negligible to detectable and are dependent on each target species' sensitivities, with the exception of the southern resident killer whale population whereby residual effects are beyond environmental and regulatory standards.
- **Probability** - high – the occurrence of combined residual effects on TMRU is considered to be likely.
- **Confidence** - high – there is a good understanding of the cause-effect relationships and of the data pertinent to the study area.

4.3.10.7 Potential United States Effects

The key issues that have been identified in Canadian waters are also considered to be similar in US waters. The shipping lanes in the Strait of Georgia, Haro Strait and Juan de Fuca Strait are located along the international boundary for much of the Marine RSA, and so the effects of Project-related marine vessels on other marine users are also considered to be similar in both countries. No differences in traditional marine resource use conditions in the US and Canadian portions of the Marine RSA were identified that would change the nature of the effects assessment. Therefore, the effects are expected to be similar in Canadian and US waters.

4.3.10.8 Summary

The results of the TMRU assessment do not contradict any management objectives of established regional marine conservation plans or planning documents for marine environments under federal and provincial jurisdiction. As identified in Table 4.3.10.4, the residual effects associated with increased Project-related marine vessel traffic on TMRU are considered not significant, with the exception of the expected residual effects on the southern resident killer whale population, which are considered to be significant (see Section 4.3.7).

4.3.11 Marine Commercial, Recreational and Tourism Use

This subsection of the ESA considers the potential effects of the Project-related increased marine vessel traffic associated with the expansion of the Westridge Marine Terminal in Burnaby, BC on other MCRTU of the coastal waters of southwest BC and US waters within the Marine RSA. Commercial use of the marine environment includes commercial fisheries and aquaculture and marine transportation of goods and services (*e.g.*, cargo and container ships, tankers, tugs and barges, and passenger ferries). Recreational uses include: fishing; boating; kayaking; and scuba diving. Tourism operators in coastal waters include: whale-watching vessels; commercial sport-fishing guides; boat charters; and cruise ships.

The potential residual effects discussed in this section apply equally to marine commercial, recreational and tourism users in both Canadian and US waters within the Marine RSA, due to the transboundary nature of the shipping lanes. The designated shipping lanes for deep draft vessels cross over the international boundary throughout much of the southern Strait of Georgia, Haro Strait and Juan de Fuca Strait. For example, in Juan de Fuca Strait the shipping lane for all deep draft inbound vessels is fully within US waters, while the outbound lane is in Canadian waters.

Project-related marine vessel traffic is expected to cause an increase from the current approximate frequency of 5 tankers per month visiting the terminal, to approximately 34 tankers a month, along with the required and additional planned tug escorts. Issues associated with the current volume of tanker traffic, of total marine vessel traffic in the study area, or of future increases in vessel traffic associated with general population growth are not assessed. Project-specific effects of the construction and operation of the proposed expansion of the Westridge Marine Terminal are addressed separately in Volume 5B. The Marine Commercial, Recreational and Tourism Use - Marine Transportation Technical Report (Volume 8B, TR 8B-6) provides further information on existing conditions related to use of BC and US coastal waters, including potential issues and interactions between users.

4.3.11.1 Assessment Indicators and Measurement Endpoints

Table 4.3.11.1 summarizes the assessment indicators, measurement endpoints and their rationale for MCRTU. The indicators selected represent components of the socio-economic environment that are of particular value or interest to Aboriginal communities, local communities and regulatory authorities. The indicators have been selected based on initial feedback from Aboriginal communities, local, regional and provincial government, and other stakeholders as well as public issues raised through media and professional judgment of the study team. For the purposes of this assessment, MCRTU is described in terms of:

- commercial fisheries and aquaculture;
- marine transportation;
- marine recreational use; and
- marine tourism use.

The measurement endpoints used to assess Project-related effects of increased marine vessel traffic on the indicators include quantitative and qualitative parameters, chosen based on available socio-economic information and a review of other assessments of similar projects.

TABLE 4.3.11.1

ASSESSMENT INDICATORS AND MEASUREMENT ENDPOINTS FOR MARINE COMMERCIAL RECREATIONAL AND TOURISM USE

Marine Commercial, Recreational and Tourism Use Indicator	Measurement Endpoints	Rationale for Indicator Selection
Commercial fisheries and aquaculture	• Species-specific or group-specific fishing effort • Fishing vessel traffic • Access to fishing grounds • Aquaculture operations	The selection of indicators and measurement endpoints considered key issues and interests identified during Aboriginal and stakeholder engagement. They also considered feedback from participants in the North Vancouver and Victoria ESA Workshops.
Marine transportation	• Use of shipping lanes • Rail bridge operations in Burrard Inlet	
Marine recreational use	• Documented recreation and tourism use areas • Marine facilities • Access to recreation areas • Quality of recreational experience • Consistency with marine use plans	See above
Marine tourism use		

4.3.11.2 Spatial Boundaries

Spatial boundaries used for the assessment of potential effects of Project-related marine vessel traffic on MCRTU are defined as follows.

4.3.11.2.1 Local Study Area

The Marine LSA for MCRTU is the area within which Project-related marine vessel traffic is expected to interact with marine commercial, recreational and tourism users. This includes the inbound and outbound marine shipping lanes, the area between the shipping lanes, where it exists, and a 2 km buffer extending from the outermost edge of each shipping lane. The shipping lanes extend from the Westridge Marine Terminal in Burnaby, through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, then westward past Victoria and through Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea, corresponding to the line of longitude of Buoy J.

Most deep draft vessels including Project-related tankers use the designated shipping lanes. Therefore, direct interactions between Project-related marine vessels and other marine users are reasonably expected to occur within the shipping lanes (CCG 2013b). The selection of the 2 km buffer area was based on potential measureable effects from other elements that pertain to marine users (*e.g.,* marine fish and fish habitat, marine mammals, marine acoustic environment). For example, the marine fish and fish habitat element has selected the 2 km Marine LSA to encompass the area in which vessel wake from a tanker would be expected to extend (Sections 4.2.6 and 4.3.6).

To examine nuances in marine use patterns, the Marine LSA is divided into four study regions, identified as the shipping lanes and a 2 km buffer extending from the outermost edge of each shipping lane, in the following areas (Figures 4.2.27 to 4.2.31).

- **Burrard Inlet** – west from the marine area around the Westridge Marine Terminal to the entrance to Vancouver's Outer Harbour.
- **Strait of Georgia** – southwest from the entrance to Vancouver Outer Harbour in the Strait of Georgia to Boundary Pass (near East Point on Saturna Island).
- **Haro Strait** – south from Boundary Pass through Haro Strait, past Turn Point on Stuart Island and continuing past Victoria to the Victoria Pilot Boarding Station.
- **Juan de Fuca Strait** – southwest from the Pilot Boarding Station near Victoria, then west through Juan de Fuca Strait, with the western boundary being the 12 nautical mile limit northwest of Cape Flattery, Washington State.

4.3.11.2.2 Regional Study Area

The Marine RSA is the area where the direct and indirect influence of other marine activities could overlap with Project-specific marine transportation effects, potentially resulting in residual and cumulative effects on MCRTU. This area is comprised of a large portion of the Salish Sea, including the inland marine waters of the southern Strait of Georgia and Juan de Fuca Strait and their connecting channels, passes and straits. The Marine RSA is generally centred on the marine shipping lanes, which extend from the Westridge Marine Terminal through Burrard Inlet, south through the Strait of Georgia, the Gulf Islands and Haro Strait, westward past Victoria and through Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea. The western boundary of the Marine RSA extends further out to sea than the western boundary of the Salish Sea and the northern boundary of the Marine RSA is limited to the southern portion of the Strait of Georgia. Puget Sound is excluded from the Marine RSA.

The spatial boundaries for MCRTU have evolved based on feedback during stakeholder engagement. Stakeholder feedback resulted in the Marine LSA and Marine RSA being extended beyond the Burrard Inlet to extend out to the 12 nautical mile limit of Canada's territorial sea. The MCRTU study area includes the areas of the Marine LSA and Marine RSA that extend into US waters. The MCRTU study areas also follow guidance indicated by the NEB in the letter titled Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Increased Marine Shipping Activities (NEB 2013b), received by Trans Mountain on September 10, 2013. The letter indicates that the marine transportation assessment should take place out to the 12 nautical mile limit of Canada's territorial seas.

Maps of the spatial boundaries for the assessment of MCRTU are provided in Section 4.2.

4.3.11.3 Marine Commercial, Recreational and Tourism Use Context

MCRTU occurs throughout the coastal waters of southwestern BC, from the area around the Westridge Marine Terminal in Burrard Inlet, through the inland waterways of the Salish Sea and out to the North Pacific Ocean. The context for marine users in the Marine LSA and Marine RSA is provided for each marine region.

4.3.11.3.1 Burrard Inlet

Burrard Inlet is a tidal salt-water inlet in the lower mainland of BC. About one million people live in the eight municipalities surrounding the inlet, namely: the cities of Vancouver, Burnaby and Port Moody on the south shore; the villages of Belcarra and Anmore on the east shore of Indian Arm and Port Moody Inlet; and the City of North Vancouver; the District of North Vancouver; and the District of West Vancouver on the north shore (BIEAP 2011; Statistics Canada 2012).

PMV oversees the operation of port facilities in Burrard Inlet, Delta and the Fraser River in the Lower Mainland (PMV 2013a). Marine terminals in Burrard Inlet include: terminals for container ships; cruise ship terminals; and cargo terminals (PMV 2013a). Other commercial uses include a commuter ferry service between Vancouver and North Vancouver and a seaplane aerodrome in the Inner Harbour. A large portion of the commercial vessel movements in Burrard Inlet consists of tug traffic, while assisting ships, engaging in towing activities, or in transit (see Volume 8C, TERMPOL Studies).

Commercial fisheries for species including Dungeness crab, prawns and shrimp occur in Burrard Inlet including portions of the Outer Harbour, the Central Harbour (near Westridge Marine Terminal) and Indian Arm (DFO 2013i,j,k). Section 4.2 provides detailed information on commercial fisheries in the Marine RSA. Marine recreational use of Burrard Inlet includes: kayaking; canoeing; cruising, paddle-boarding; kite surfing; windsurfing; fishing and swimming (Greater Vancouver Visitors and Convention Bureau 2013b). Fishing is popular throughout the inlet for salmon, groundfish and other species (Bird pers. comm.). The area is designated as a sportfishing area and is closed to the commercial groundfish fishery (DFO 2013m). Marine tourism uses in Burrard Inlet include: cruise ships berthing in the inner harbour; dive charters to sites in Indian Arm; and yacht cruises throughout the inlet. Boat and fishing charter companies and whale watching operators are based in marinas in the Inner Harbour and False Creek (and Convention Bureau 2013b).

4.3.11.3.2 Strait of Georgia

The Strait of Georgia is a navigable channel situated between Vancouver Island and the mainland coast of BC, bounded at both ends by narrow passages and a large number of islands. Most of the population of BC is located on the periphery of the Strait of Georgia, and the strait is a waterway for a large variety of marine traffic. The Marine LSA and Marine RSA include the southern portion of the Strait of Georgia, between the approach to Vancouver Harbour and Juan de Fuca Strait. Commercial fishing in the Strait of Georgia occurs year-round for groundfish. Openings for other fisheries are variable and tend to occur between late-spring and late-fall. Prawns, shrimp, crab, salmon, herring and other species are fished commercially in various areas of the strait. Preferred fishing grounds include the approach to Vancouver harbour and nearshore areas of Richmond and Delta (*i.e.*, Roberts Bank).

The Strait of Georgia is a regionally important shipping channel. Marine terminals in Burrard Inlet, the Lower Mainland, and ports in Canada and the US generate commercial vessel traffic in the Strait of Georgia (CCG 2013b). Passenger ferries cross the Strait of Georgia between ferry terminals in the Lower Mainland, Vancouver Island, and the Southern Gulf Islands (BC Ferry Services 2013b). Marine recreational users including fishers and pleasure boaters use the strait to access destinations in the Gulf Islands, Vancouver Island and other locations. Recreational fishing occurs in many areas, in particular for salmon, halibut, rockfish and crab. Recreational shellfish harvesting occurs along shoreline areas for oysters, clams and other shellfish, subject to sanitary closures (DFO 2013l).

Tourism users include whale-watching operators and sportfishing guides. Commercial sportfishing guides operate out of Richmond and Vancouver, with charters targeting specific salmon species year-round around Vancouver, the Gulf Islands and Vancouver Harbour (Worldweb 2013).

4.3.11.3.3 Haro Strait

Haro Strait is the main navigable channel in Canadian waters that connects the Strait of Georgia to Juan de Fuca Strait. Haro Strait also defines part of the international boundary between Canada and the US, dividing the Southern Gulf Islands from the US San Juan Islands. Haro Strait is approximately 50 km long, including Boundary Pass. The shipping lanes are situated on or near the international boundary for most of the strait. The strait is narrow throughout much of its length and has a number of known navigational hazards and strong tidal currents (CCG 2013a).

Commercial fishing for some species such as Dungeness crab occurs throughout Haro Strait. Other commercial fisheries such as the prawn trap fishery have short seasons; however, the prawn fishery is lucrative and Haro Strait is an important fishing area (DFO 2013j). Salmon, shrimp, red and green urchin and other species are also commercially fished in Haro Strait (DFO 2013j).

Commercial vessel traffic from terminals in Vancouver use Haro Strait to access international waters via Juan de Fuca Strait. Special operating rules for deep draft vessels are in place in navigationally constrained areas such as Turn Point (CCG 2013b).

Ferry services transport passengers and some cargo between ports in BC and Washington State, crossing the shipping lanes in the strait daily between Sidney on Vancouver Island and Anacortes in Washington (Washington State Department of Transportation 2013a). Passenger ferries also run regularly between Victoria, BC and Seattle Washington, and Victoria, BC and Port Angeles, Washington.

The Southern Gulf Islands are located in Haro Strait and are a key destination for recreational and tourism users. The Southern Gulf Islands contain marine parks and coastal campsites, which are popular destinations for marine recreational users including kayakers, boaters, fishers and scuba divers. Tourism uses include whale-watching and commercial sport fishing.

4.3.11.3.4 Juan de Fuca Strait

Juan de Fuca Strait separates southeast Vancouver Island from the north coast of the State of Washington. The strait connects the Pacific Ocean with the Strait of Georgia and Puget Sound (US Office of Coast Survey 2013). The eastern entrance is marked by Race Rocks Ecological Reserve, south of Metchosin on Vancouver Island. The western boundary of the strait is generally defined by a north-south line between Cape Flattery, on the northeast edge of the Olympic Peninsula (US) to Carmanah Point on Vancouver Island. The international boundary runs down the centre of the strait. The Marine RSA extends another 12 nautical miles (about 22 km) west of this point into the Pacific Ocean, also defining the extent of Canada's Territorial Sea (DFO 2013i).

Commercial fishing in Juan de Fuca Strait includes fisheries for salmon, groundfish, crab and prawns. Salmon fisheries typically occur between April and September, subject to management decisions by DFO (2013b). Groundfish are fished year-round by trawlers and hook and line fisheries (DFO 2013m). Crabs and prawns are fished by trap in nearshore areas of Vancouver

Island (DFO 2013i, g). The eastern area of the strait south of Victoria Harbour can experience a high level of effort for both commercial and recreational fishers.

Aside from commercial fishing traffic, Juan de Fuca Strait is used by vessels including cargo and container ships, tankers bound for Westridge Marine Terminal and other Canadian and US terminals, cruise ships bound for Vancouver, Victoria and US ports, tugs and barges, and Canadian and US naval vessels. Marine recreational use in Juan de Fuca Strait includes: sailing; boating; fishing; surfing; and kayaking. The area is also known for high quality scuba diving. Marine tourism in Juan de Fuca Strait includes: sportfishing charters; kayak tours; and whale-watching tours.

4.3.11.3.5 United States Marine Areas

The shipping lanes in the Strait of Georgia, Haro Strait and Juan de Fuca Strait are partly located within the coastal waters of Washington in the US and roughly follow the international boundary throughout much of the Salish Sea. The commercial fishing industry in Washington includes: major fisheries for halibut and other groundfish; salmon; albacore tuna; and shellfish (including Dungeness crab, shrimp and clams) (WDFW 2008). Port facilities in Washington generate commercial vessel traffic in the Strait of Georgia and other areas of the Salish Sea. Shipping lanes in Juan de Fuca Strait, the Strait of Georgia and Puget Sound are used by both Canadian and US-bound commercial marine vessels, including: tankers; bulk carriers; container ships; vehicle carriers; cruise ships; navy and coast guard vessels; tugs and barges; and passenger ferries (van Dorp 2008, Washington State Department of Transportation 2013a).

Marine recreational use in US areas includes boating, paddling, diving, fishing and whale-watching. Recreational users use shoreline and nearshore areas throughout the Marine RSA including marine parks, beaches and recreational fishing areas. Marine tourism in US waters within the Marine RSA includes whale-watching, commercial sport fishing, cruise ships, yacht charters, kayak outfitters and dive charters.

4.3.11.4 Potential Effects and Mitigation Measures

The potential effects on MCRTU associated with the increased Project-related marine vessel traffic were identified based on the results of the literature review, desktop analysis, feedback during marine ESA Workshops, interviews, and Project-wide consultation with Aboriginal communities, government agencies and stakeholders (see Section 3.0). Potential interactions between marine users already exist. However, the increased Project-related marine vessel traffic increases the likelihood of such interactions.

Trans Mountain will require that a tug accompany the Project-related tankers through the entire transit, including in the Strait of Georgia and between Race Rocks and the 12 nautical mile limit to assist with navigation. The tug escort is an enhancement to existing tug requirements. The tug can be tethered for extra navigational assistance if needed (refer to Table 4.3.11.2, Point 1.1 for a list of key mitigation measures with respect to marine safety). The potential socio-economic effects of the additional tug escort include increased jobs and capital investment in the form of extra tugs. A full analysis of the positive economic effects was considered to be outside the scope of this assessment (refer to Section 5.3.2 for more detail on the additional tug escort as a safety measure).

4.3.11.4.1 Effects Considerations

A range of issues potentially related to MCRTU was identified during desktop research, stakeholder engagement and in the media related to the Project; however, were not included in the assessment. These include:

- the potential effect of the increased Project-related marine vessel traffic on tourism revenues for the hotel industry;
- the potential effect of the increased Project-related marine vessel traffic on property values for waterfront properties;
- the potential effect of Project-related marine vessel wakes on aquaculture operations;
- the potential effect of Project-related marine vessel wakes on marine infrastructure or shorelines;
- the potential effect of Project-related marine vessel traffic on port service suppliers;
- the potential for interactions between Project-related marine vessels and float planes; and
- the potential effect of increased underwater noise from Project-related marine vessel traffic on the behaviour of southern resident killer whales.

Concern about the potential effects of the Project on the hotel industry and other businesses that rely on tourism was identified by participants at the North Vancouver and Victoria ESA Workshops. The potential effect on coastal property values with view of the shipping lanes was also identified through stakeholder consultation. Both issues are considered to be outside the scope of this ESA due to the difficulty in establishing a cause-effect relationship. While it is possible that normal operations of increased Project-related marine vessels could contribute to these effects, many other economic factors may affect tourism revenues and property values. The effect of the current movement of oil tankers on tourism and property values is not documented and would require considerable study in the context of the tourism and real estate sectors. Such issues have been noted by KMC during the Stakeholder Consultation and Engagement program related to the Project. Responses to such issues are discussed in Volume 3A, Public Consultation.

The potential effects of Project-related marine vessel wake on aquaculture operations were considered for inclusion in the ESA; however, the results of desktop analysis determined that no active aquaculture operations are present within the Marine LSA in Canadian waters. The effects of vessel wake on fish and fish habitat is described in Section 4.3.6. It was determined that the effects of vessel wake from Project-related marine vessels on fish and fish habitat would be negligible at a distance of approximately 2 km. As such, no potential effects on aquaculture from the Project have been identified.

The potential effects of Project-related marine vessel wake on marine infrastructure (*e.g.*, docks and berths) and shorelines were stated concerns by participants at the Victoria and North Vancouver Marine ESA Workshops. The wake generated by the transit of Project-related marine vessels generates waves which may reach shoreline areas where the shipping lanes are close to shore, such as between the First and Second Narrows in Burrard Inlet. Piloted vessels are required to travel at a maximum of six knots throughout much of Burrard Inlet (PMV 2010). Waves generated by Aframax tankers and associated escort vessels at this speed are not considered likely to affect marine infrastructure or shorelines (see Section 4.3.6 for more detail). The potential effects of Project-related marine vessel traffic on float plane operations were considered for inclusion in the ESA; however, these were scoped out due to the location of designated areas for float plane use in relation to the inbound and outbound shipping lanes in Burrard Inlet. While float plane operations are present in the Marine LSA in Burrard Inlet, there is a designated area in the Inner Harbour beyond which float planes are restricted. As such, no potential effects on float planes from the increased Project-related marine vessel traffic are anticipated.

Concerns about the effects of increased underwater noise resulting from a general increase in marine vessel traffic in critical habitat areas for southern resident killer whales are identified in Appendix E, Table 3.3.1. The potential effects of increased underwater noise from Project-related marine vessel traffic on the behaviour of southern resident killer whales are described and analysed in Section 4.3.7. An analysis of associated effects on marine tourism activities was considered to be outside the scope of the assessment of Project effects on MCRTU; however, it is acknowledged that Project-related residual effects on southern resident killer whales may have a concomitant effect on whale-watching operators.

The potential effect of Project-related marine vessel traffic on port service suppliers was considered to be potentially positive overall. Specifically, it is considered that the Project may have a positive economic effect on tug operators and providers of ships' services, such as pilots, fuel and food and provide opportunities for these businesses to expand or improve their productivity. An analysis of the potential economic benefits of the Project was considered to be outside of the scope of the assessment of Project-related effects on MCRTU; consequently, no further analysis was completed on this potential effect.

The potential occurrence and associated effects of collisions and other non-spill accidental interactions between Project-related marine vessels and other marine commercial, recreational and tourism users are discussed in this subsection. The avoidance of collisions and other accidents is the responsibility of all ships' masters and crews, in terms of compliance with regulations including: the *International Regulations for Preventing Collisions at Sea (1972) with Canadian Modifications* and the *Navigation Safety Regulations* under the *Canada Shipping Act,* 2001; Fishing Vessel Advisory Notices issued by the CCG (2013a); and the PPA Compulsory Pilotage Areas (PPA 2013).

The first level of responsibility to respond to marine incidents such as collisions is with ships' masters and crew; however, a collision or other interaction that takes place between Project-related marine vessels and other marine users is also a potential effect of the Project on other MCRTU vessels. Therefore, the significance of the potential residual effects of non-spill collisions on other marine users are evaluated in the following subsections, along with proactive steps to avoid collisions and other recommended mitigation measures.

The potential effects of credible worst case and smaller marine spills on marine users are discussed in Section 5.0.

It is recognised that marine commercial, recreational and tourism users of the Marine RSA are both Aboriginal and non-Aboriginal. While potential TMRU effects are discussed in Section 4.3.10, many commercial fishers and recreational marine users in the Marine RSA are

Aboriginal. The potential effects described in this subsection apply equally to Aboriginal and non-Aboriginal users.

4.3.11.4.2 Identified Potential Effects

Potential effects associated with the increased Project-related marine vessel traffic on MCRTU indicators are listed in Table 4.3.11.2. These interactions are based on the results of the literature review, desktop analysis, interviews, Project-wide consultation and engagement with Aboriginal communities, government agencies and other stakeholders (Section 3.0), and the experience of the assessment team.

A summary of mitigation measures provided in Table 4.3.11.2 was principally developed in accordance with KMC standards as well as industry best practices.

TABLE 4.3.11.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations[2]	Potential Residual Effect(s)
1. Marine Commercial Recreational and Tourism Use Indicator – Commercial Fisheries and Aquaculture			
1.1 Disruption of commercial fishing activities	LSA	• Project tankers shall utilize the common shipping lanes, already used by all large commercial vessels for passage between the Pacific Ocean and PMV. • Trans Mountain will continue to provide information about Project-related shipping to other marine users. Specifically: – provide regular updated information on Project-related marine vessel traffic to fishing industry organizations, Aboriginal communities, and other affected stakeholders, where possible through the Chamber of Shipping of BC (COSBC); and – initiate a public outreach program prior to Project operations phase. Communicate any applicable information on Project-related timing and scheduling with fishing industry organisations, Aboriginal communities and other affected stakeholders. • Transport Canada requires all vessels, including tankers, to comply with the *International Regulations for Preventing Collisions at Sea* (with Canadian Modifications) and other major international maritime conventions. • Transport Canada requires compliance by all vessels with the *Canada Shipping Act,* 2001*, Collision Regulations,* the *Navigation Safety Regulations* pursuant to the Act and other applicable regulations and standards, except Government or Military vessels. • The CCG ensures that all large vessels, including Project-related tankers, register with MCTS for communications with port authorities and CCG, and employ Automatic Identification Systems (AIS).	• Disruption of commercial fishing activities. • Alteration of existing marine vessel movement patterns.

TABLE 4.3.11.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE (continued)

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations[2]	Potential Residual Effect(s)
1. Marine Commercial Recreational and Tourism Use Indicator – Commercial Fisheries			
1.1 Disruption of commercial fishing activities (cont'd)	LSA	• The CCG requires compliance with the CCG fishing vessel advisory notice for commercial ships and fishing vessels using the inside passage waters of BC during the commercial fishing season. This notice refers to all inside marine waters of BC. • The PPA requires compliance with the PPA Compulsory Pilotage Areas (PPA 2013). • PMV ensures compliance with PMV's MRA regulations, including "Clear Narrows" regulations (PMV 2010). • To enhance preventive measures currently in place through applicable legislation and regulations, implement May 2013 recommendations of Canadian Marine Pilot's Association Submission to the Tanker Safety Expert Panel. • Trans Mountain will require tug escort of all Project-related tankers for the entire transit from the Westridge Marine Terminal to the Pacific Ocean. This enhancement is in addition to tug requirements to assist with navigation. The tug can be tethered for extra navigational assistance if needed.	• See above
1.2 Marine vessel collisions with commercial fishers	RSA	• Mitigation measures listed in potential effect 1.1 are applied by the appropriate parties. • Tanker owners have third-party insurance coverage in place to address vessel damage, gear loss or injury. • Transport Canada and the Transportation Safety Board carry out investigations at the appropriate level in case of a collision between vessels. • Refer to Section 4.3.13 Accidents and Malfunctions.	• Damage to marine vessels and/or injury. • Damage or loss of gear. • Disruption of marine user activities from Project-related marine vessel wake. • Lost or reduced economic opportunity for commercial marine users.
1.3 Marine vessel wake effects on small fishing vessels	RSA		
1.4 Sensory disturbance (*e.g.*, noise, visual effect, air quality) for commercial fishers	LSA	• Trans Mountain will continue to engage with those affected, including Aboriginal communities, throughout the operational life of the Project. • Refer to Section 4.3.3 Air Emissions, Section 4.3.4 GHG Emissions and Section 4.3.5 Acoustic Environment for measures pertaining to nuisance air and noise emissions, respectively.	• Refer to Section 4.3.10 Traditional Marine Resource Use. • Increased sensory disturbance for marine users.
1.5 Change in distribution	RSA	• Refer to Section 4.3.6 Marine Fish and Fish Habitat.	• Lost or reduced economic

TABLE 4.3.11.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE (continued)

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations[2]	Potential Residual Effect(s)
and abundance of target species			opportunity (refer to potential effects 1.2 and 1.3 of this table).
2. Marine Commercial, Recreational and Tourism Use Indicator – Marine Transportation			
2.1 Alteration of existing movement patterns of marine commercial users	LSA	• Mitigation measures in potential effect 1.1 are applied by the appropriate parties. • Trans Mountain will provide regular updated information on Project-related marine vessel traffic to shipping associations, such as Chamber of Shipping.	• Alteration of existing marine vessel movement patterns (refer to potential effect 1.1 of this table).
2.2 Increased rail bridge operations	LSA	• Mitigation measures in potential effect 1.1 are applied by the appropriate parties. • PMV ensures procedures for bridge operations are correctly implemented and facilitate communications protocols between bridge operators and vessels. • Trans Mountain will provide regular updated information on Project-related marine vessel traffic to CN Rail.	• Disruption to rail traffic on CN Rail Bridge at Second Narrows.
2.3 Marine vessel collision with built infrastructure, marine facilities or shoreline with a commercial use 2.4 Marine vessel collisions with marine commercial users	LSA	• Mitigation measures listed in potential effect 1.1 are applied by the appropriate parties. • Tanker owners have third-party insurance coverage in place to address vessel damage, gear loss or injury • Transport Canada and the Transportation Safety Board carry out investigations at the appropriate level in case of a collision between vessels. • Refer to Section 4.3.13 Accidents and Malfunctions.	• Damage to built infrastructure, marine facilities, or shorelines. • Damage to marine vessels and/or (refer to potential effect 1.2 of this table). • Lost or reduced economic opportunity (refer to potential effects 1.2 and 1.3 of this table).
3. Marine Commercial, Recreational and Tourism Use Indicator – Marine Recreational Use			
3.1 Alteration of existing movement patterns of marine recreational users	LSA	• Mitigation measures in potential effect 1.1 are applied by the appropriate parties. • Trans Mountain will provide regular updated information on Project-related marine vessel traffic to recreational organisations.	• Alteration of existing marine vessel movement patterns (refer to potential effect 1.1 of this table).
3.2 Marine vessel collision with built infrastructure, marine facilities or shoreline with a recreational	LSA	• Mitigation measures listed in potential effect 1.1 are applied by the appropriate parties. • Tanker owners have third-party insurance coverage in place to address vessel damage, gear loss or injury • Transport Canada and the Transportation Safety Board carry out investigations at the appropriate level in case of a collision between vessels.	• Damage to built infrastructure, marine facilities, or shoreline (refer to potential effects 2.3 and 2.4 of this table).

TABLE 4.3.11.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE (continued)

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations[2]	Potential Residual Effect(s)
use.		• Refer to Section 4.3.13 Accidents and Malfunctions.	
3. Marine Commercial, Recreational and Tourism Use Indicator – Marine Recreational Use			
3.3 Marine vessel collisions with other marine recreational users 3.4 Marine vessel wake effects on small recreational vessels	LSA	• See above	• Damage to marine vessels and/or injury (refer to potential effect 1.2 of this table). • Damage or loss to gear (refer to potential effect 1.3 of this table). • Lost or reduced economic opportunity (refer to potential effects 1.2 and 1.3 of this table). • Disruption of marine user activities from Project-related marine vessel wake (refer to potential effect 1.3 of this table). • Refer to Section 5.0 Marine Spill Scenarios.
3.5 Sensory disturbance (*e.g.*, noise, visual effect, air quality) for recreational users	RSA	• Trans Mountain will continue to conduct consultative discussions with those affected, including the Aboriginal community, throughout the operational life of the Project. • Refer to Section 4.3.3 Air Emissions, Section 4.3.4 GHG Emissions and Section 4.3.5 Acoustic Environment for measures pertaining to nuisance air and noise emissions, respectively.	• Refer to Section 4.3.10 Traditional Marine Resource Use. • Increased sensory disturbance for marine users (refer to potential effect 1.4 of this table).
3.6 Negative recreational user perspectives of increased Project-related marine vessel traffic	RSA	• Mitigation measures listed in potential effects 1.1 to 1.4 are applied by the appropriate parties.	• Negative user perspectives of increased marine vessel traffic.

TABLE 4.3.11.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE (continued)

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations[2]	Potential Residual Effect(s)
4. Marine Commercial Recreational and Tourism Use Indicator – Marine Tourism Use			
4.1 Alteration of existing movement patterns of marine tourism users	LSA	• Mitigation measures listed in potential effect 1.1 are applied by the appropriate parties. • Trans Mountain will provide regular updated information on Project-related marine vessel traffic to tourism organisations.	• Alteration of existing marine vessel movement patterns (refer to potential effect 1.1 of this table).
4.2 Marine vessel collisions with marine tourism users 4.3 Marine vessel collision with built infrastructure, marine facilities or shoreline with a tourism use 4.4 Marine vessel wake effects on small tourism operator vessels	LSA	• Mitigation measures listed in potential effect 1.1 are applied by the appropriate parties. • Tanker owners have third-party insurance coverage in place to address vessel damage, gear loss or injury • Transport Canada and the Transportation Safety Board carry out investigations at the appropriate level in case of a collision between vessels. • Refer to Section 4.3.13 Accidents and Malfunctions.	• Damage to built infrastructure, marine facilities, or shorelines (refer to potential effects 2.3 and 2.4 of this table). • Damage to marine vessels and/or injury (refer to potential effect 1.2 of this table). • Damage or loss to gear (refer to potential effect 1.3 of this table). • Lost or reduced economic opportunity (refer to potential effects 1.2 and 1.3 of this table). • Disruption of marine user activities from Project-related marine vessel wake (refer to potential effect 1.3 of this table).

TABLE 4.3.11.2

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE (continued)

Potential Effect	Spatial Boundary[1]	Key Mitigation Measures in Place/Additional Recommendations[2]	Potential Residual Effect(s)
4.5 Sensory disturbance (*e.g.*, noise, visual effect, air quality) for tourism users	LSA	• Trans Mountain will continue to conduct consultative discussions with those affected, including the Aboriginal community, throughout the operational life of the Project. • Refer to Section 4.3.3 Air Emissions, Section 4.3.4 GHG Emissions and Section 4.3.5 Acoustic Environment for measures pertaining to nuisance air and noise emissions, respectively.	• Refer to Section 4.3.10 Traditional Marine Resource Use. • Increased sensory disturbance for marine users (refer to potential effect 1.4 of this table). • Decrease in marine tourism activities.
4.6 Negative tourism user perspectives of increased Project-related marine vessel traffic	RSA	• Mitigation measures listed in potential effect 3.5 are applied by the appropriate parties.	• Negative user perspectives of increased tanker traffic (refer to potential effect 3.5 of this table).

Notes: 1 LSA = Marine LSA; RSA = Marine RSA

2 This may be coordinated with Trans Mountain's mitigation measure of providing information related to Project activities affecting marine use areas (*i.e.*, the construction and operations of the Westridge Marine Terminal), as outlined in the Socio-economic Management Plan in Volume 6B, Appendix C Section 8.4.10.

4.3.11.5 Potential Residual Effects

The potential residual socio-economic effects on marine commercial, recreational and tourism use indicators associated with the increased Project-related marine vessel traffic (Table 4.3.11.2) are:

- disruption of commercial fishing activities;
- alteration of existing marine vessel movement patterns;
- damage to marine vessels and/or injury;
- damage or loss of gear;
- disruption of marine user activities from Project-related marine vessel wake;
- lost or reduced economic opportunity for commercial marine users;
- increased sensory disturbance for marine users;

- increased disruption to rail traffic on CN Rail Bridge at Second Narrows;
- damage to built infrastructure, marine facilities, or shorelines;
- negative user perspectives of increased marine vessel traffic; and
- decrease in marine tourism activities.

As noted by the cross-references appearing in Table 4.3.11.2, many of these effects are pertinent to marine commercial users, recreational users and tourism users alike. Also, many vessels using the Marine RSA fall into multiple categories; some commercial users are also tourism users (*e.g.,* commercial sportfishing outfitters and whale-watching tours). As such, many potential residual effects discussed below, though presented in relation to a certain marine user category are assessed in relation to all pertinent marine users in an integrated manner.

4.3.11.6 Significance Evaluation of Potential Residual Effects

A qualitative assessment of MCRTU was determined to be the most appropriate approach to evaluate the significance of potential residual socio-economic effects due to a lack of regulatory thresholds, standards or guidelines for indicators associated with this element. Consequently, the evaluation of significance of each of the potential residual effects relies on the professional judgment of the assessment team that includes members with extensive socio-economic impact assessment and marine experience.

Table 4.3.11.3 provides a summary of the significance evaluation of the potential residual socio-economic effects of the increased Project-related marine vessel traffic on MCRTU. The rationale used to evaluate the significance of each of the residual socio-economic effects is provided below.

TABLE 4.3.11.3

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE

Potential Residual Effects		Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
				Duration	Frequency	Reversibility				
1.	**Marine Commercial Recreational and Tourism Use Indicator – Commercial Fisheries and Aquaculture**									
1(a)	Disruption to commercial fishing activities.	Negative	RSA	Long-term	Periodic	Long-term	Low	Low	High	Not significant
1(b)	Alteration of existing marine vessel movement patterns.	Negative	RSA	Long-term	Periodic	Short- to long-term	Low to medium	High	High	Not significant
1(c)	Damage to marine vessels and/or injury.	Negative	LSA	Long-term	Accidental	Short-term to permanent	High	Low	High	Not significant

TABLE 4.3.11.3

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE (continued)

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
1(d) Damage or loss of gear.	Negative	LSA	Long-term	Accidental	Short-term	Low to medium	Low	Moderate	Not significant
1(e) Disruption of marine user activities from Project-related marine vessel wake.	Negative	LSA	Long-term	Occasional	Short-term	Low to medium	Low	Moderate	Not significant
1(f) Lost or reduced economic opportunity for commercial marine users.	Negative	RSA	Long-term	Accidental	Short- to medium-term	Low to high	Low	High	Not significant
1(g) Increased sensory disturbance to marine users.	Negative	LSA	Long-term	Periodic	Short-term	Low	High	High	Not significant
1(h) Combined effects on the commercial fisheries and aquaculture indicator (1[b] and 1[g]).	Negative	LSA to RSA	Long-term	Periodic	Long-term	Low to medium	High	High	Not significant
2. Marine Commercial Recreational and Tourism Use Indicator – Marine Transportation									
2(a) Disruption to rail traffic on CN Rail Bridge at Second Narrows.	Negative	LSA specific to CN Rail Bridge at Second Narrows, Burrard Inlet	Long-term	Periodic	Short-term	Medium	High	High	Not significant
2(b) Damage to built infrastructure, marine facilities or shorelines.	Negative	LSA specific to Burrard Inlet	Long-term	Accidental	Short- to medium-term	Low to high	Low	High	Not significant
2(c) Alteration of existing marine vessel movement patterns.	Negative	RSA	Long-term	Periodic	Short- to long-term	Low to medium	High	High	Not significant
2(d) Damage to marine vessels and/or injury.	Negative	LSA	Long-term	Accidental	Short-term to permanent	High	Low	High	Not significant
2(e) Lost or reduced economic opportunity for commercial marine users.	Negative	RSA	Long-term	Accidental	Short- to medium-term	Low to high	Low	High	Not significant
2(f) Combined effects on the Marine Transportation indicator (2[a] and 2[c]).	Negative	LSA to RSA	Long-term	Periodic	Long-term	Low to medium	High	High	Not significant
3. Marine Commercial Recreational and Tourism Use Indicator – Marine Recreational Use									
3(a) Negative user perspectives of increased Project-related marine vessel traffic.	Negative	RSA	Long-term	Continuous	Long-term	Low	High	Moderate	Not significant

TABLE 4.3.11.3

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE (continued)

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
3(b) Alteration of existing marine vessel movement patterns.	Negative	RSA	Long-term	Periodic	Short- to long-term	Low to medium	High	High	Not significant
3(c) Damage to built infrastructure, marine facilities, or shorelines.	Negative	LSA specific to Burrard Inlet	Long-term	Accidental	Short- to medium -term	Low to high	Low	High	Not significant
3(d) Damage to marine vessels and/or injury.	Negative	LSA	Long-term	Accidental	Short-term to permanent	High	Low	High	Not significant
3(e) Damage or loss of gear.	Negative	LSA	Long-term	Accidental	Short-term	Low to medium	Low	Moderate	Not significant
3(f) Disruption of marine user activities from Project-related marine vessel wake.	Negative	LSA	Long-term	Occasional	Short-term	Low to medium	Low	Moderate	Not significant
3(g) Increased sensory disturbance to marine users.	Negative	LSA	Long-term	Periodic	Short-term	Low	High	High	Not significant
3(h) Combined effects on the marine recreational use indicator (3[a], 3[b] and 3[g]).	Negative	LSA to RSA	Long-term	Periodic to continuous	Long-term	Low to medium	High	High	Not significant
4. Marine Commercial Recreational and Tourism Use Indicator – Marine Tourism Use									
4(a) Decrease in marine tourism activities.	Negative	RSA	Long-term	Continuous	Long-term	Medium	Low	High	Not significant
4(b) Alteration of existing marine vessel movement patterns.	Negative	RSA	Long-term	Periodic	Short- to long-term	Low to medium	High	High	Not significant
4(c) Damage to built infrastructure, marine facilities, or shorelines.	Negative	LSA specific to Burrard Inlet	Long-term	Accidental	Short- to medium-term	Low to high	Low	High	Not significant
4(d) Damage to marine vessels and/or injury.	Negative	LSA	Long-term	Accidental	Short-term to permanent	High	Low	High	Not significant
4(e) Damage or loss of gear.	Negative	LSA	Long-term	Accidental	Short-term	Low to medium	Low	Moderate	Not significant
4(f) Lost or reduced economic opportunity for commercial marine users.	Negative	RSA	Long-term	Accidental	Short- to medium-term	Low to high	Low	High	Not significant
4(g) Disruption of marine user activities from Project-related marine vessel wake.	Negative	LSA	Long-term	Occasional	Short-term	Low to medium	Low	Moderate	Not significant
4(h) Increased sensory disturbance to marine users.	Negative	LSA	Long-term	Periodic	Short-term	Low	High	High	Not significant
4(i) Combined effects on the marine tourism use indicator (4[b], and 4[h]).	Negative	LSA to RSA	Long-term	Periodic	Long-term	Low to medium	High	High	Not significant

TABLE 4.3.11.3

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE (continued)

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
5. Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Commercial, Recreation and Tourism Use									
5(a) Combined effects of increased Project-related marine vessel traffic on the MCRTU indicators (2[f], 3[h] and 4[i]).	Negative	RSA	Long-term	Periodic	Long-term	Low to medium	High	High	Not significant

Notes: 1 LSA = Marine LSA; RSA = Marine RSA

2 **Significant Residual Socio-Economic Effect:** a residual socio-economic effect is considered significant if the effect is predicted to be:

- high magnitude, high probability, long-term or permanent reversibility, and any spatial boundary that cannot be technically or economically mitigated.

4.3.11.6.1 Marine Commercial, Recreational and Tourism Use Indicator – Commercial Fisheries and Aquaculture

The following discusses the significance rationale for the potential residual effects identified for the commercial fishing indicator.

Disruption to Commercial Fishing Activities

The disruption of commercial fishing activities is a potential residual effect of interactions between commercial fishing vessels and Project-related marine vessel traffic that could occur when Project-related marine vessels are in transit in the shipping lanes. Fishing vessels are permitted to cross and fish within shipping lanes if the area is clear; however, fishers are not permitted to impede the passage of other vessels (CCG 2013c). Transits of Project-related marine vessel traffic through the Marine RSA will increase from approximately weekly to daily. Disruption of fishing activities by Project-related marine vessel traffic may result in a missed fishing opportunity. Fishing vessels may be present in the shipping lanes during fishery openings in the Strait of Georgia and Juan de Fuca Strait (CCG 2013b). Incidents between deep draft vessels and vessels engaged in fishing are rare but not without precedent. In 1994, a collision occurred in heavy fog off Nova Scotia between a loaded bulk carrier “Federal Oslo” and a fishing vessel “Shelley Dawn II” that was actively hauling gear (TSB 2013). A lost fishing opportunity may result in a lost economic opportunity for the fisher.

Preferred fishing locations in some areas of the Marine RSA are situated along or near the shipping lanes. For example, areas of higher effort for the prawn trap fishery include around the shipping lanes in Haro Strait near Stuart Island. Openings for the salmon gillnet fishery occur around the mouth of the Fraser River, in the Roberts Bank area adjacent to the shipping lanes (CCG 2013b).

Smaller marine vessels including many fishing vessels are not required to register with the CCG Marine Communications and Traffic Services, and many are not equipped with AIS transponders, radar reflectors or other equipment that improves their visibility to large deep sea vessels, especially in poor weather (CCG 2013b). Transport Canada and the CCG continue to encourage small vessels to use technology to improve visibility.

Mitigation measures recommended for this residual effect include communication measures as described in Table 4.3.11.2. Project-related marine vessels will be fully compliant with all applicable navigational, communications and safety regulations as outlined in Section 1.1 and Table 4.3.11.2.

The impact balance of this potential residual effect is considered to be negative. The spatial boundary is the Marine RSA. Although interactions may occur wherever fishing grounds are in or near the shipping lanes, fishing vessels also may be displaced to other areas in the Marine RSA. The duration of the event causing the disruption of commercial fishing activities is long-term, and the reversibility of the residual effect is considered to be long-term, since all effects of Project-related marine vessel traffic would extend for the operational life of the Project.

Commercial fishing is permitted in the shipping lanes during fishing seasons (CCG 2013a). Since fishing boats could be encountered by Project-related marine vessels whenever these vessels are transiting through the shipping lanes, the frequency of the event is periodic. The magnitude of the effect is considered to be low, since it is expected that the disruption would be temporary in the unlikely event that a Project-related disruption did occur. Such disruptions to fishing activities are equally likely to occur in relation to all large vessels currently using the shipping lanes, and Project-related marine vessels will make up only a small portion of the total marine traffic (TMEP TERMPOL 3.2 in Volume 8C, TR 8C-2).

Confidence in this evaluation is high; although the possible locations of fishers can only be inferred based on known fishing season openings for specific fisheries and the locations of preferred fishing areas, incidents between marine vessels are rare and are mitigated by measures outlined in Table 4.3.11.3, point 1[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – interactions between Project-related marine vessels and commercial fishing activities that lead to delays or disruptions in fishing activities could occur at any point along the shipping lanes and may also indirectly affect the distribution of vessels in other areas of the Marine RSA.
- **Duration** - long-term – interactions between Project-related marine vessels and commercial fishing activities will begin during the operations phase and will extend for the operational life of the Project.
- **Frequency** - periodic – Project-related marine vessels will be present daily in the shipping lanes over the operational life of the Project.
- **Reversibility** - long-term – the potential disruptions to commercial fishing activities are expected to extend throughout the operations phase of the Project.
- **Magnitude** - low – fishing activities may be interrupted due to increased Project-related marine vessel traffic, but are likely to be resumed in most cases once the vessel has passed.

- **Probability** - low – interactions between Project-related marine vessels and commercial fishing vessels that disrupt fishing activities are considered to have a low likelihood of occurrence.
- **Confidence** - high – there is a good understanding of general cause-effect relationships between increased Project-related marine vessels and interactions with commercial fishing activities in the Marine RSA.

Alteration of Existing Marine Vessel Movement Patterns

The alteration of existing marine vessel movement patterns is a potential residual effect of interactions between the increased Project-related marine vessel traffic and other marine vessels that could occur when Project-related marine vessels (or other marine vessels) are in transit at any point in the shipping lanes . Although this potential residual effect applies to the Marine RSA in general, marine vessels in Burrard Inlet may be the most affected due to the confined nature of this marine area. In Burrard Inlet, specific procedures are in place to ensure that tankers (including Project-related tankers) and other deep draft vessels are able to navigate through Burrard Inlet safely (PMV 2010). Aframax tankers are required to transit through the Second Narrows area in daylight hours only and only during slack tides. Vessels are required to retain a minimum underkeel clearance and to ensure adequate manoeuvrability in the First and Second Narrows (PMV 2010). During transits of all piloted marine vessels in Burrard Inlet, all other vessels must keep clear of the shipping lanes. The CCG MCTS must inform any other marine vessels intending to transit through the Narrows within 20 minutes of the transit time clearance for deep sea vessels; that is, other vessels are required to keep clear and wait until the cleared vessel has transited (PMV 2010). The Harbour Master for PMV and the CCG assist in keeping other vessels clear of the channel, and communicate with smaller vessels directly if necessary (PMV 2010). In addition, for laden tankers PMV provides a “Clear Narrows” procedure that also includes the use of a port patrol craft. The increased Project-related marine vessel traffic will result in more frequent tanker transits through Burrard Inlet, and may result in delays and inconvenience for other vessels as they keep clear of the channel. A limited amount of commercial fishing (*e.g.*, for Dungeness crab) occurs in areas of Burrard Inlet; however, it is possible that increased marine vessels transits may reduce the time available for fishing activity. For all commercial operators, changes to scheduling due to vessels waiting for Project-related marine vessels to transit could have financial repercussions.

Other areas of the Marine RSA where marine vessel movement patterns have the potential to be altered by the increased Project-related marine vessel traffic include locations of navigational concern along the shipping lanes (refer to Volume 8C, TR 8C-2, TERMPOL 3.2). These areas include Turn Point, which connects Haro Strait and Boundary Pass. Vessels entering the designated Special Operating Area around Turn Point are required to be in contact with one another to avoid vessels arriving at Turn Point simultaneously. Increased marine vessel traffic in navigationally constrained areas may affect the passage of other marine vessels and lead to alteration in movement patterns.

Other designated areas in the Marine RSA that may partially overlap with the shipping lanes are used for activities such as ocean dumping, military operations or offshore exploration. Ocean dumping sites are present in the Strait of Georgia near Point Grey and at Sand Heads offshore from the mouth of the Fraser River. Mariners are notified of ocean dumping activities and active military or exploration operations through VTS

Mitigation measures recommended for this residual effect include communication measures as described in Table 4.3.11.2. Project-related marine vessels will be fully compliant with all applicable navigational, communications and safety regulations as outlined in Section 1.1 and Table 4.3.11.2.

The potential alteration of existing marine vessel movement patterns applies to all marine users and is considered to have a net negative impact balance. The duration of the event causing the altered vessel movement patterns is considered to be long-term, since the Project-related marine vessel traffic would be present for the operational life of the Project. Since changes in vessel movements may occur whenever Project-related marine vessels are transiting though the Marine RSA, the frequency of the event is periodic. Reversibility of the residual effect is long-term because marine vessels have the potential to alter their movement patterns whenever they come into contact with Project-related marine vessel traffic throughout the life of the Project. The magnitude of the residual effect is considered to be low to medium. Marine vessels may be temporarily inconvenienced by the presence of Project-related marine vessels (low), but for some commercial fishing and other commercial vessels delays could have business implications (medium). In the case of fishing vessels the route alteration could potentially result in a delay or reduction in fishing activity. For example, commercial fishing vessels may choose to alter routes to fishing grounds or between ports to avoid increased marine vessel traffic, or fishers may not be able to fish in preferred locations due to increased Project-related marine vessel traffic. This is a conservative evaluation of magnitude, however, as discussions with marine users including commercial fishing industry representatives, recreational organizations, and marine tourism operators (identified in Table 2.1.1 in the Marine Commercial, Recreational and Tourism Use – Marine Transportation Technical Report in Volume 8B, TR 8B-6) indicated that the additional marine traffic that will be generated by the Project is unlikely to materially affect the activities of most marine users in the Marine RSA.

Generally, the potential for some alternation of marine vessel traffic in consideration of Project-related marine vessels is considered likely to occur and thus of high probability. However, specific effects will vary between marine vessel types, locations in the Marine RSA and choices of individual vessel operators. For example, due to the low levels of commercial fishing effort identified in Burrard Inlet, the probability of Project related marine vessel traffic affecting commercial fishing vessel movements in this part of the Marine RSA is considered to be unlikely. However, the movements of other commercial vessels and recreational vessels accessing marinas or terminals in Burrard Inlet are considered likely to be affected by increased Project-related marine vessel traffic, due to the "Clear Narrows" procedure and the navigational constraints already present (Table 4.3.11.3, point 1[b]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – Alteration of existing marine vessel movement patterns due to interactions with increased Project-related marine vessel traffic could occur at any point in the Marine RSA and may also affect the distribution of vessels in other areas of the Marine RSA.
- **Duration** - long-term – interactions between Project-related marine vessels and other marine users would begin during the operations phase and extend for the operational life of the Project.
- **Frequency** - periodic – interactions between Project-related marine vessels and other marine users have the potential to occur intermittently; however, repeatedly over the life of the Project.

- **Reversibility** - short- to long-term – the reversibility of the residual effect could be temporary, if marine users change course to avoid Project-related marine vessels; however, the residual effect could be long-term if the user chose to alter their movement patterns to avoid all interactions with Project-related marine vessel traffic. .
- **Magnitude** - low to medium – commercial fishing vessels and other marine vessels may be temporarily inconvenienced by the presence of Project-related marine vessels (low), but delays may have business implications for some vessels (medium).
- **Probability** - high –generally, some alternation of marine vessel traffic in consideration of Project-related marine vessels is considered likely; however, the likelihood of effects will vary between marine vessel types, locations in the Marine RSA and choices of individual vessel operators.
- **Confidence** - high – there is a good understanding of general cause-effect relationships between increased Project-related marine vessel traffic and interactions with other marine users in the Marine RSA. .

Damage to Marine Vessels and/or Injury

The loss or damage to marine vessels as a result of the increased Project-related marine vessels is a negative potential residual effect that could occur at any point along the Marine LSA, for the operational life of the Project. The frequency of such events is considered to be accidental, with a low probability of occurrence. The Transportation Safety Board of Canada (TSB) is notified of marine collisions and other incidents that occur in Canadian waters when non-pleasure craft are involved, and also monitors incident statistics to identify trends and emerging safety issues (TSB 2013). In 2012, there were 236 shipping accidents reported across Canada and only 6 of the 236 accidents were collisions between vessels. However, the TSB has identified the safety of fishing vessels as an area of high concern since 45 per cent of all vessels involved in shipping accidents were fishing vessels (TSB 2013). Reported incidents involving fishing or other small vessels and cargo ships or tankers point to multiple potential causes such as lack of communications between vessels, sudden course changes, excessive speeds of the larger vessel in the presence of the smaller vessels, and poor estimation of the collision risk from both parties (TSB 2013).

Standard operating procedures that are implemented by most deep draft commercial marine vessels should aid in avoidance of collisions under most circumstances. These measures include: the widespread use of ship's radar; the compulsory use of CCG MCTS for most vessels to facilitate communications with ports and other vessels; the use of loudhailers on bridges to communicate with smaller vessels that are not registered with CCG MCTS; the compulsory use of pilots in coastal BC waters; the use of escort tugs in Haro Strait and Burrard Inlet; and other standard navigational measures. According to the IMO and as a *Canada Shipping Act* requirement it is mandatory for commercial vessels above 500 GT and SMS is currently practiced and enforced on all Project-tankers. Fishing vessels less than 24 m in length and 150 gross tonnes, and pleasure craft less than 30 m in length are not required to call in to VTS (CCG 2013a). Notices are issued by the CCG that specifically caution vessels to be aware of fishing activity at certain locations and times (CCG 2013b).

The TSB has recommended additional safety measures for commercial marine vessels, including mandatory Safety Management Systems (SMS), regardless of vessel size. SMS is a proactive system that includes regular safety drills and exercises, clear roles and responsibilities for crew, hazard identification systems and tools to improve vessel operations (TSB 2013).

The reversibility of the potential residual effect is considered to range from short-term to permanent. In the case of minimal damage, repairs could be completed in the short-term. However, in the case of vessel loss the reversibility may be long-term, and if injury or loss of life occurs the reversibility is considered to be permanent. The magnitude is, therefore, considered to be high, depending on the severity of the loss or damage to the marine vessel. Vessel damage or loss, and personal injury or loss of life, have serious ramifications for the marine user and, consequently, the magnitude of the residual effect is considered to be high (Table 4.3.11.3, point 1[c]). Vessel damage or loss can result in lost economic and long-term financial effects while the owner waits for repairs or replacement. In the case of injury, the effects equate to possible permanent loss in economic opportunity as well as family and community impacts. Compensation for vessel damages and injury are regulated under the MLA. Marine vessels carry insurance and liability is determined through the court process. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA – collisions between Project-related marine vessels and other marine users could occur at any point in the shipping lanes in the Marine LSA.
- **Duration** - long-term – the possibility of collisions between Project-related marine vessels and other marine users would be present for the operational life of the Project.
- **Frequency** - accidental – collisions between Project-related marine vessels and other marine users that result in loss or damage to the vessels are expected to occur very rarely during the operational life of the Project.
- **Reversibility** - short-term to permanent – the reversibility of a loss or damage to a marine vessel may range from less than a year to several years if the vessel is salvageable; however, for a collision which resulted in vessel loss or injury, the actual loss or injury could be considered permanent.
- **Magnitude** - high – loss or damage to a marine vessel is considered to have severe modification to the socio-economic environment.
- **Probability** - low – collisions between Project-related marine vessels and other marine users that result in vessel loss or damage are considered to be unlikely due to general compliance with standard mitigation measures as described in the above rationale.
- **Confidence** - high – there is a good understanding of general cause-effect relationships between Project-related marine vessel traffic and the possibility of collisions with other vessels, based on marine collision statistics from the TSB.

Damage or Loss of Gear

Interactions between commercial fishing vessels, recreational fishing vessels or commercial fishing guide vessels and Project-related marine vessels may cause entanglement and damage or loss of fishing gear. This potential residual effect could occur wherever Project-related marine vessel traffic is present in the Marine LSA.

Gear damage or loss could potentially occur to commercial fishers, recreational fishers, or commercial fishing guides. Gillnet fishers are one example of a marine user group that may have a higher probability of gear loss or damage from transiting Project-related marine vessels. Gillnets are deployed from fishing vessels and are attached to the vessel at one end, with the net left to hang in the water to catch fish such as herring and salmon. Gillnets are often deployed near the mouths of rivers when salmon runs are returning to the river to spawn. The far end of the net is often equipped with a light to show its position, but the nets are difficult to spot for other ships (CCG 2013b). Nets can be hundreds of metres long (CCG 2013b). Gillnetters can be present between July and November in large numbers in the Roberts Bank area at the mouth of the Fraser River, while fishing intensively for returning salmon (CCG 2013b). Gillnets can extend many hundreds of metres from the fishing vessel, and could be entangled by passing ships where the net locations are not clearly visible. Some of this area is directly in the shipping lanes in the Strait of Georgia; however, due to the mitigation already in place, incidents of nets becoming entangled with large vessels are at best, rare in their occurrence.

The commercial and recreational crab trap fisheries also have the potential for gear loss. Crab and prawn traps are deployed on long fishing lines and left in the water for hours or days (DFO 2013i). Passing vessels can become entangled in crab trap lines. A BC Ferries vessel in Skidegate, Haida Gwaii recently was out of commission on two consecutive occasions when crab trap lines became tangled around the propeller (Canadian Broadcasting Corporation 2009).

Transiting marine vessels have the potential to run into fishing gear whenever fishing activities are occurring in or near the shipping lanes. Loss or damage to fishing gear could be an inconvenience or nuisance, and assuming that compensation plans are in place, replacement or repair of gear could be quickly expedited and financial compensation supplied as appropriate. The residual effect is considered to be of low magnitude; however, if fishing activity was curtailed or reduced as a result of gear loss and financial compensation was not adequate, the magnitude of the effect would be considered to be medium.

Gear interactions with large vessels are few and far between and can be mitigated by the measures for vessel communications described in previous subsections. The CCG Annual Notices to Mariners describe specific areas where fishers are likely to be present during fishing seasons, and cautions shipping vessels to avoid fishing gear (CCG 2013b). It is also possible to surmise that fishers have already adapted their fishing patterns in keeping with the location and use of the shipping lanes and that further helps alleviate possible gear interaction with large vessels.

The potential residual effect of damage or loss of gear is considered to have a negative impact balance. Frequency of this residual effect is accidental, since damage or loss of gear as a result of Project-related marine vessel interactions is expected to occur rarely during the operational life of the Project. The reversibility is considered to be short-term since fishing gear can be repaired or replaced typically within one year, although if the fisher is not compensated for gear loss or damage the reversibility period may be longer due to resulting financial loss. The magnitude of the effect is considered to be low to medium, ranging from a temporary inconvenience (low) to a disruption in fishing activity with potential financial ramifications (medium), depending on whether gear replacement was expedient or financial compensation was adequate (Table 4.3.11.3, point 1[d]).

Damage or loss of gear is considered to have a low probability of occurrence; however, this residual effect is more likely than vessel damage or loss due to the fact that gear such as fishing nets and lines are located over a much larger area than the fishing vessel from which they are deployed and are mostly located under the sea surface. Interactions with other vessels are, therefore, considered to be more likely to result in gear damage than vessel damage; however, occurrences are still not likely to be high due to general compliance with standard mitigation measures as described above.

A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA – damage or loss of gear could occur at any point along the shipping lanes within the Marine LSA.
- **Duration** - long-term – the possibility of damage or loss of gear is present for the operational life of the Project.
- **Frequency** - accidental – damage or loss of gear as a result of Project-related marine vessel interactions is expected to occur rarely during the operational life of the Project.
- **Reversibility** - short-term – damage or loss of gear from an accidental incident involving a Project-related marine vessel is considered reversible over the short term; damage could likely be resolved within one year during the operations phase
- **Magnitude** - low to medium – loss of fishing gear from entanglement with Project-related marine vessels ranges from an inconvenience (low) to a moderate modification of the socio-economic environment (medium) depending on whether gear replacement was expedient or financial compensation was adequate.
- **Probability** - low – damage or loss of gear is considered to be unlikely, but more likely than vessel damage or loss. Stakeholder consultation will increase confidence in ascertaining the probability of this residual effect.
- **Confidence** - moderate – there is a good understanding of general cause-effect relationships between Project-related marine vessel traffic and the possibility of fishing gear damage or loss.

Disruption of Marine User Activities from Project-Related Marine Vessel Wake

The increased disruption of marine user activities from Project-related marine vessel wake is a potential residual effect that is considered to have a net negative impact balance. This potential effect refers to the possibility that marine commercial, recreational or tourism users could be disrupted in their activities from the wake of transiting Project-related marine vessels, in the event that the user is adjacent to or within the shipping lanes at the time of transit. Specific marine users that may be affected include small commercial or recreational fishing vessels, kayaks and sailboats. During the Victoria ESA Workshop, it was noted that there are occurrences where fishing vessels in the shipping lanes are severely disrupted by the wake of large commercial vessels. The bow waves of deep draft have the potential to swamp a small vessel within the shipping lane. In addition, strong underwater currents can be caused by the engines of large ships that can create water turbulence behind large vessels. Small vessels may also be difficult to identify on the ship's radar.

The increased disruption of marine user activities from Project-related marine vessel wake is considered to have a net negative impact balance. Although the spatial boundary of this potential residual effect is considered to be anywhere in the Marine LSA, specific areas where fishing or other recreational activities occur very close to the shipping lanes include the Vancouver Outer Harbour and its approach in the Strait of Georgia, the shipping lanes outside Roberts Bank at the mouth of the Fraser River, Haro Strait, the Discovery Islands and Chatham Islands groups off Victoria as well as Constance Bank, Race Rocks and Swiftsure Bank in Juan de Fuca Strait.

Wake effects from Project-related or other large marine vessel traffic are likely to affect small vessels that are too close to them. The frequency of occurrence is expected to be occasional rather than accidental, since there are many specific locations in the Marine RSA where users may be in close proximity to passing tankers in the shipping lanes. Also, some marine users may not aware of the effects that large vessels can have on smaller vessels. Reversibility is considered to be short-term, because effects on individual marine users would be limited to particular periods where Project-related marine vessels are in close proximity.

The probability of a disruption of marine user activities from Project-related marine vessel wake is considered to be low, due to the general compliance of marine users with navigational and safety regulations and if proposed mitigation measures, such as the communications measures, are followed (see Table 4.3.11.2). Nevertheless, in specific areas where this interaction has already been noted related to other large marine vessels, the increased Project-related marine vessel traffic may increase the possibility of this potential residual effect.

Confidence in the significance evaluation of this potential residual effect is moderate, due to limited examples of current interactions that small vessels have with wakes from transiting large marine vessels and the high variability of small vessel experiences. Confidence is also the result of the magnitude range, which is from low to medium (Table 4.3.11.3, point 1[e]). The range in magnitude of this effect is due to the factors such as the distance between the Project-related marine vessel and the smaller vessel, and the size and position of the smaller vessel. Therefore, the effect could range from an inconvenience to an unsafe situation for the smaller vessel. The inclusion of this effect as a potential residual effect is based on limited stakeholder consultation. Further stakeholder consultation may increase confidence. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA – disruption of marine user activities from Project-related marine vessel wake effects could occur at any point along the shipping lanes in the Marine LSA.
- **Duration** - long-term – the disruption of marine user activities from Project-related marine vessel wake effects would be present for the operational life of the Project.
- **Frequency** - occasional – vessels are likely to be situated close enough to passing Project-related marine vessels that wake effects are felt only intermittently and sporadically over the assessment period.
- **Reversibility** - short-term – the disruption of marine user activities from an incident involving the wake from a Project-related marine vessel will occur only when the vessels are in close proximity.

- **Magnitude** - low to medium – Project-related marine vessel wake effects are considered to have a low to medium magnitude, ranging from an inconvenience (low) to a dangerous situation for the smaller vessel (medium).
- **Probability** - low – Project-related marine vessel wake effects may affect small vessels that are too close to transiting Project-related marine vessels; however, the probability is considered to be low (unlikely to occur) given the general compliance of marine users with navigational and safety regulations and the implementation of proposed mitigation measures. The increased Project-related marine vessel traffic may increase the probability of this potential residual effect.
- **Confidence** - moderate – there is a good understanding of the general cause-effect relationships between Project-related marine vessel wake and other marine users; however, confidence is based on limited examples of current interactions that small vessels have with wakes from transiting large marine vessels and the high variability of small vessel experiences (see earlier discussion in Section 4.3.6).

Lost or Reduced Economic Opportunity for Marine Commercial Users

The lost or reduced economic opportunity could apply to commercial fishers, marine transportation users, and tourism users. Lost economic opportunities to marine users could result from: damage or loss of marine vessels; damage to fishing gear; injury; physical displacement of marine users from the presence of Project-related marine vessels in transit or occupying anchorages within the Marine RSA; or a decrease in marine tourism customers related to the presence of Project-related marine vessels.

Commercial fishers that participate in fisheries with short seasons and limited openings such as the Fraser River sockeye salmon fishery and the roe herring fishery may be particularly vulnerable to financial losses, from lost economic opportunity. These fisheries often have single, brief annual openings when fishing is permitted. A lost opportunity due to an interaction with a Project-related marine vessel could result in a period of lost wages for the ship's captain and crew. Vessel damages to a whale-watching operator resulting from an interaction with a Project-related marine vessel may result in a lost economic opportunity if the operator cannot book tours while repairs are underway. However, such occurrences would be rare as tankers and accompanying tugs will be actively transiting through the shipping lanes and be in any one location only briefly. Lost or reduced economic opportunities are, therefore, expected to be minor as a result of interactions with Project-related marine vessels, and economic loss would only occur if the marine activity was prevented or severely disrupted.

Mitigation measures for this potential residual effect include compliance with the mitigation measures to avoid marine collisions (see Table 4.3.11.2). Marine liability law requires all marine vessels to have insurance, and liability is determined through the courts.

Lost or reduced economic opportunity is an indirect residual effect which is considered to have a negative impact balance. The frequency would be accidental, since this indirect effect would be a direct result of accidental interactions between Project-related marine vessels and other marine users.

The reversibility of the effect is short to medium-term, since the financial losses from lost economic opportunity could occur at any time throughout the operational life of the Project but would depend on the severity of the accident or the particular interaction. The magnitude of the economic loss depends on the severity of the incident, and could range from low to high. A severe incident between vessels may have notable effects on the livelihood of commercial fishers or other marine vessel operators (Table 4.3.11.3, point 1[f]). The probability of this residual effect is considered to be low due to compliance of the majority of marine users with applicable navigational regulations (Table 4.3.11.2). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – Financial loss due to lost economic opportunity could occur at any point in the Marine RSA.
- **Duration** - long-term – the possibility of lost economic opportunities due to interactions with Project-related marine vessels would be present for the operational life of the Project.
- **Frequency** - accidental – interactions with Project-related marine vessel traffic causing economic loss would be a rare occurrence.
- **Reversibility** - short- to medium-term –lost economic opportunities caused by accidental interactions between Project-related marine vessels and other marine vessels is reversible over the short or medium-term, depending on the severity of the accident or extent of the interaction. Magnitude: low to high – the indirect effect of economic loss may have mild or severe effects on the livelihood of commercial fishers. Compensation plans would reduce the magnitude of this effect; however, such plans are outside the responsibility of KMC.
- **Magnitude** - low to high – the indirect effect of economic loss may have mild or severe effects on the livelihood of commercial fishers. Compensation plans would reduce the magnitude of this effect; however, such plans are outside the responsibility of KMC.
- **Probability** - low – interactions between Project-related marine vessels and other marine users that result in economic loss are considered to be unlikely.
- **Confidence** - high – there is a good understanding of general cause-effect relationships between lost or reduced fishing opportunity resulting in economic loss for marine vessel operators.

Increased Sensory Disturbance to Marine Users

The increased sensory disturbance to marine users is a potential residual effect that could occur for all marine use categories. Sensory disturbance will predominantly apply to marine recreational users and clients of marine tourism operators as it pertains to the quality of their experience. The effect could apply to commercial fishers though it is likely to be less of a concern.

Since this residual effect refers to a sensory disturbance, the effect is not likely to extend far from the actual transit path of Project-related marine vessels. The visual effect of Project-related marine vessels transiting through the shipping lanes may be a nuisance to other marine users; however, once the tanker has passed, the nuisance effect quickly declines. The nuisance residual effect of dock lighting, noise and other sensory disturbance at the Westridge Marine

Terminal is considered separately as part of the human occupancy and resource use effects assessment in Section 7.6 of Volume 5B.

Aside from the visual effect of the increased presence of Project-related marine vessel traffic, the sensory disturbances related to noise and air emissions warrant separate discussion. The noise of a passing large vessel (including tankers) emanates from the ship's engines, and depending on the size and actual transit speed of the vessel may be heard from a distance. Another source of noise is the anchor chain being dropped or hauled in while vessels are anchoring, which may cause concern to residents near anchorage areas around the Westridge Marine Terminal and outer Vancouver Harbour (see Section 4.3.5). The potential residual effects of underwater noise on marine species that rely on sound for their orientation, such as killer whales, are assessed in Section 4.3.7

Exhaust emissions from large, deep draft ships are a source of air pollution. Mitigation is already in place through creation of the North American Emission Control Area (ECA) that requires all vessels passing within 200 NM of the coast to only use higher quality fuel. The standards are expected to progressively improve when additional regulations come in to force in 2015 and 2020 respectively. The significance of the effects of emissions from Project-related marine vessels is assessed separately in Section 4.3.3 and Section 4.3.4. In terms of sensory disturbance, the exhaust from Project-related marine vessels is considered to be a nuisance effect while the vessels are transiting near the affected marine user, and may remain a nuisance for a period after the ship has moved past depending on local winds and other microclimate factors (Section 4.3.3).

The increased sensory disturbance to marine users is considered to have a negative impact balance. The spatial boundary is the Marine LSA, since the effect could occur anywhere in or near the shipping lanes. The duration of the event causing increased sensory disturbance to marine users is the increased Project-related marine vessel traffic over the operational life of the Project which is considered to be long-term. The frequency is periodic since the effect would potentially occur only whenever Project-related marine vessels are nearby. As with many other potential residual effects of increased marine vessel traffic, the nuisance effect presumably applies equally to other deep sea vessels transiting through the Marine LSA.

The reversibility of this residual effect is short-term, since the effect would only occur when Project-related marine vessels are transiting near the marine user. Magnitude of this effect would be low because the sensory disturbance from one tanker would be specific to the proximity of the tanker, temporary, and reversible (Table 4.3.11.3, point 1[g]). The residual effect is considered to be likely for marine recreational and tourism users and unlikely for commercial users. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA – negative sensory disturbance (*e.g.*, visual effects, noise, and air quality) from increased Project-related marine vessel traffic on other marine users could occur at any point in the shipping lanes in the Marine LSA.
- **Duration** - long-term – interactions between Project-related marine vessels and other marine users will begin during the operations phase and extend for the operational life of the Project.
- **Frequency** - periodic – the event causing an increase in sensory disturbance to marine users is presence of Project-related marine vessels, which will be

present in any given part of the Marine LSA intermittently but repeatedly throughout the operations phase of the Project.

- **Reversibility** - short-term – the sensory disturbance to marine users and the consequent quality of the marine user's experience will occur only when Project-related marine vessels are in close proximity to the user.
- **Magnitude** - low – sensory disturbance would be temporary, site-specific and reversible, and the nuisance effect would occur only when Project-related marine vessels are actively transiting areas where other marine users are present.
- **Probability** - high – it is likely that low-level sensory disturbance will occur for nearby marine users while Project-related marine vessels are transiting.
- **Confidence** - high – there is a good understanding of general cause-effect relationships and data pertinent to the study area.

Combined Effects of Increased Project-Related Marine Vessel Traffic on Commercial Fishing

An evaluation of the combined effects considers those residual socio-economic effects that are likely to occur. For the commercial fishing indicator, likely residual socio-economic effects include alteration of existing marine vessel movement patterns and increased sensory disturbance to marine users (Table 4.3.11.3, points 1[b] and 1[g]). The remaining potential residual effects are unlikely to occur and, consequently, were not considered in the evaluation of the combined effects on the commercial fishing se indicator.

Potential effects on commercial fishing vessels may be limited to the Marine LSA related to sensory disturbance from transiting Project-related marine vessels, but effects related to alteration of movement patterns could occur at any point in the Marine RSA and may also affect the distribution of vessels in areas of the Marine RSA. The duration of the potential combined residual effect on commercial fishing is considered long-term, as it is caused by the presence of Project-related marine vessels throughout the operational life of the Project. The frequency of the potential effect is considered periodic, since Project-related marine vessels will be present at particular points in the Marine RSA intermittently but repeatedly over the assessment period; consequently, Project-related marine vessels will transit any particular area where commercial fishing vessels may be present in a relatively brief period of time. The magnitude of the combined effect is considered low to medium. Sensory effects and alteration of movement patterns are likely to only represent an inconveince or nuisance for many commercial fishing operators who interact with Project-related marine vessels (low magnitude). However there is potential for alternation of movement patterns to result in business implications if fishers miss a catch opportunity due to delays or changes in access to select fishing locations at times (medium magnitude) (Table 4.3.11.3, point 1(h)). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA to RSA – negative sensory disturbance (e.g., visual effects, noise, and air quality) from increased Project-related marine vessel traffic could occur at any point in the shipping lanes in the Marine LSA. Potential effects related to alteration of movement patterns could occur at any point in the Marine RSA and may also affect the distribution of vessels in areas of the Marine RSA.

- **Duration** - long-term – interactions between Project-related marine vessels and other marine users will begin during the operations phase and extend for the operational life of the Project.
- **Frequency** - periodic – interactions between Project-related marine vessels and other marine users have the potential to occur intermittently, however, repeatedly over the life of the Project.
- **Reversibility** - long-term – the potential residual effects on commercial fishing will occur throughout the operational life of the Project; however specific interactions will occur only when Project-related marine vessels are in close proximity to the user.
- **Magnitude** - low to medium – commercial fishing vessels may be temporarily inconvenienced by the presence of Project-related marine vessels (low), but delays may have business implications for some commercial fishing operators at select times (medium).
- **Probability** - high – it is likely that the combined effects on commercial fishing, as characterized, will occur for some operators.
- **Confidence** - high – there is a good understanding of general cause-effect relationships and data pertinent to the study area.

4.3.11.6.2 Marine Commercial, Recreational and Tourism Use Indicator – Marine Transportation

The following subsection provides a discussion of the significance rationale for potential residual effects related to the Marine Transportation indicator.

Disruption to Rail Traffic on CN Rail Bridge at Second Narrows

The rail bridge at the Second Narrows in Burrard Inlet is operated by CN Rail, and is used by freight trains between Vancouver and North Vancouver, bound for terminals on the North Shore. Larger marine vessels including Project-related tankers require that the bridge be raised to accommodate passage through the Second Narrows. The CN Rail bridge operator is expected to make the bridge available to marine traffic with the lift span elevated within 30 minutes prior to the estimated time of arrival of a marine vessel (PMV 2010). Increased Project-related marine vessel traffic in the Second Narrows will cause an increase in the number of bridge lift span elevations, which may cause delays for freight trains using the bridge.

This potential residual effect of rail delays on the CN Bridge constitutes a general disruption to rail traffic, and is considered to have a negative impact balance. The spatial boundary is considered to be specific only to the bridge crossing within the Marine LSA since the residual effect is otherwise terrestrial and is outside the Marine LSA.

The reversibility of this effect is long-term (Table 4.3.11.3, point 2[a]). Bridge lift span elevations will be required by all Project-related tankers, and it is unlikely that the bridge will be replaced or that rail traffic will be re-routed elsewhere. The magnitude of the increased disruption of rail traffic is considered to be medium, because the change is clearly detectable in terms of increased rail bridge lift span elevations and the disruption to bridge traffic has commercial implications. Rail bridge operations can be resumed whenever the span is lowered. Confidence in this significance evaluation is high, because there is a good understanding of cause-effect relationships and of the data pertinent to the study area. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA specific to CN Rail Bridge at Second Narrows, Burrard Inlet – rail delays on the CN Rail Bridge at the Second Narrows in Burrard Inlet will only occur at that specific location.
- **Duration** - long-term – the event causing the disruption of train traffic on the CN Rail Bridge is the transit of Project-related marine vessels which occurs throughout the operational life of the Project.
- **Frequency** - periodic – bridge lift span elevations would be required for every transiting Project-related tanker from the Westridge Marine Terminal. The event causing the disruption of train traffic on the CN Rail Bridge is the transit of Project-related marine vessels which occurs intermittently and is repeated throughout the operational life of the Project.
- **Reversibility** - short-term – the periodic disruption of train traffic on the CN Rail Bridge will occur when Project-related marine vessels are transiting through Burrard Inlet
- **Magnitude** - medium – although the change is clearly detectable in terms of increased rail bridge lift span elevations, the magnitude is considered to be medium, since bridge operations will be able to continue whenever the span is lowered.
- **Probability** - high – the likelihood of occurrence of this residual effect is high, since the elevation of the lift span is required for the passage of Project-related marine vessel traffic.
- **Confidence** - high – there is a good understanding of cause-effect relationships and of the data pertinent to the study area.

Damage to Built Infrastructure, Marine Facilities or Shorelines

Damage to built infrastructure, marine facilities, or shorelines as a result of the movements of Project-related marine vessel traffic is a potential residual effect considered to have a negative impact balance. The potential effect could occur anywhere in the Marine RSA where other marine structures or facilities are present in or near the shipping lanes. However, interactions specifically associated with the operations phase are primarily discussed with respect to Burrard Inlet, where the narrow marine area contains multiple bridges and related infrastructure, marinas, navigational aids, docks and many other marine facilities.

The potential residual effect is the result of accidental vessel strikes by Project-related marine vessels to marine infrastructure, and by definition the frequency is expected to be rare. The highest potential for vessel strikes is expected to be in the First and Second Narrows of Burrard Inlet and vessel strikes on marine infrastructure in this area have occurred in the past. In October of 1979, the ship *Japan Erica* struck the CN Rail Bridge at the Second Narrows and caused extensive damage. It was estimated at the time that the accident would reduce harbour capacity for grain exports by 15 percent. In 1979, the rail bridge was the only link between the grain storage silos on the North Shore and mainline CN and CP rail grain cars arriving from the

Canadian Prairies (Montreal Gazette 1979). Over Westridge Marine Terminal's 60 year operating history, there have been no known occurrences of marine vessels associated with the existing operations striking marine infrastructure in Burrard Inlet. The existing mitigation measures continue to provide significant alleviation to concerns of a vessel strike against the CN Rail Bridge.

The reversibility of any damage to built infrastructure, marine facilities or shorelines is considered short- to medium-term since the physical damage would likely be remediated over a relatively brief time period, depending on the degree of impact. The magnitude of such an accident is considered to range from low to high. A minor collision would likely have few repercussions, but a major impact may represent a severe modification to the socio-economic environment and have repercussions for commercial operations (Table 4.3.11.3, point 2[b]). The probability of accidental vessel strikes is considered to be low, given the safety regulations in place for transits of large vessels through Burrard Inlet. PMV has specific regulations in place for the safe navigation of large vessels, including the presence of marine pilots, multiple tugs for assisting and manoeuvring vessels in the event of a rudder malfunction or other potential problems, and transiting only in daylight and at high slack tides to avoid tidal currents and for adequate clearance with the sea floor (PMV 2010).

A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA specific to Burrard Inlet – damage to built infrastructure, marine facilities, or shorelines from strikes by Project-related marine vessels is assessed for Burrard Inlet because many marine facilities and other infrastructure are located in this region of the Marine LSA.

- **Duration** - long-term – the event causing the damage to built infrastructure, marine facilities or shorelines is the increased Project-related marine vessel traffic during the operations phase of the Project.

- **Frequency** - accidental – damage related to Project-related marine vessels would be a rare occurrence.

- **Reversibility** - short- to medium-term – the damage to built infrastructure, marine facilities or shorelines from an incident involving a Project-related marine vessel is reversible over the short or medium term, depending on the severity of the accident.

- **Magnitude** - low to high – a minor impact is likely to have minor repercussions (low), however, severe damage to marine infrastructure will result in a severe modification to the socio-economic environment (high)

- **Probability** - low – with the safety regulations in place for the transits of large marine vessels through Burrard Inlet, and the proven safety track record of marine vessels currently calling on Westridge Marine Terminal, it is unlikely that increased Project-related marine vessel traffic will cause damage to built infrastructure, marine facilities or shorelines.

- **Confidence** - high – there is a good understanding of the cause-effect relationships and of the data pertinent to the study area.

Alteration of Existing Marine Vessel Movement Patterns

Project-related tankers anchor in designated anchorages located in English Bay, the Inner Harbour and southern Indian Arm (PMV 2010). Outbound tankers and other deep draft marine vessels which miss the appropriate tidal window for transit must remain anchored in designated anchorage areas in English Bay until the next window is available.

If designated anchorages in PMV are fully occupied, inbound vessels must adjust their arrival times until a berth becomes available, or request alternative anchorages such as those managed by the Port of Nanaimo. With the increased Project-related marine vessel traffic, more anchorage areas may be required. An increase in commercial anchorages is likely to cause displacement of other users from these areas and a may lead to modification of the movement patterns of marine users. The Project does not seek to request any increases to the existing number of designated anchorage locations.

Passenger ferry vessels operated by BC Ferries, Washington State Ferries, the Alaska State Ferries and other private companies that use or cross the shipping lanes may be occasionally required to adjust their preferred routes due to the passage of Project-related marine vessels, as may be needed in the existing environment for other vessels. Passenger ferries must cross the shipping lanes at points in the Strait of Georgia, Haro Strait, and Juan de Fuca Strait, to access ports between Vancouver Island and the Lower Mainland or the US. Deep draft vessels have the right-of-way in the shipping lanes, and it is the responsibility of other ships that cross the shipping lanes to plan for route diversions, if necessary. The increase in marine vessel traffic resulting from the Project may cause short-term delays for passenger ferries in the straits, if vessels are required to chart a longer course or wait for marine vessels to pass.

The increased Project-related marine vessel traffic may result in the alteration of existing vessel movement patterns in relation to marine transportation users. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 2[c]). Readers should refer to the more detailed discussion of this residual effect, which includes marine transportation users as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Damage to Marine Vessels and/or Injury

The increased Project-related marine vessel traffic may result in damage to marine vessels and or injury in relation to other marine commercial users. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 2[d]). Readers should refer to the more detailed discussion of this residual effect, which includes other marine commercial users as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Lost or Reduced Economic Opportunity for Marine Commercial Users

The increased Project-related marine vessel traffic may result in lost or reduced economic opportunity in relation to other marine commercial users. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 2[e]). Readers should refer to the more detailed discussion of this residual effect, which includes other marine commercial users as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Transportation

An evaluation of the combined effects considers those residual socio-economic effects that are likely to occur. For the marine transportation indicator, likely residual socio-economic effects include disruption to rail traffic on CN Rail bridge at Second Narrows and alteration of existing marine vessel movement patterns (Table 4.3.11.3, points 2[a] and 2[c]). The remaining potential residual effects are unlikely to occur and, consequently, were not considered in the evaluation of the combined effects on the other marine commercial use indicator.

The impact balance of the combined residual effects to the marine transportation indicator is negative. The lifting of the CN Rail Bridge at the Second Narrows in Burrard Inlet is required for passage of Project-related marine vessel traffic, and other marine vessels must stay clear of the area between the First and Second Narrows when vessels such as Aframax tankers are in transit.

Other marine vessels could be displaced by Project-related marine vessel traffic and may be inconvenienced or may need to occasionally alter their preferred routes or timing of transit. The duration of Project-related marine vessel traffic is long-term, extending over the life of the Project, and the frequency of the effect is considered periodic, since Project-related marine vessels will be transiting intermittently but repeatedly through the Marine RSA. The magnitude is low to medium; although effects on some users may constitute only a nuisance (low), effects on some marine commercial users may be detectable and may constitute restrictions on passage of marine vessels due to increased bridge span lifts, delays in rail transits across the CN Rail Bridge, and alteration in marine vessel movements (medium). These effects are considered to be likely, in particular in Burrard Inlet in the context of the geographical and navigational constraints already present. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA to RSA -– rail delays on the CN Rail Bridge at the Second Narrows in Burrard Inlet will only occur at that specific location in the Marine LSA around Second Narrows in Burrard Inlet; potential effects related to alteration of movement patterns could occur at various points in the Marine RSA.
- **Duration** - long-term – the event causing the combined residual effects on the marine transportation indicator is the transit of Project-related marine vessels which occurs throughout the operational life of the Project.
- **Frequency** - periodic – the event causing the combined residual effects on the marine transportation indicator is the transit of Project-related marine vessels which occurs intermittently and is repeated throughout the operational life of the Project.
- **Reversibility** - long-term – overall, the combined residual effects will occur periodically throughout the operational life of the Project; however specific interactions will occur only when Project-related marine vessels are in close proximity to the user.
- **Magnitude** - low to medium – the combined residual effects will be at a minimum a nuisance (low); however, the effects may have business

implications for some commercial vessel operators and rail bridge users (medium).

- **Probability** - high – the occurrence of combined residual effects on the marine transportation indicator is considered to be likely,
- **Confidence** - high – there is a good understanding of the cause-effect relationships and of the data pertinent to the study area.

4.3.11.6.3 Marine Commercial, Recreational and Tourism Use Indicator – Marine Recreational Use

The following subsection provides the significance rationale for potential residual effects related to the marine recreational use indicator.

Negative User Perspectives of Increased Project-related Marine Vessel Traffic

Increased Project-related marine vessel traffic may result in negative user perspectives for marine recreational users, including boaters, paddlers (kayakers and canoeists), recreational fishers and scuba divers. This potential residual effect is included in the assessment as a result of comments from participants at the Victoria and Vancouver ESA Workshops. Participants stated concern about the anticipated increased Project-related marine vessel traffic due to a negative perception of oil tanker traffic, without specific objective views other than the increased possibility of oil spills.

This potential residual effect is considered to have a negative impact balance. Consultation and engagement conducted supported this impact balance assessment. The spatial boundary of this potential residual effect is expected to be the Marine RSA. Unlike a sensory disturbance effect, a negative perspective of Project-related marine vessel traffic is not limited to being physically near transiting tankers; however, is the result of the marine user's knowledge that oil tankers are present in BC coastal waters. Therefore, the frequency is continuous.

The duration is long-term since tankers will be present in regional marine waters for the operational life of the Project. The reversibility is also long-term since the increased Project-related traffic may remain a nuisance to some marine users for the operational life of the Project, whether or not tankers are physically present. The magnitude of this effect is low since the effect is considered to be that of a nuisance for some marine users. It is considered to be likely that this effect will continue to occur, given that the proposed Project has already generated diverse points of view in the media (Table 4.3.11.3, point 3[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – Negative user perspectives of increased Project-related marine vessel traffic could occur at any point in the Marine RSA.
- **Duration** - long-term – the event resulting in negative user perspectives of increased Project-related marine vessel traffic will occur for the operational life of the Project.
- **Frequency** - continuous – user perspectives depend upon the knowledge that Project-related marine vessels are present; therefore, the frequency of this effect is continual over the assessment period.

- **Reversibility** - long-term – the residual effect is expected to be present as long as the Project is in operation.
- **Magnitude** - low – the presence of Project-related marine vessels will be a nuisance to some marine users.
- **Probability** - high – the presence of Project-related marine vessels is likely to cause negative user perspectives.
- **Confidence** - moderate – feedback from Project engagement and in the media indicates this potential residual effect will be likely for some stakeholders; however individual perspectives are highly variable.

Alteration of Existing Marine Vessel Movement Patterns

Recreational users and tourism operators may change their movement patterns in order to avoid Project-related marine vessel traffic, if the increase is perceived to have a negative effect on the quality of their experience. For recreational users, this may lead to long-term avoidance of certain areas that are near the shipping lanes. For example, recreational fishers in Juan de Fuca Strait often travel to the area around Swiftsure Bank, in the middle of the channel northwest of Cape Flattery, for high quality fishing for salmon, halibut and other species. The increased Project-related marine vessel traffic may reduce the quality of this experience. Another example is the area around Constance Bank, south of Victoria Harbour, where the shipping lanes overlap popular fishing areas. As the locations of Project tankers will always be available to subscribers to the ship tracking website, commercial fishing guides and others may alter movement patterns to avoid increased Project-related marine vessel traffic.

The increased Project-related marine vessel traffic may result in the alteration of existing vessel movement patterns in relation to some marine recreational users. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 3[b]). Readers should refer to the more detailed discussion of this residual effect, which includes marine recreational users as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Damage to Built Infrastructure, Marine Facilities or Shorelines

The increased Project-related marine vessel traffic may result in damage to built infrastructure, marine facilities or shorelines in relation to marine recreational users. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 3[c]). Readers should refer to the more detailed discussion of this residual effect, which includes marine recreational users as well as other marine user types, under the marine transportation indicator provided above for an explanation of the rationale of the significance criteria.

Damage to Marine Vessels and/or Injury

The increased Project-related marine vessel traffic may result in damage to marine vessels and or injury in relation to marine recreational users. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 3[d]). Readers should refer to the more detailed discussion of this residual effect, which includes marine recreational users as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Damage or Loss of Gear

The increased Project-related marine vessel traffic may result in damage or loss of gear in relation to marine recreational users. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 3[e]). Readers should refer to the more detailed discussion of this residual effect, which includes marine recreational users as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Disruption of Marine User Activities from Project-Related Marine Vessel Wake

Disruption of marine user activities from project-related marine vessel wake in relation to marine recreational users is considered to be not significant (Table 4.3.11.3, point 3[f]). The significance rationale for this residual effect applies to all marine users and is previously discussed in an integrated manner under the commercial fisheries indicator.

The increased Project-related marine vessel traffic may result in disruption of marine recreational activities from Project-related marine vessel wake. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 3[f]). Readers should refer to the more detailed discussion of this residual effect, which includes marine recreational users as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Increased Sensory Disturbance to Marine Users

Increased sensory disturbance from Project-related marine vessel traffic in relation to marine recreational users is considered to be not significant (Table 4.3.11.3, point 3[g]). The significance rationale for this residual effect applies to all marine users and is previously discussed in an integrated manner under the commercial fisheries indicator.

The increased Project-related marine vessel traffic may result in increased sensory disturbance to marine users in relation to marine recreational users. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 3[g]). Readers should refer to the more detailed discussion of this residual effect, which includes marine recreational users as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Combined Effects of Increased Project-Related Marine Vessel Traffic on Marine Recreational Use

An evaluation of the combined effects considers those residual socio-economic effects that are likely to occur. For the marine recreational use indicator, likely residual socio-economic effects include negative user perspectives of increased Project-related marine vessel traffic, alteration of existing marine vessel movement patterns and increased sensory disturbance to marine users (Table 4.3.11.3, points 3[a], 3[b] and 3[g]). The remaining potential residual effects are unlikely to occur and, consequently, were not considered in the evaluation of the combined effects on the marine recreational use indicator.

The likely combined residual effects on marine recreational users may be felt anywhere along the shipping lanes and other areas of the Marine RSA, All likely residual effects may be more pronounced in Burrard Inlet where marine users are likely to be affected to some degree by increased transits of large ships. Marine vessels greater than approximately 10 m in height based in marinas around the Second Narrows area may be affected by increased openings of the CN Rail Bridge, if increased Project-related marine vessel traffic reduces the daily opportunities for the passage of other vessels. Other marine users may be more aware of Project-related marine vessel transits in Burrard Inlet due to existing navigational constraints and so the area may have the most negative user perspectives due to close proximity to Project operations.

The duration of the event is long-term. The frequency of vessel transits will be periodic, occurring intermittently but repeatedly over the life of the Project. The effects may be an inconvenience to some users, causing effects such as delays to travel plans or general negative perspectives on the Project. The reversibility of the effects is considered to be long-term in general since effects will occur over the life of the Project. For sensory disturbance the reversibility is short-term as the nuisance effect is specifically related to the proximity of marine tankers. If long-term changes in preferred routes occur as a result of the Project, indirect impacts on local marinas or other businesses are possible. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA to RSA – negative sensory disturbance (e.g., visual effects, noise, and air quality) from increased Project-related marine vessel traffic could occur at any point in the shipping lanes in the Marine LSA. Potential effects related to alteration of movement patterns could occur at any point in the Marine RSA and may also affect the distribution of vessels in areas of the Marine RSA.

- **Duration** - long-term – the event causing the combined residual effects on marine recreational use indicator is the transit of Project-related marine vessels which occurs throughout the operational life of the Project.

- **Frequency** - periodic to continuous – the passage of Project-related marine vessel traffic that could cause disruption to marine recreational use will occur intermittently; however, repeatedly over the life of the Project. The overall presence of Project-related marine vessels in the Marine RSA may be viewed as continuously affecting negative user perspectives.

- **Reversibility** - long-term – the combined residual effects will occur throughout the operational life of the Project; however, specific interactions will occur only when Project-related marine vessels are in close proximity to the user.

- **Magnitude** - low to medium – the combined residual effects are detectable by marine recreational users. In most cases the effects are likely to represent only an inconvenience to those affected; however, if marine recreational users alter preferred routes the magnitude may be considered to be medium.

- **Probability** - high – the occurrence of combined residual effects on marine recreational users is considered to be likely,

- **Confidence** - high – there is a good understanding of the cause-effect relationships and of the data pertinent to the study area.

4.3.11.6.4 Marine Commercial, Recreational and Tourism Use Indicator – Marine Tourism Use

The following subsection provides the significance rationale for potential residual effects related to the marine tourism use indicator.

Decrease in Marine Tourism

It is perceived by some that increased marine vessel traffic from Project operations may indirectly lead to a decrease in marine tourism. This potential residual effect is included in the assessment as a result of comments received from the Vancouver and Victoria ESA Workshops. The comments were in reference to the operations phase of the Project and not specific to accidents or malfunctions. Participants referred to the image of BC as an international ecotourism destination with unspoiled wilderness attributes, and questioned whether increasing oil tankers in BC coastal waters would present an unfavourable image of BC to the world. The possibility of a decrease in marine tourism relates to the negative user perspectives of increased Project-related marine vessel traffic under the marine recreational use indicator.

This potential residual effect is considered to have a negative impact balance within the Marine RSA. The potential decrease in marine tourism that could be attributed to increased Project-related marine vessel traffic would occur for the operational life of the Project, and, therefore, is considered to be reversible in the long-term. The magnitude of this potential residual effect, should it occur, is considered medium; if a decline in coastal and marine tourism can be specifically attributed to increased Project-related marine vessel traffic then this residual effect is more than a nuisance or inconvenience (Table 4.3.11.3, point 4[a]).

The probability that this effect will occur is considered to be low; tankers have been transiting in the Marine RSA for 60 years, co-existing with the tourism industry. Any decrease in tourism could have any number of contributing factors and it is unlikely that increased Project-related marine vessel traffic could be directly attributed to a decline. Discussion with tourism organizations and marine tourism operators listed in Table 2.1.1 in the Marine Commercial, Recreational and Tourism Use – Marine Transportation Technical Report (Volume 8B, TR 8B-6) support this conclusion. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – a decrease in marine tourism activities could occur throughout the Marine RSA.
- **Duration** - long-term – the event resulting in a potential decrease in marine tourism use is the increased Project-related marine vessel traffic, which will occur for the operational life of the Project.
- **Frequency** - continuous – the decrease in marine tourism activities as a result of increased Project-related marine vessel traffic would occur continually over the assessment period.
- **Reversibility** - long-term – this residual effect is expected to continue over the operational life of the Project.

- **Magnitude** - medium – any decline in marine tourism, if it were to occur, would constitute a detectable modification to the socio-economic environment considered to be beyond that of a nuisance or inconvenience.
- **Probability** - low – the residual effect is considered to be unlikely, since tankers have been transiting in the Marine RSA for almost 60 years co-existing with the marine tourism industry.
- **Confidence** - high –there is a good understanding of the potential cause-effect relationship between the presence of Project-related marine vessels and a perceived decrease in marine tourism activities.

Alteration of Existing Marine Vessel Movement Patterns

Tourism operators may change their movement patterns in order to avoid Project-related marine vessel traffic, if the increase is perceived to have a negative effect on the quality of their clients' experience. This may lead to long-term avoidance of certain areas that are near the shipping lanes. For example, fishers in Juan de Fuca Strait often travel to the area around Swiftsure Bank, in the middle of the channel northwest of Cape Flattery, for high quality fishing of salmon, halibut and other species. The increased Project-related marine vessel traffic may reduce the quality of this experience. Commercial fishing guides may alter movement patterns to avoid increased Project-related marine vessel traffic.

The increased Project-related marine vessel traffic may result in the alteration of existing vessel movement patterns in relation to marine tourism use. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 4[b]). Readers should refer to the more detailed discussion of this residual effect, which includes marine tourism use as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Damage to Built Infrastructure, Marine Facilities or Shorelines

The increased Project-related marine vessel traffic may result in damage to built infrastructure, marine facilities or shorelines in relation to marine tourism use. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 4[c]). Readers should refer to the more detailed discussion of this residual effect, which includes marine tourism use as well as other marine user types, under the other marine commercial use indicator provided above for an explanation of the rationale of the significance criteria.

Damage to Marine Vessels and/or Injury

The increased Project-related marine vessel traffic may result in damage to marine vessels and or injury in relation to marine tourism use. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 4[d]). Readers should refer to the more detailed discussion of this residual effect, which includes marine tourism use as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Damage or Loss of Gear

The increased Project-related marine vessel traffic may result in damage or loss of gear in relation to marine tourism use. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 4[e]). Readers should refer to the more detailed discussion of this residual effect, which includes marine tourism use as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Lost or Reduced Economic Opportunity for Commercial Marine Users

The increased Project-related marine vessel traffic may result in lost or reduced economic opportunity in relation to marine tourism use. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 4[f]). Readers should refer to the more detailed discussion of this residual effect, which includes marine tourism use as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Disruption of Marine User Activities from Project-Related Marine Vessel Wake

The increased Project-related marine vessel traffic may result in disruption of marine user activities from Project-related marine vessel wake in relation to marine tourism use. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 4[g]). Readers should refer to the more detailed discussion of this residual effect, which includes marine tourism use as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Increased Sensory Disturbance to Marine Users

Increased sensory disturbance from project-related marine vessel traffic in relation to marine tourism users is considered to be not significant (Table 4.3.11.3, point 4[h]). The significance rationale for this residual effect applies to all marine users and is previously discussed in an integrated manner under the commercial fisheries indicator.

The increased Project-related marine vessel traffic may result in increased sensory disturbance to marine users in relation to marine tourism use. The significance evaluation of this residual effect is provided in Table 4.3.11.3 (point 4[h]). Readers should refer to the more detailed discussion of this residual effect, which includes marine tourism use as well as other marine user types, under the commercial fishing indicator provided above for an explanation of the rationale of the significance criteria.

Combined Effects of Project-Related Marine Vessel Traffic on Marine Tourism Use

An evaluation of the combined effects considers those residual socio-economic effects that are likely to occur. For the marine tourism use indicator, likely residual socio-economic effects include alteration of existing marine vessel movement patterns and increased sensory disturbance to marine users (Table 4.3.11.3, points 4[b] and 4[h]). The remaining potential residual effects are unlikely to occur and, consequently, were not considered in the evaluation of the combined effects on the marine tourism use indicator.

The likely combined residual effects on marine tourism users are considered to have a negative impact balance. Marine tourism use takes place throughout the Marine RSA. Tourism users may be in the shipping lanes to access destinations throughout the region. Of the many types of marine tourism users, commercial fishing charters may be affected for short durations for access to preferred fishing grounds near the shipping lanes when a tanker passes a particular location.

The duration of the event is long-term because tourism operators could be affected by the presence of Project-related marine vessel traffic throughout the life of the Project. The passage of Project-related marine vessels will be periodic as vessels will be present at any point in the Marine RSA only intermittently and briefly, but repeatedly, thoughout Project operations. The reversibility of the effects is considered to be long-term in general, since Project-related marine vessels will be present over the life of the Project; however effects related to sensory disturbance will only occur for specific times when in the proximity of Project-related marine vessels. The magnitude of the combined effects is low to medium. In most cases effects are likely to only represent an inconvenience or nuisance for tourism-related marine vessels (low); however, if the increased Project-related marine vessel traffic implications for business practices of some operators (medium) (Table 4.3.11.3, points 4[i]. For example, if the Project-related marine vessel traffic has a significant negative effect on southern resident killer whales due to increased sensory disturbance, the effect may extend to alterations in the operations of whale-watching vessels; however, whale-watching tour operators' routes are typically variable depending on the location of whales at specific times. More pronounced effects on marine tourism operators such as day cruises and commercial sport fishing charters may be felt in areas such as eastern Burrard Inlet where Project operations are in close proximity to other users. Marine tourism users accessing Indian Arm may be more affected in terms of access. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA to RSA – negative sensory disturbance (e.g., visual effects, noise, and air quality) from increased Project-related marine vessel traffic could occur at any point in the shipping lanes in the Marine LSA. Potential effects related to alteration of movement patterns could occur at any point in the Marine RSA and may also affect the distribution of vessels in areas of the Marine RSA.

- **Duration** - long-term – the event causing the combined residual effects on marine tourism use indicator is the transit of Project-related marine vessels which occurs throughout the operational life of the Project.

- **Frequency** - periodic – the event causing the combined residual effects on marine tourism use is the transit of Project-related marine vessels which occurs intermittently and is repeated throughout the operational life of the Project.

- **Reversibility** - long-term – the combined residual effects will occur throughout the operational life of the Project.

- **Magnitude** - low to medium – the combined residual effects will be detectable by individual marine vessel operators, but in most cases are likely to represent an inconvenience or nuisance to those affected. However, the magnitude may be considered to be medium in cases of route alterations that may have business implications for commercial vessel operators.

- **Probability** - high – the occurrence of combined residual effects on marine tourism users is considered to be likely.

- **Confidence** - high – there is a good understanding of the cause-effect relationships and of the data pertinent to the study area.

Combined Effects of Project-Related Marine Vessel Traffic on MCRTU

The evaluation of the combined effects of increased Project-related marine vessel traffic on the MCRTU indicators considers collectively the assessment of the following indicators: commercial fishing; other marine commercial use; marine recreational use; and marine tourism use. The combined residual effects considered to be likely are: alteration of vessel movement patterns for all types of marine vessels; increased sensory disturbance to commercial fishers and recreational and tourism users; disruption to rail traffic on the CN Rail Bridge in Burrard Inlet; and negative user perspectives of Project-related marine vessel traffic.

Project-related marine vessels will be present in the shipping lanes for the life of the Project, at a frequency of approximately one daily transit, In the context of the total marine vessel traffic in the Marine RSA, the likely effects of Project-related marine vessels on other marine users are not considered to be significant, although the effects will be felt differently depending on the location and timing of the interaction. The combined residual effects may also be more pronounced for marine vessel types which are more likely to be present in the shipping lanes, such as fishing vessels and marine transportation vessels.

The overall effects of the Project on MCRTU are evaluated in consideration of the objectives of land and resource use management plans and government policies which contain a marine component. The Marine RSA contains shipping lanes servicing ports in the US and Canada, and the assessment of combined effects has been considered in this context. The results of the MCRTU assessment do not contradict any management objectives of established land and resource use management plans or government policies. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the residual socio-economic effects on MCRTU could occur at any point in the Marine RSA.
- **Duration**:- long-term – the event causing the combined residual effects on MCRTU is the transit of Project-related marine vessels which occurs throughout the operational life of the Project.
- **Frequency** - periodic – the event causing the combined residual effects on MCRTU is the transit of Project-related marine vessels which occurs intermittently and is repeated throughout the operational life of the Project.
- **Reversibility** - long-term – the combined residual effects will occur throughout the operational life of the Project.
- **Magnitude** - low to medium – the combined residual effects will potentially be detectable by marine vessels. In most cases the effects are likely to represent only an inconvenience or nuisance to those affected; however, the magnitude may be considered to be medium in the case of route alterations that may have business implications for commercial vessel operators.
- **Probability** - high – the occurrence of combined residual effects on MCRTU, as characterized, is considered to be likely..
- **Confidence** - high – there is a good understanding of the cause-effect relationships and of the data pertinent to the study area.

4.3.11.7 Potential United States Effects

The key issues that have been identified in Canadian waters are also considered to be similar in US waters. The shipping lanes in the Strait of Georgia, Haro Strait and Juan de Fuca Strait are located along the international boundary for much of the Marine RSA, and so the effects of Project-related marine vessels on other marine users are also considered to be similar in both countries. The region is subject to co-management between US and Canadian agencies. For example, the USCG and the CCG share management of marine communications and traffic services in areas of overlap, and emergency tugs will assist vessels on both sides of the international boundary. Tourism operators such as whale-watching boats access all areas regardless of the international boundary. No differences in MCRTU conditions in the US and Canadian portions of the Marine RSA were identified that would change the nature of the effects assessment. Therefore, the effects are expected to be similar in Canadian and US waters.

4.3.11.8 Summary

As identified in Table 4.3.11.3, there are no situations for MCRTU indicators that would result in a significant residual socio-economic effect. Consequently, it is concluded that the residual socio-economic effects of increased Project-related marine vessel traffic on MCRTU will be not significant.

4.3.12 Human Health Risk Assessment

This subsection outlines the nature of potential health risks to people associated with short-term and long-term exposures to the chemical emissions from the increased Project-related marine vessel traffic. As described in Section 4.2, the screening level HHRA was performed step-wise following a conventional risk assessment “paradigm”.

Details specific to the design of the HHRA for the marine transportation assessment as well as the results that emerged and the conclusions reached can be found in the Screening Level Human Health Risk Assessment of Marine Transportation in Volume 8B. Details regarding the HHRA conducted for marine spills can be found in Sections 5.6 and 5.7.

4.3.12.1 Assessment Indicators and Measurement Endpoints

For the purposes of the HHRA, the assessment indicators are people whose health might be adversely impacted as a result of exposures to the chemical emissions originating from increased Project-related marine vessel traffic through the marine shipping lanes. The choice of assessment indicators was based on the following factors.

- The need to assess the potential impacts of the chemical emissions on the health of people either living in the area (hereafter referred to as “residents”), or who might frequent the area for recreation or other purposes (hereafter referred to as “area users”).
- The need to consider the influence of the residents’ lifestyle characteristics, such as dietary patterns, on the potential chemical exposures caused by the Project, and the corresponding health risks that could be presented.
- The need to acknowledge that the manner and degree to which people may respond to chemical exposures can vary from one individual to another due to factors such as their age, sex and/or health status.

The assessment indicators used for the HHRA are described below:

- Residents:
  - **Aboriginal communities** – specific consideration was given to Aboriginal peoples living in the area to accommodate the unique opportunities for chemical exposures that might occur among these individuals, some of whom may practice a subsistence lifestyle, including the consumption of traditional foods such as game meat, marine food stuffs and natural plants.
  - **Urban dwellers** – people living in an urban environment, with allowance for potential chemical exposures through the consumption of home-garden produce and marine foodstuffs.
  - **Non-urban dwellers** – people living in a rural environment, practicing an agricultural lifestyle with reliance on home-grown foodstuffs, including beef, lamb, chicken, dairy, eggs and home-garden produce and marine foodstuffs.
- Area users – people who might frequent the area periodically for recreation or other purposes. Unlike the residents, it is unlikely that these individuals would remain in the area for extended periods of time, thereby precluding any reasonable opportunity for these people to be exposed to the COPC emissions on a long-term basis and/or through the regular consumption of locally grown or harvested foodstuffs.

The measurement endpoints for the HHRA refer to the potential adverse health effects that could be presented to the residents and area users from exposure to the COPC from increased Project-related marine vessel traffic along the marine shipping lanes. The assessment considers the toxic properties of the chemicals and the amount, frequency and duration of the exposure to the chemicals that people in the area might experience.

Distinction was made between the potential adverse health effects that might be presented to the indicators (residents and area users) on the basis of the following.

- The length of exposure (*i.e.*, short-term exposures lasting several hours to a few days versus long-term exposures lasting for several months or years, possibly up to a lifetime). The emissions associated with the increased Project-related marine vessel traffic along the marine shipping lanes will occur up to twice per day and will extend over the more than 50 year life of the Project, thereby presenting opportunity for both short-term and long-term exposure. For the purposes of the HHRA, the potential health risks associated with short-term and long-term exposure are referred to as acute and chronic health risks, respectively.
- The pathway of exposure (*i.e.*, the avenue(s) by which the residents and/or area users might be exposed to the COPC emissions from the increased Project-related marine vessel traffic). Since the chemicals will be emitted directly into the air, the primary pathway by which people could be exposed is via inhalation (*i.e.*, breathing in chemicals). Exposure through secondary pathways also could occur and is explored as part of the HHRA. For example, the chemicals might 'fall-out' or deposit from the air onto the ground or into the

water and enter the 'food chain' (*i.e.*, deposition of the chemicals directly onto the leafy surfaces of vegetables or other home-garden produce and/or deposition onto soils, with subsequent uptake by plants through the root system). The affected foods could then be consumed by people (*i.e.*, a secondary pathway). As a further example, the fall-out of the chemicals from the air could result in their appearance in sands along the shoreline or into the water, with the chemicals possibly taken up by shellfish and subsequently consumed by people (*i.e.*, another secondary pathway). More than one secondary pathway of exposure may be involved.

- The assessment indicator (*i.e.*, residents versus area users). Both indicators could, theoretically, be exposed to the emissions from the marine vessel traffic via inhalation on a short-term basis. However, the opportunity also exists for the residents to be exposed to the emissions on a longer-term basis through multiple pathways, including inhalation and/or secondary pathways (*e.g.*, consumption of home-grown produce, consumption of shellfish).

The assessment indicators and measurement endpoints evaluated as part of the HHRA are specified in Table 4.3.12.1 below.

TABLE 4.3.12.1

ASSESSMENT INDICATORS AND MEASUREMENT ENDPOINTS FOR THE SCREENING LEVEL HUMAN HEALTH RISK ASSESSMENT

<table>
<tr><th colspan="2">HHRA Indicator</th><th>Measurement Endpoints</th><th>Rationale for Indicator Selection</th></tr>
<tr><td rowspan="3">Residents</td><td>Aboriginal peoples</td><td rowspan="3">Adverse health effects associated with:
• short-term inhalation of chemicals of potential concern (COPC)
• long-term inhalation of the COPC
• long-term exposures to the COPC through multiple pathways</td><td rowspan="4">The selection of indicators and measurement endpoints was guided by information contained in the NEB Filing Manual (2013c) as well as guidance provided by BC MOE, Health Canada and the Canadian Council of Ministers of the Environment (CCME) (see Section 3.0).
Specific consideration was given to the human health-related concerns identified through the various Aboriginal engagement and stakeholder consultation activities.</td></tr>
<tr><td>Urban dwellers</td></tr>
<tr><td>Non-urban dwellers</td></tr>
<tr><td colspan="2">Area users</td><td>Acute inhalation risks</td></tr>
</table>

4.3.12.2 Spatial Boundaries

The spatial boundaries for the assessment of potential increased Project-related marine vessel traffic on human health were defined in terms of a HHRA LSA and the Marine Air Quality RSA, as described below (and as shown on Figure 4.2.32).

- **HHRA LSA** - includes the inbound and outbound marine shipping lanes, the area between the shipping lanes, where it exists, and a 5 km buffer extending from the outermost edge of each shipping lane. The shipping lanes extend from the Westridge Marine Terminal in Burnaby, through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, then westward past Victoria and through Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea.

- **Marine Air Quality RSA** - a 150 km × 150 km area, generally centred on the marine shipping lanes, which extend from the Westridge Marine Terminal through Burrard Inlet, south through the southern part of the Strait of Georgia, the Gulf Islands and Haro Strait, westward past Victoria and Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea.

The HHRA LSA represents the predicted spatial extent of the chemical emissions from the Project-related marine vessel traffic to which people along the shipping lanes might be exposed. The Marine Air Quality RSA was used for the purposes of assessing the cumulative health effects associated with the chemical emissions from the increased Project-related marine vessel traffic. The Marine Air Quality RSA was defined as the area for which ambient or background air quality data were obtained and all reasonably foreseeable developments were identified for the purposes of assessing the cumulative effects within the HHRA LSA.

4.3.12.3 Screening Level Human Health Risk Assessment Context

Information related to the HHRA context for the marine transportation component can be found in Section 4.2.12.4. The information outlines the current health status of people residing in the Marine Air Quality RSA and consists of population-based health statistics compiled by several Canadian and US-based health agencies. The health statistics relied on healthcare data collected by Health Authorities in BC and Washington. More specifically, the BC health information was based on health data compiled by the Fraser East and Fraser North HSDA of the FHA, the North Shore/Coast Garibaldi and Vancouver HSDAs of the VCHA, and the Central Vancouver Island and South Vancouver Island HSDAs of the VIHA. Health-based data for Washington were compiled by the counties of Whatcom, Jefferson, San Juan Islands and Clallam. The baseline health status is described principally in terms of cancer and respiratory health, since these indices have been identified as two of the more commonly-cited health concerns in the region and they are among the most relevant parameters for assessing the potential effects of exposures to COPC emissions. The baseline health information served as a benchmark for assessing the potential health impacts that might occur among the people residing in the Marine Air Quality RSA from exposure to the chemical emissions associated with the increased Project-related marine vessel traffic along the marine shipping lanes. Detailed information is presented in Tables 4.2.12.1 and for BC and Washington, respectively.

4.3.12.4 Potential Effects and Mitigation Measures

The HHRA evaluated the potential health risks to people associated with short-term and long-term exposures to the chemical emissions from the increased Project-related marine vessel traffic. The chemical emissions inventory for marine vessel traffic consisted of more than 100 chemicals, including CACs, metals, polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons, sulphur-containing chemicals and VOCs that were carried forward for consideration as COPC in the HHRA. The HHRA was completed using a series of conservative assumptions reflecting 'worst-case' circumstances, which collectively contributed to an exposure event being strictly hypothetical in nature, with a low probability of occurrence. In particular, the HHRA assumed that people would be found on both a short-term and long-term basis at the location within the HHRA LSA corresponding to the "maximum point of impingement" (MPOI). The MPOI refers to the location at which the highest ground-level air concentrations of each of the COPC would be expected to occur, and at which the exposures received by the people within the HHRA LSA would be greatest. The choice of the MPOI location was meant to ensure that any potential health effects that could result from exposure to the chemical emissions associated with the Project on the health of the people, regardless of where they might be found, would not be underestimated. The decision to use the MPOI to represent the location at which people would be found was made by default; that is, consideration was not given as to whether or not the MPOI location was suitable for a permanent residence and/or for residents to obtain their entire complement of locally grown or harvested foodstuffs, including garden vegetables, beef, chicken, dairy, eggs, game meat, fish, beach-foods and wild plants, from the local area.

The results of the HHRA revealed that, despite the conservative assumptions employed, with very few exceptions, the maximum predicted levels of exposure to the COPC (acting either singulary or in combination) remained below the levels of exposure that would be expected to cause health effects. In the majority of cases, the exposure levels were well below those associated with health effects. The exceedances revealed by the HHRA were very few in number and in virtually all cases were modest in magnitude. The high degree of conservatism incorporated into both the exposure estimates and the exposure limits used for comparison as part of the HHRA must be considered in the interpretation of the exceedances. Based on the weight of evidence, it is unlikely that people would experience health effects from the potential increase in chemical exposures associated with the increase in Project-related marine vessel traffic. A detailed quantitative HHRA will be conducted to expand on these findings with a report discussing the detailed HHRA to be submitted to the NEB in early 2014.

4.3.12.5 Potential United States Effects

No differences in the baseline conditions in the US and Canadian portions of the Marine Air Emissions RSA were identified that would change the nature of the effects assessment. Therefore, the effects are expected to be similar in Canadian and US waters.

4.3.12.6 Summary

The levels of exposure associated with the potential increase in Project-related marine vessel traffic are expected to remain below levels at which adverse health effects have been identified for the majority of the COPC. As such, adverse health effects are not expected as a result of these COPC emissions associated with the potential increase in Project-related marine vessel traffic. Those COPC associated with elevated health risks under the worst-case conditions assumed in the HHRA will be evaluated further in the comprehensive assessment.

4.3.13 Accidents and Malfunctions

Accidents and malfunctions are unplanned events that could result in significant adverse effects to human health, property or the environment; however, are unlikely to occur. While accidents and malfunctions are predicted to be unlikely for the increased Project-related marine vessel traffic, the potential consequences are evaluated so that emergency response and contingency planning can be identified to ensure the risk is further mitigated.

The following subsections contain an assessment of potential non-spill accidents and malfunctions from the increased Project-related marine vessel traffic. The potential effects of a spill from the increased Project-related marine vessel traffic are discussed in Section 5.0.

4.3.13.1 Assessment Indicators and Measurement Endpoints

Indicators considered in the assessment of accidents and malfunctions include those indicators previously described for the marine transportation elements in Sections 4.3.2 to 4.3.12. The measurement endpoints for accidents and malfunctions consist of a qualitative assessment of potential residual effects of accidents and malfunctions.

4.3.13.2 Spatial Boundaries

The spatial boundaries used in the effects assessment of accidents and malfunctions considered the applicable element-specific LSAs and RSAs as described in Sections 4.3.2 to 4.3.12. In general, the LSA is the ZOI in which socio-economic indicators are most likely to be affected by the operation of the increased Project-related marine vessel traffic. The RSA is considered the area where the direct and indirect influence of other marine activities could overlap with Project effects and cause cumulative effects on the indicator.

4.3.13.3 Potential Effects and Mitigation Measures

As stated in the NEB Filing Manual (NEB 2013c), an ESA must identify and assess the effects on workers, the public and biophysical and socio-economic elements of potential accidents and malfunctions. Events causing accidents and malfunctions could include equipment failure on tankers, human error, or natural perils such as floods, hurricanes or earthquakes.

Trans Mountain recognizes the high consequence potential of the operation of the increased Project-related marine vessel traffic. Trans Mountain is committed to keeping their operations safe and protecting their employees, facility users and visitors, the public and the environment. Trans Mountain strives to safeguard their facilities and to meet or exceed all applicable federal, provincial and local safety regulations.

4.3.13.3.1 Incident Types

Operation of tanker traffic is highly regulated in Canadian waters, and the marine shipping industry has a long history of safe operations. However, incidents such as accidental release of untreated bilge water, grounding of a vessel, the strike of a marine mammal, or the inadvertent venting of a tanker's cargo tank could occur. To ensure the continued safe and reliable operation of marine vessels off the coast of BC, many federal and international agencies regulate the movement of tanker traffic (see Section 1.4.1).

Accidental Release of Bilge Water

Bilge water results primarily from small weeps and leaks at the joints of moving machinery (pump glands) and the effects of condensation within the machinery spaces. It accumulates in the lowest part of the vessel's machinery spaces, such as the engine room, and may contain very small amounts of residual oils, lubricants, and grease, etc. It is processed and discharged periodically to prevent excess accumulation of water. Discharge of bilges when a vessel is in port is normally avoided.

Tankers of the size and type expected to be used by the Project are required to treat bilge water prior to discharge to the environment to reduce oil content to no more than 15 parts per million (mg/L) using a certified filtration or oil/water separator system and pumps. Accidental releases of bilge water can occur if the treatment equipment or any of the fitted sensors malfunctions while discharging treated bilge water, resulting in the release of oily water. Vessels with treatment systems are required to be fitted with automatic warning alarms and shut-off valves when the oil content exceeds 15 mg/L, which limits the potential for accidental releases of oily water. A small amount may be released between the alarm being triggered and stopping of discharge. A larger amount may be released during a total equipment failure if the alarm or the discharge-stopping mechanism does not function.

The requirement to treat bilge water is contained in the IMO MARPOL (IMO 2013b). In Canada, MARPOL is enforced through the *Vessel Pollution and Dangerous Chemicals* Regulations (annexed to the *Canada Shipping Act,* 2001). Regulations were put in place to prevent the recognized adverse effects of oil on water and sediment quality and on the health of marine birds and mammals. Bilge water must be treated before being discharged at sea or must be disposed of at an authorized facility.

Non-spill Grounding of Vessel

Collisions or groundings involving large cargo vessels such as tankers, bulk carriers and container ships are rare. Masters of these vessels are highly experienced mariners and are intimately familiar with the navigation and handling of their ships. In BC, this expertise is complemented with the local knowledge of BC Coast Pilots, who are required to be on board all vessels 300 DWT or larger that transit within BC's coastal waters. Tankers calling on the Westridge Marine Terminal are required to have two pilots on board when laden between the Westridge Marine Terminal berth and the Brotchie Ledge pilot boarding station (near Victoria). These pilots have intimate knowledge of their local waters, including the tides, currents, wind and wave conditions, transit procedures and traffic patterns. It is the responsibility of these pilots to advise the captain on local conditions and procedures in order to ensure the integrity of the vessel and the safety of its crew.

All large vessels transiting the shipping lanes are monitored by the CCG MCTS. Much in the same way airport control tower operators coordinate take-offs, landings and taxiing of aircraft, MCTS operators coordinate the movements of large vessels to ensure navigational safety and efficiency. All large vessels must also adhere to the rules and regulations established by the IMO and the *Canada Shipping Act*, including the *Collision Regulations*, which establish procedures for minimizing the risk of vessel collisions and groundings. Further risk mitigation is provided by rules established by the PMV and the PPA, such as the requirement for all laden tankers to be escorted by tugs through Burrard Inlet, Haro Strait and Boundary Pass, and timing restrictions for tankers transiting the Second Narrows.

With the stringent legislation governing the movements of oil tankers in Canadian waters, a collision or grounding event is considered very unlikely as noted in the Section 5.2. However, incidents have occurred in the past, and despite best efforts, could occur in the future.

The nature and magnitude of potential environmental and socio-economic effects of a tanker collision or grounding would depend on the type of incident and severity of impact. For the purposes of this assessment, it is assumed that the incident does not result in a breach of the hull, which could lead to foundering (*i.e.*, sinking). Further, it is assumed that the impact would result in damage to mechanical and/or electrical systems, which could affect propulsion and steerage. In such a scenario, escort tugs would be required to assist the tanker to berth.

In the event of a tanker collision with no release of product, potential effects to marine biophysical elements other than fish and fish habitat (*i.e.*, sediment and water quality, marine birds and marine mammals) would be negligible, if any, and are not considered further. Potential socio-economic effects exist and are discussed in this subsection.

During consultation with PMV and other agencies, the potential of a fire on a vessel was raised. The potential effect on the environment from a fire on a vessel while underway is the potential of a grounding from the disabling of the navigational systems. Therefore, the potential effects associated with a fire on a Project-related marine vessel are assessed under the effects related to a non-spill grounding of a vessel.

Strike of a Marine Mammal

All vessels, large or small, fast or slow, and regardless of what they are transporting (*e.g.*, oil, LNG, cargo, whale watching or passengers) have the potential to accidentally strike marine mammals. A vessel strike with a marine mammal may result in either physical injury or direct or indirect mortality. Most injuries sustained by marine mammals because of vessel strikes involve either blunt force trauma from impact on the bow of the vessel or lacerations from contact with propellers (Laist *et al.* 2001). Independent of where a vessel is transiting, the statistical likelihood of a vessel strike causing serious or fatal injury to a marine mammal depends on three factors: the probability of encounter; the probability of a strike occurring; and the probability that the strike results in severe or fatal injuries.

The probability of encounter is simply the likelihood of a marine mammal and vessel being in the same spot at the same time. This probability therefore depends in part, on whether the marine mammal and vessel are on a collision course, and is positively correlated with both the density of ship traffic and the density of marine mammals in a given area. Therefore, areas of overlap between high shipping traffic (*e.g.*, near major ports and along shipping lanes) and high marine mammal aggregation or concentration areas (*e.g.*, critical habitat, major feeding or breeding grounds, *etc.*) are at higher relative risk of an encounter (see for example Williams and O'Hara 2009).

The probability of a strike occurring considers whether a marine mammal and vessel actually make contact and, therefore, depends in part on the success or failure of any avoidance measure by either the marine mammal or vessel. The probability of strike has been positively correlated with the speed of the vessel. Kite-Powell *et al.* (2007) used data from observed encounters with right whales and from whale diving behaviour to model the probability of a strike based on vessel speed, and assuming the whale is initially on a collision course with the vessel. Based on this model, a large vessel travelling at 25 knots has a 50 per cent chance of striking a whale travelling in its path. At a speed of 10 knots, the chance of a strike is reduced to 30 per cent (Kite-Powell *et al.* 2007). The strike probability also varies by species. Smaller, faster species of marine mammals, such as dolphins, porpoises, and pinnipeds are more likely to exhibit successful avoidance responses and also present smaller surface areas for potential contact. In contrast, larger whales, such as the baleen whales, and in particular slower moving species such as right whales, are more prone to vessel strikes (Laist *et al.* 2001). Calves and resting whales also have reduced avoidance capacity.

The probability that a strike ultimately results in severe or fatal injury is also positively correlated to vessel speed. Vanderlaan and Taggart (2007) used historical records (1885 to 2002) of vessel strikes to large whales to mathematically model the probability of severe or lethal injury based on vessel speed. Vessel speeds of 18 knots and higher were predicted to have over a 92 per cent probability of lethality. Probabilities decreased with speed: from 78 per cent at 15 knots, 61 per cent at 13 knots, 31 per cent at 10 knots, to below 12 per cent at speeds of 7 knots or less (Vanderlaan and Taggart 2007). Based on historical records of motorized ship collisions with large whales, Laist *et al.* (2001) similarly concluded that serious injuries to whales are infrequent at vessel speeds of less than 14 knots, and rare at vessel speeds of less than 10 knots. Most reported lethal or severe injuries are caused by vessels 80 m or longer and by vessels traveling 14 knots or faster (Laist *et al.* 2001).

As noted above, different species have different likelihoods of being struck by a vessel. Jensen and Silber (2004) reviewed 292 records of ship strikes, and reported that fin whales were the most commonly struck species, while blue and sei whales were two of the least likely to be struck (although strikes that occur offshore are likely under-reported). Globally, humpback whales are the second most commonly struck species resulting in mortality or an unknown fate, on both an overall basis and after factoring in relative abundance (Jensen and Silber 2004, Laist *et al.* 2001). In BC, humpback whales are the most commonly struck species, as reported to the BC Marine Mammal Response Network (DFO 2013). Although strikes involving toothed whales remain possible, species such as killer whales are struck far less frequently than other whales and most historically reported instances involve smaller vessels moving at higher speeds. DFO's Recovery Strategy for the Transient Killer Whale recognizes collisions with vessels as a stressor with 'demonstrated' causal certainty, but a 'low' level of concern (DFO 2007). Likewise, vessel strikes involving any species of seal or sea lion are rare and DFO's Management Plan for Steller Sea Lions does not list vessel strikes as a potential threat (DFO 2010a).

According to strike event records obtained from DFO's Marine Mammal Incident Database (1973 to October 2012), only one confirmed/probable record of a pinniped strike has been reported in BC. This involved a Steller sea lion that was struck by a whale-watching boat near Race Rocks in 2009. There are also a few reports of harbour seal injuries that are consistent with vessel strikes, although many remain inconclusive and the strike events themselves were not witnessed. The Marine Mammal Incident Database (up to October 2012) has eight records of strikes with toothed whales that were confirmed or deemed likely to have occurred in BC: one involved a Dall's porpoise calf; one involved a harbour porpoise calf; and six involved killer whales (maximum vessel size reported for a killer whale strike was a ferry in the Strait of Georgia). It is important to note that data obtained from the BC Marine Mammal Incident Database was collected by voluntary reporting of dead and distressed animals. It is unknown to what extent all incidents are reported. As a result, absence of incidents at any location does not demonstrate absence of a threat in the report's timeframe. Furthermore, there remain a large number of uncertainties concerning the frequency, distribution and seasonality of strike events, and the ability to accurately collect records of such events. These include:

- unknown reporting compliance following a strike (either because the vessel operator did not know that a strike should be reported or to whom; refusal to report the incident; or the vessel operator was not aware that the strike even occurred). Despite the fact that pilots are expected to report marine mammal strikes, operators of large vessels are often unaware that a strike has occurred, and may be unable to determine the outcome of strike events;
- unknown frequency with which struck animals sink before they can be discovered/examined to determine cause of death, as well as ability to determine if the strike occurred pre- or post-mortem;
- limited capacity to re-sight and investigate carcasses of reported dead floating animals, free-swimming but potentially injured animals, or beach-cast carcasses in remote locations; and
- inconclusive cause of death determinations when examining carcasses in advanced stages of decomposition due to tissue autolysis.

Despite the above uncertainties, and the fact that vessel strike events are likely under-reported, the species' of marine mammal at highest relative risk of a vessel strike in the Marine RSA are most likely humpback whales and fin whales, along with other less frequently-observed species of baleen whales. The BC Marine Mammal Incident Database (up to October 2012) includes 19 records of humpback whale strike events, all of which occurred in BC between 2004 and 2011.

Most of these involved vessels less than 75 m in length, although larger vessels are also the least likely to detect and, therefore, report a strike event. Other records of baleen whale strike events include four records of grey whales, one fin whale, and three unidentified whales.

Venting of a Tanker's Cargo Tank

Pressure may accumulate in the cargo tanks of Project-related marine tankers as the crude oil export cargo vaporizes and releases gas into the headspace. Empty tankers waiting to load at Westridge would not normally discharge emissions while at anchor. However, if waiting with cargo onboard, given certain environmental conditions (*e.g.,* high solar radiation flux there could be a pronounced increase of temperature of the gases at the surface of the cargo in a tanker's cargo tanks). Such increase in temperature could lead to an increase in pressure of the tank that could cause the lifting of pressure relief devices fitted to the tanks (see Section 4.3.3). Factors such as increased product agitation and increased ambient and cargo temperatures that are more likely to occur on a hot summer day may also cause increases in pressure. Partially filled cargo holds would be more likely to pressurise as the head space above the liquid is larger.

If the build-up of gases in the cargo tank occurs rapidly and increases the pressure beyond safe levels despite normal venting, this elevated release rate has the potential to impact the local air quality and/or create nuisance odours. This venting could occur under most of the ship activity modes such as at anchor or in transit; however, not during product loading, when the vapour recovery unit is operating and fugitive vapours are being collected at the berth. The types of emissions to be vented to atmosphere from the relief valve would typically include petroleum hydrocarbons like methane, volatile organic compounds like toluene and reduced sulphur species like hydrogen sulphide.

All tankers in Canadian waters are required to have a VOC management plan.

4.3.13.3.2 Identified Potential Effects

The potential effects associated with accidents and malfunctions from the pipeline and facilities component of the Project are provided in Volumes 5A and 5B. The potential direct and indirect effects of an operational pipeline or marine spill are evaluated in Volume 7 and Section 5.0, respectively, including the risk of a spill, the anticipated spill response and the potential effects for several spill scenarios. Events causing accidents and malfunctions from natural perils such as tornadoes, floods, hurricanes and earthquakes are discussed in Section 4.3.14.

Potential effects associated with accidents and malfunctions from the increased Project-related marine vessel traffic are listed in Table 4.3.13.1. These interactions are based on the results of the literature review, desktop analysis, consultation/engagement with Aboriginal communities, government agencies (*e.g.*, regulatory authorities, municipalities), stakeholders and the general public (Section 3.0), as well as the experience of the assessment team.

A summary of mitigation measures provided in Table 4.3.13.1 was principally developed in accordance with industry standards and regulatory guidelines including those from PMV, PPA, CCG, Transport Canada and the IMO.

TABLE 4.3.13.1

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON ACCIDENTS AND MALFUNCTIONS

Potential Effect	Spatial Boundary	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1.1 Change in marine water quality from an accidental release of contaminated bilge water	Marine RSA	• Transport Canada will ensure all tankers will comply with the pollution prevention provisions of the *Canada Shipping Act, 2001* and MARPOL. • Trans Mountain will provide reception facilities at the Westridge Marine Terminal as necessary to service the needs of the Project-related marine vessels. • Trans Mountain will screen the tankers nominated to call on the Westridge Marine Terminal to check that they do not have any malfunctions to pollution prevention equipment or history of non-adherence to provisions of the *Canada Shipping Act, 2001* and MARPOL. • Trans Mountain will require all tankers to process and empty their bilges prior to arrival and to have the discharge valve of the bilge water locked while in Canadian waters.	• Degradation of marine water quality.
2.1 Physical contact between a tanker's hull and marine subtidal habitat from a vessel grounding	Marine RSA	• Transport Canada and the CCG will monitor the movement of all tankers. • Tankers will comply with regulations set out by the IMO and the *Canada Shipping Act, 2001*, including the *Collision Regulations*. • Tankers will transit within the Transport Canada defined shipping lanes unless otherwise directed by the pilots or CCG MCTS operators. • BCCP will ensure that all tankers follow transit procedures set out by PMV and the PPA, including escort tug requirements in Burrard Inlet, Haro Strait and Boundary Pass, and timing restrictions for the Second Narrows. • Trans Mountain will require tug escort of all Project-related tankers for the entire transit from the Westridge Marine Terminal to the Pacific Ocean. This enhancement is in addition to tug requirements to assist with navigation. The tug can be tethered for extra navigational assistance if needed. • TSB will investigate collisions and groundings.	• Alteration of subtidal habitat.
3.1 Interference with navigation from a vessel grounding	Marine RSA	• Trans Mountain will apply mitigation measures listed in potential effect 1.1 of Table 4.3.11.2. • To enhance preventive measures currently in place through applicable legislation and regulations, implement May 2013 recommendations of Canadian Marine Pilot's Association Submission to the Tanker Safety Expert Panel. • Trans Mountain will require tug escort of all Project-related tankers for the entire transit from the Westridge Marine Terminal to the Pacific Ocean. This enhancement is in addition to tug requirements to assist with navigation. The tug can be tethered for extra navigational assistance if needed.	• Interference with navigation.

TABLE 4.3.13.1

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON ACCIDENTS AND MALFUNCTIONS (continued)

Potential Effect	Spatial Boundary	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
4.1 Physical injury or mortality of a marine mammal due to a vessel strike	Marine RSA	• Project-related vessels are owned and operated by a third party. Marine transportation in Canadian waters is authorized and regulated through the *Canada Shipping Act, 2001* and related legislation and regulations are administered by Transport Canada and the CCG. • Trans Mountain would be interested in supporting and participating in a joint industry-government advisory group that would be charged with determining and/or developing effective mitigation measures to reduce potential effects on marine mammals.	• Physical injury or mortality of a marine mammal due to a vessel strike.
5.1 Venting of tanker at anchor or in transit	Marine RSA	• Each tanker must be outfitted with pressure relief valves on each cargo tank as a safety measure. • Tankers generally reduce the risk of emissions building in tanks by keeping a record of varying tank pressure, cooling the decks during daytime, cooling the cargo by taking water in the surrounding ballast tanks if possible, and loading the tanks that are used to as full as possible instead of leaving empty space in some tanks. • KMC will screen the tankers nominated to call on the Westridge Marine Terminal to check that they are implementing a VOC management plan.	• Odours or degradation of local air quality.

4.3.13.4 Potential Residual Effects

The potential residual effects that could occur as a result of non-spill accidents and malfunctions during the operations of the increased Project-related marine vessel traffic (Table 4.13.3.1) are:

- degradation of marine water quality;
- alteration of subtidal habitat;
- interference with navigation;
- physical injury or mortality of a marine mammal due to a vessel strike; and
- odours or degradation of local air quality.

4.3.13.5 Significance Evaluation of Potential Residual Effects

A qualitative assessment of accidents and malfunctions was determined to be the most appropriate approach to evaluate the significance of potential residual effects due to a lack of regulatory thresholds, standards or guidelines for indicators associated with elements described in Sections 4.3.2 to 4.2.12 as they relate to accidents and malfunctions. Consequently, the evaluation of significance of each of the potential residual effects relies on the professional judgment of the assessment team.

Table 4.3.13.2 provides a summary of the significance evaluation of the potential residual effects associated with accidents and malfunctions during operation of the increased Project-related marine vessel traffic. The rationale used to evaluate the significance of each of the residual effects is provided below.

TABLE 4.3.13.2

SIGNIFICANCE EVALUATION OF POTENTIAL RESIDUAL EFFECTS OF INCREASED PROJECT-RELATED MARINE VESSEL TRAFFIC ON ACCIDENTS AND MALFUNCTIONS

Potential Residual Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
(a) Degradation of water quality.	Negative	RSA	Immediate	Accidental	Short-term	Low	Low	High	Not significant
(b) Alteration of subtidal habitat.	Negative	RSA	Immediate	Accidental	Short to medium-term	Low	Low	High	Not significant
(c) Interference with navigation.	Negative	RSA	Immediate	Accidental	Short-term	Low to medium	Low	High	Not significant
(d) physical injury or mortality of a marine mammal due to a vessel strike	Negative	RSA	Immediate	Accidental	Short-term to permanent	Low to high	Low	Moderate	Not Significant
(e) Odours and degradation local of air quality.	Negative	RSA	Immediate	Accidental	Short-term	Low	Low	High	Not significant

Notes: 1 RSA = Marine RSA. While the effect could occur anywhere within the Marine RSA, an accidental release would affect a localized area, not the entire Marine RSA

2 **Significant Residual Environmental Effect:** A high probability of occurrence of a permanent or long-term residual effect of high magnitude that cannot be technically or economically mitigated.

Significant Residual Socio-Economic Effect: a residual socio-economic effect is considered significant if the effect is predicted to be:

- high magnitude, high probability, long-term or permanent reversibility, and any spatial boundary that cannot be technically or economically mitigated.

4.3.13.5.1 Degradation of Water Quality

Oil accidently released with bilge water is already mixed in the bilge water and typically spreads quickly as a sheen on the water surface. The oil begins breaking down immediately, through processes such as dissolution, sedimentation, bio-degradation, evaporation, weathering and dispersion (NRC 2003b). Degradation is facilitated by the thinness of the sheen and occurs rapidly for bilge water, compared to oil from a cargo spill. These processes would have a short-term effect on marine water quality, during dispersal of the sheen and degradation of the volatile hydrocarbon contaminants. There could be a longer-term increase (small and likely indistinguishable from ambient levels) in concentrations of persistent PAHs that reach the marine sediments.

Effects of oily bilge water on marine biota have not been well documented and are likely to be minimal, due to the low volume of oil released and its rapid dispersion. The oil may contribute to ambient and cumulative levels of persistent contaminants such as PAH in sediment. While not comparable to oily bilge water releases, the effects of oil spills on biota have been better documented, particularly for marine birds and mammals, which can be affected through direct contact with oil or chronic toxicity of hydrocarbon contaminants (Brown 2013).

The principal mitigation measure for minimizing potential effects of bilge water releases on the marine environment is compliance with the pollution prevention provisions of the *Canada Shipping Act,* 2001 and MARPOL. All Project-associated vessels are required, by law, to follow these regulations. Trans Mountain is committed to further mitigating potential effects of bilge water releases by using reputable vessel owners and operators who strictly adhere to regulations and ensure continued maintenance of vessel discharge treatment equipment and safety mechanisms.

The release of contaminated bilge water is prohibited by law. In the unlikely event of an accidental release of oily bilge water, a thin sheen would form over the water's surface but this would rapidly dissipate as the hydrocarbons volatilized and dispersed. The temporary increase in contaminant concentrations in the water column would quickly return to baseline conditions as the oil was weathered by physical forces and degraded by microbial activity.

The release of contaminated bilge water is expected to have a negative impact balance. A release of contaminated bilge water is illegal, unlikely to occur, and would result in only a short-term degradation of marine water quality (Table 4.3.13.2, point [a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – while an accidental release of oily bilge water could occur anywhere within the Marine RSA, there is likely to be rapid dispersion and evaporation of contaminants within a short distance of the vessel.
- **Duration** - immediate – introduction of oil would occur immediately upon release of bilge water.
- **Frequency** - accidental – bilge water releases are unplanned; discharge of bilge water is regulated.
- **Reversibility** - short-term – each event may take more than two days; however, less than or equal to one year to reverse the residual effect; sheen will rapidly evaporate or disperse.
- **Magnitude** - low – accidental releases typically are of small volumes and are not expected to result in quantifiable changes in baseline conditions (*e.g.*, sediment PAH levels) or to exceed sediment quality guidelines; the resulting sheen rapidly disperses and evaporates.
- **Probability** - low – bilge water discharges are regulated and accidental releases are a result of malfunction of the warning and discharge-stopping systems.
- **Confidence** - high – there is a good understanding of the cause-effect relationships between water contaminant conditions and potential for adverse effects on water quality, effectiveness of the regulations and mitigations.

4.3.13.5.2 Alteration of Subtidal Habitat

In the unlikely event of a tanker grounding, the most probable effect on the marine biophysical environment would be the alteration of subtidal habitat. The nature of this alteration and the areal extent of habitat affected would depend on the speed of the vessel and the physical properties of the seabed (*e.g.*, substrate type, compactness, depth, slope). For soft sediment habitats, the tanker's hull would displace sediments perpendicular to the vessel's trajectory, carving a trench into the seafloor. For rocky habitats (*e.g.*, cobbles, boulders, bedrock), the physical impact would displace smaller, moveable rocks and may fracture extruding portions of bedrock. The area of habitat affected would be site- and scenario-specific; however, would likely range from several hundred to several thousand metres squared.

The physical impact of the tanker's hull on the seabed would likely result in the mortality of some benthic organisms, particularly those with limited ability to move. The particular species affected would depend on the habitat type; however, could include crabs, shrimps, clams, snails, anemones, sea cucumbers, and a variety of algae. A small number of benthic fish such as sculpins, gunnels, pricklebacks and flatfish could also be injured or killed; however, pelagic fish such as salmon and herring would likely move to avoid the vessel. Although organisms would begin recolonizing the affected area as soon as the grounded vessel was removed, it could take anywhere from several months to two years for the biotic community to return to pre-disturbance levels of diversity and abundance. During this time, the productive capacity of the habitat would be diminished.

Project-associated tankers transiting the shipping lanes within the Marine RSA are required to follow a number of procedures that are specifically designed to reduce the likelihood of collisions or groundings. These measures include mandatory pilotage (2 pilots), escort tug requirements in Burrard Inlet, Haro Strait and Boundary Pass, timing restrictions for transits through the Second Narrows, as well as a number of rules and regulations set out by the IMO and the *Canada Shipping Act*. With these measures in place, the likelihood of a grounding event resulting in the alteration of subtidal habitat is considered to be low. However, accidents can occur, and in the event of a grounding, subtidal habitat would be altered. The nature and magnitude of this effect would depend on a number of factors, including the physical properties of the seafloor, the species utilizing this habitat, and the speed of the vessel at impact.

Although it is difficult to estimate the area of subtidal habitat that would be altered as a result of a grounding event, it is conservatively estimated that a maximum of several thousand square metres of habitat would be affected. This is considered to have a negative impact balance. Within this area, benthic algae and invertebrates could be injured or killed as a result of crushing or burial, and a small number of bottom-dwelling fish may also be lost. The physical alteration of the habitat coupled with the loss of biota would result in a temporary reduction in the productive capacity of the affected habitat. The reversibility of this effect would depend on the type of habitat affected. Re-colonization would begin as soon as the tanker was removed; however, full recovery of species diversity and abundance could take between several months for soft sediment habitats to three years for rocky habitats. The magnitude of this effect would be low, since only a small fraction of marine subtidal habitat within the Marine RSA would be affected (Table 4.3.13.2, point [b]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – although a tanker grounding event would most likely occur within the Marine LSA, it could occur at any shallow-water location within the Marine RSA.

- **Duration** - immediate – a tanker grounding event would occur over a short period of time.
- **Frequency** - accidental – a tanker grounding event would constitute a rare accident.
- **Reversibility** - short to medium-term – re-colonization of the affected area would begin as soon as the tanker was removed; however, full recovery of species diversity and abundance could take between several months and three years depending on the type of habitat affected.
- **Magnitude** - low – the area of subtidal habitat potentially affected by a grounded tanker (up to several thousand square metres) would represent a very small percentage of the total subtidal habitat present within the Marine RSA. Further, the injury or mortality of a small number of benthic organisms would not be detectable at the population level.
- **Probability** - low – numerous mitigation measures are in place to prevent vessel groundings and no Trans Mountain-associated tankers have ever grounded in over 60 years of operations.
- **Confidence** - high – based on a good understanding of the potential effects of subtidal habitat alteration on marine fish and fish habitat and the low probability of a grounding incident.

4.3.13.5.3 Interference with Navigation

Marine incidents resulting in grounding or collision of Project-related marine tankers with other vessels, land or marine infrastructure may interfere with navigation of other marine vessels. This is considered to have a negative impact balance. The spatial boundary of the event is considered to be the Marine RSA. Navigation of other vessels could be disrupted by the presence of the stranded Project-related tanker within or near the designated shipping lanes. Marine vessels that are required to alter travel routes may be displaced to other areas in the Marine RSA. Additionally, if the Project-related tanker involved in the incident loses power prior to grounding or collision, the incident may occur outside the shipping lanes.

A grounding or collision with no loss of product could occur at any time during the operations phase of the Project; however, the frequency of the event occurring is considered to be accidental. Required mitigation measures that are implemented by most deep draft commercial marine vessels should aid in avoidance of groundings and collisions under most circumstances. These measures include: the widespread use of ship's radar; the compulsory use of VTS for larger vessels to facilitate communications with ports and other vessels; the use of loudhailers on bridges to communicate with smaller vessels that are not registered with VTS; the compulsory use of pilots in coastal BC waters; the use of escort tugs in Haro Strait and Burrard Inlet; and other standard navigational measures. The TSB has recommended additional safety measures for commercial marine vessels, including mandatory Safety Management Systems (SMS). SMS is a requirement for all Project-related tankers. SMS is a proactive system that includes regular safety drills and exercises, clear roles and responsibilities for crew, hazard identification systems and tools to improve vessel operations (TSB 2013). In addition, all tankers use navigational equipment that allows for frequent updates of the location of hazards and other navigational information (TSB 2013).

The reversibility of the residual effect of interference with navigation is likely to be short-term. Only if a stranded vessel is obstructing the navigation channel or if re-floating activities are obstructing the channel, will there be any interference with navigation for other vessels. Once the stranded vessel has been removed from the area, navigation should resume unobstructed. The exception may be in the case of a vessel strike with marine infrastructure such as a bridge, where the marine area may need to be closed for a longer period for replacement or repairs to infrastructure. The location of the incident in the Marine RSA is important to the assessment of the magnitude of the event. For example, a vessel grounding or collision in the Second Narrows in Burrard Inlet would be likely to pose a greater navigational obstruction than such an incident occurring in more open areas of the Marine RSA. In addition, a grounding or collision in Burrard Inlet may have increased implications for damage to marine infrastructure (*e.g.*, bridges, docks, and marinas) and to moored vessels. For recreational marine traffic, a short-term disruption may be an inconvenience; however, an incident that temporarily blocks the passage of commercial marine vessels may result in financial losses for the operators if shipping, fishing or tourism activities are disrupted. An incident involving the CN Rail Bridge may also disrupt rail traffic over the Second Narrows.

The probability of interference with navigation of marine vessels is low, since the grounding event is unlikely to take place (Table 4.3.13.2, point [c]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – a grounding or collision of a Project-related tanker with no release of product could occur within or outside the shipping lanes in the Marine RSA.
- **Duration** - immediate – a grounding or collision of a Project-related tanker would occur over a short period of time.
- **Frequency** - accidental – a grounding or collision of a Project-related tanker with no release of product is likely to occur rarely during the operations phase.
- **Reversibility** - short-term – the residual effect of interference with navigation of marine vessels resulting from a grounding or collision of a Project-related tanker likely to be less than a year.
- **Magnitude** - low to medium – depending upon the location of the event, the magnitude of the residual effect is likely to range from low, being a nuisance to other vessels, or medium, resulting in delays for commercial vessels.
- **Probability** - low – numerous mitigation measures are in place to prevent vessel groundings and no Trans Mountain-associated tankers have ever grounded or collided with other vessels or marine infrastructure in over 60 years of operations.
- **Confidence** - high – the degree of certainty related to the significance evaluation is based on a good understanding of cause-effect relationships and data pertinent to the study area.

4.3.13.5.4 Physical Injury or Mortality of a Marine Mammal Due to a Vessel Strike

A vessel strike with a marine mammal could result in physical injury or mortality of that individual, resulting in a negative impact balance. The spatial boundary of this effect is the

Marine RSA. The risk is concentrated along the shipping lanes. Areas of higher relative risk occur where shipping traffic overlaps with higher density areas for marine mammals. In the Marine RSA, this is most likely to be the western-most region, where more offshore species of baleen whale such as fin whale are expected to be more common. This area also overlaps with critical habitat for humpback whales, which are expected to be present here in higher densities (relative to other areas of the Marine RSA) primarily in the summer and fall.

The occurrence of a strike would be immediate (*i.e.,* upon contact). Actual frequency of vessel strikes in BC for any species of marine mammal and for any size or class of vessel are unknown and events are likely under-reported. However, the frequency of such events is considered accidental and rare for any particular vessel. Depending on the severity of the strike, an individual marine mammal may or may not recover from the event. While the primary effects associated with being struck are blunt-force trauma or lacerations, long-term consequences may include immediate direct mortality; indirect mortality resulting from complications or infection of internal or external injuries; long-term or permanent injuries; reduced fitness or fecundity; or short-term recoverable injuries. The magnitude of this effect may therefore range from low to high. While a strike resulting in minor injuries may be low magnitude, mortality of a *SARA*-listed species would be considered a high magnitude effect.

The overall probability of a Project-related vessel striking and injuring a marine mammal is considered low. While ship strikes leading to marine mammal fatalities can and do occur, such occurrences are infrequent relative to the number of vessels (of all sizes and classes) on the water. The probability for any particular vessel is therefore quite small, although the cumulative effects across all marine transportation activities may be an important threat in the consideration and development of management policies for species of conservation concern.

The potential effect of accidental physical injury or mortality of a marine mammal due to a vessel strike is determined to be not significant (Table 4.3.13.2, point [d]).

A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – a vessel strike could occur at any location along the shipping lanes within the Marine RSA.
- **Duration** - immediate – a vessel strike event would be instantaneous and could occur at any time during the operations phase.
- **Frequency** - accidental – a marine mammal strike event with a Project-related vessel would constitute a rare accident.
- **Reversibility** - short-term to permanent – depending on the severity of the injury, an individual marine mammal may or may not recover from a vessel strike. At the population scale, recovery from the mortality of an individual would depend on the population in question, its generation time, and its conservation status. Whereas population-level effects for some species may be reversible in the medium-term, mortality of individuals listed as *Endangered* (*e.g.*, a North Pacific right whale) could have long-term or permanent population-level consequences.
- **Magnitude** - low to high – this would depend on the severity of the injury and the species in question. While a strike resulting in minor injuries may be low

magnitude, mortality of a *SARA*-listed species would be considered a high magnitude effect.

- **Probability** - low – while marine mammal vessel strikes can and do occur globally, the overall probability of an individual vessel striking and injuring or killing a marine mammal is low.
- **Confidence** - moderate – while the Project specific risk of this effect is considered to be low, the long-term per-incident consequences to individuals and the population-level frequency of occurrence of this effect is not well understood.

4.3.13.5.5 Venting of Cargo Tank Vapours by a Tanker

The release of air emissions from an over-pressurized cargo tank in a Project-related marine tanker could result in degradation of air quality in the vicinity of the tanker. This is considered to have a negative impact balance. The spatial boundary of the event is considered to be the Marine RSA. The potential effect to air quality could occur outside of the Marine LSA, depending on the volume of emissions released from the tanker, the composition of the release of emissions, and environmental conditions at the location of the tanker at the time of the event.

A release of air emissions from an over-pressurized tanker could occur at any time during the operations phase of the Project; however, the frequency of the event occurring is considered to be accidental, as loaded tankers are not likely to be anchored for long enough periods for an occurrence. Required mitigation measures that are implemented by most deep draft commercial marine vessels should aid in avoidance of the release of air emissions from an over-pressurized tanker under most circumstances. These measures include cooling the decks during daytime; cooling the cargo by taking water in the surrounding ballast tanks, if possible; and loading the tanks that are used to as full as possible instead of leaving empty space in some tanks.

The reversibility of the residual effect of degradation of air quality is likely to be short-term. Once the emissions have been released from the cargo tank, they will dissipate into the atmospheric environment. Therefore, it is likely that the reversibility of the effect would be less than a year.

The magnitude of the event is anticipated to be low, given that the only effect of the short-term degradation of air quality is nuisance to nearby residents and marine users, if any.

The probability of degradation of air quality from the over-pressurization of a cargo tank in a Project-related marine vessel is low, since the sudden release of a large amount of pressure is unlikely to take place (Table 4.3.13.2, point [e]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – a release of air emissions from an over-pressurized tanker could potentially affect areas beyond the Marine LSA.
- **Duration** - immediate – a release of air emissions from an over-pressurized tanker occurs over a short period of time.
- **Frequency** - accidental – a release of air emissions from an over-pressurized tanker is likely to occur only rarely during the operations phase.

- **Reversibility** - short-term – the residual effect of degradation of air quality resulting from release of air emissions from an over-pressurized tanker is likely to be reversed in less than a year.
- **Magnitude** - low – the magnitude of the residual effect is low since it may be a nuisance to nearby residents and marine users.
- **Probability** - low – several mitigation measures are in place to prevent release of air emissions from an over-pressurized tanker.
- **Confidence** - high – the degree of certainty related to the significance evaluation is based on a good understanding of cause-effect relationships and data pertinent to the study area.

4.3.13.6 Combined Effects Resulting from Accidents and Malfunctions

An evaluation of the combined effects considers those residual effects that are likely to occur. Since the probability of an accident or malfunction is low, an evaluation of combined effects of accidents and malfunctions is not warranted.

4.3.13.7 Potential United States Effects

The key issues relating to accidents and malfunctions that have been identified in Canadian waters are also considered to be similar in US waters. The shipping lanes in the Strait of Georgia, Haro Strait and Juan de Fuca Strait are located along the international boundary for much of the Marine RSA, and so the potential effects of accidents and malfunctions arising from Project-related marine vessels are considered to be similar. No differences in environmental or socio-economic conditions in the US and Canadian portions of the Marine RSA were identified that would change the nature of the effects assessment. Therefore, the effects are expected to be similar in Canadian and US waters.

4.3.13.8 Summary

As identified in Table 4.3.13.2, there are no situations arising from accidents and malfunctions that would result in a significant residual effect. Consequently, it is concluded that the residual effects arising from an accident or malfunction during the operation of the increased Project-related marine vessel traffic will be not significant.

4.3.14 Changes to the Project Caused by the Environment

Marine tanker traffic has been operating safely on the West Coast of Canada for well over 60 years. Knowledge gained from experience in previous years is reflected in the engineering design of tankers and federal and international regulatory guidelines that contribute to safe shipping.

4.3.14.1 Environmental Conditions Not Considered

Seismic activity was not considered to have the potential to adversely affect the increased Project-related marine vessel traffic during operations. An earthquake, either on land or under the ocean, would not produce a mechanism by which Project-related marine traffic could become affected. The marine shipping lanes are not in close enough proximity to the shoreline that an earthquake-related tsunami would produce a noticeably large wave (see TERMPOL 3.15 in Volume 8C [TR 8C-12] for more information).

Sea water rise was not considered to have the potential to adversely affect the increased Project-related marine vessel traffic during operations. There is no mechanism by which sea water rise could potentially affect or delay Project-related marine traffic.

4.3.14.2 Potential Effects and Mitigation Measures

Environmental conditions may have adverse effects on the increased Project-related marine vessel traffic. The following environmental conditions were identified by the assessment team as having the potential to adversely affect the marine transportation component of the Project:

- severe weather events including high wind speeds, heavy/persistent precipitation (*e.g.*, from storms), extreme temperatures, lightning, temperature inversions and rogue waves;
- low visibility; and
- changing weather trends.

Table 4.3.14.1 summarizes the potential effects of the environment on the increased Project-related marine vessel traffic.

TABLE 4.3.14.1

POTENTIAL EFFECTS, MITIGATION MEASURES AND RESIDUAL EFFECTS OF CHANGES TO THE PROJECT CAUSED BY THE ENVIRONMENT

Potential Effect	Spatial Boundary	Key Mitigation Measures in Place/Additional Recommendations	Potential Residual Effect(s)
1. Severe weather events	Marine LSA	• No additional mitigation measures recommended for the changes to the Project caused by the environment.	• Severe weather, low visibility or changing weather trends could delay Project-related marine vessels or contribute to the possibility of an accident.
2. Low visibility	Marine LSA	• No additional mitigation measures recommended for the changes to the Project caused by the environment.	
3. Changing weather trends	Marine LSA	• No additional mitigation measures recommended for the changes to the Project caused by the environment.	

4.3.14.3 Potential Residual Effects

The potential residual effect of the changes to the increased Project-related marine vessel traffic caused by the environment (Table 4.3.14.1) is that severe weather or low visibility could delay Project-related marine vessels or contribute to the possibility of an accident.

Severe weather events (including high wind speeds, heavy/persistent precipitation [*e.g.*, from storms], extreme temperatures, lightning, temperature inversions and rogue waves) and low visibility could cause delays in Project-related marine vessel traffic. Severe weather and/or low visibility could cause tankers to lower their speeds, or stop transit in a safe location until weather conditions improve. Trans Mountain's operations are engineered with the possibility that Project-related marine vessels may not be able to transit Burrard Inlet for periods of days at a time due to weather. Slower tanker transit or the potential for a tanker to be anchored for multiple days due to adverse weather could have potential effects on the environment (*e.g.*, underwater noise, air quality). Since the assessment of potential environmental and socio-economic effects considers a general average of approximately 34 tankers per month, fluctuations in tanker transit time are considered in the assessment of potential effects.

Severe weather events and low visibility could increase the potential for a Project-related tanker to be involved in an accident (*e.g.*, high winds could cause the grounding of a tanker, although unlikely). Non-spill related accidents and malfunctions (*i.e.*, normal operations) are discussed in Section 4.3.13. The potential effects of a spill are discussed in Section 5.0.

Marine vessels, including those associated with the increased Project-related marine vessel traffic are designed to navigate safely in all extremely poor weather conditions. Vessels are staffed by trained mariners who are able to ensure the vessel's safety under poor conditions. General weather conditions in the Marine RSA are considered relatively benign, compared to other parts of the world and open ocean conditions. Weather reports and metrological information are obtained by the tankers using onboard equipment to assist in good decision making. Finally, BC pilots have their own weather limits and will not board or pilot Project-related vessels to sea if the conditions are not suitable, which ensures the transit cannot take place.

Changing weather trends are considered to have the potential to increase the frequency and magnitude of severe weather events. The consideration of severe weather events is inclusive of the potential for more frequent and harsher events in the future.

4.3.14.4 Combined Effects of Changes to the Project Caused by the Environment

An evaluation of the combined effects considers those residual effects that are likely to occur. Since the probability of environmental conditions affecting marine transportation is low, an evaluation of combined effects on increased Project-related marine vessel traffic caused by the environment is not warranted.

4.3.14.5 Summary

As identified in Table 4.3.14.1, the potential exists that severe weather, low visibility or changing weather trends could delay Project-related tankers or contribute to the possibility of an accident. Potential effects resulting from these events are considered to be unlikely. Marine vessel operators have been safely shipping in the Marine RSA for well over 60 years.

4.3.15 Summary of Environmental and Socio-Economic Effects

4.3.15.1 Summary of the Assessment of Potential Effects of the Project on the Environment

The environmental and socio-economic effects associated with the Project are similar to those routinely encountered during existing marine transportation operations by vessels associated with Trans Mountain.

The potential environmental and socio-economic effects associated with the Project were identified through: consultation with the federal and provincial government representatives, other stakeholders and the general public; engagement with Aboriginal communities; review of existing literature; and the professional judgment of the assessment team. These potential effects were related to environmental and socio-economic elements including:

- physical elements such as marine sediment and water quality, marine air emissions, marine GHG emissions, and marine acoustic environment;

- biological elements such as marine fish and fish habitat, marine mammals, marine birds, and marine species at risk;
- socio-economic elements such as traditional marine resource use, marine commercial, recreational, and tourism use and human health; and
- accidents and malfunctions.

For the purposes of the marine transportation assessment, since Trans Mountain has little direct control over the actions of vessel owners and operators, mitigation is considered to include existing legislation and shipping standards that are monitored by several federal and international authorities (*e.g.*, PMV, PPA, CCG, Transport Canada, USCG and IMO). Trans Mountain expects that through its tanker acceptance process the calling vessels are maintained and operated to high industry standards.

Through the implementation of the mitigation measures, the residual effects associated with the increase in marine transportation on the environmental and socio-economic elements were considered to be not significant in all cases except one. Given that past and current activities are considered to have caused significant adverse effects on the southern resident killer whale population, the effects associated with the increased Project-related marine vessel traffic on this species is considered to be significant.

4.3.15.2 Summary of the Changes to the Project Caused by the Environment

As identified in Table 4.3.14.1, the potential exists that severe weather, low visibility or changing weather trends could delay Project-related tankers or contribute to the possibility of an accident. Potential effects resulting from these events are considered to be unlikely. Marine vessel operators calling on the Westridge Marine Terminal have been safely shipping in the Marine RSA for over 60 years.

4.4 Cumulative Effects Assessment

Cumulative effects are changes to the environment that are caused by an action in combination with other past, present and future human actions (Hegmann *et al.* 1999). A cumulative effects assessment is conducted to identify how impacts from a proposed project could interact with impacts from other developments occurring in the same ecosystem or region. The cumulative effects assessment background and methodology described for onshore facilities in volumes 5A and 5B is also applicable to the effects of increased Project-related marine vessel traffic. The marine transportation cumulative effects assessment expands the scope of traditional environmental assessment to evaluate how combined vessel traffic may cause cumulative effects at both the local and regional scales.

The scope of the cumulative effects assessment is a Project-specific cumulative effects assessment as required under the *CEA Act*, *2012* which is appropriate for the scale of the marine transportation component of the Project. Project-specific cumulative effects assessments must determine if that particular project is incrementally responsible for adversely affecting a given element (Hegmann *et al.* 1999). They may also assist provincial and federal agencies and others by identifying requirements for additional planning, monitoring or mitigation that are beyond the direct control of the proponent and need to be implemented or led by others. Therefore, the total cumulative effect on a given environmental or socio-economic indicator from all actions must be identified; however, the cumulative effects assessment must also make clear to what degree the project under review is contributing to that total effect.

According to the *CEA Act, 2012,* a project-specific cumulative effects assessment need only focus on regional concerns where the principal project's activities may incrementally contribute to these concerns. Only those resources that will be directly affected by the project under review, as well as other projects or activities that overlap with these effects, need to be included in the project-specific cumulative effects assessment. This assessment therefore focuses on increased tanker and associated tug traffic from the Project (as identified in Section 2) in combination with the likely residual effects arising from other current or likely marine vessel traffic in the element-specific RSA (*i.e.*, Marine RSA or Marine Air Emissions RSA).

4.4.1 Methodology

The marine transportation cumulative effects assessment applies the following steps.

- Identify potential residual effects of increased Project-related marine vessel traffic (Section 4.4.1.1).
- Determine spatial and temporal boundaries for each environmental and socio-economic indicator where residual effects have been identified (Section 4.4.1.2).
- Identify existing and reasonably foreseeable marine vessel traffic that may act in combination with the residual effects of Project-related marine vessel traffic (Sections 4.4.1.3 and 4.4.1.4).
- Identify potential cumulative effects (Section 4.4.1.5).
- Identify technically and economically feasible mitigation measures and industry standards, if any are warranted (Section 4.4.1.6).
- Determine the significance of the contribution of increased Project-related marine vessel traffic to cumulative effects (Section 4.4.1.7).

Each of the above steps is described below in the applicable methodology subsection. This cumulative effects assessment methodology has been developed based on FEARO's The Authority's Guide to the *Canadian Environmental Assessment Act*: Part II: The Practitioner's Guide (FEARO 1994a), FEARO's A Reference Guide for the *Canadian Environmental Assessment Act*: Addressing Cumulative Environmental Effects (FEARO 1994b), FEARO's A Reference Guide for the *Canadian Environmental Assessment Act*: Determining Whether a Project is Likely to Cause Significant Environmental Effects (FEARO 1994c), CEA Agency's Cumulative Effects Assessment Practitioners Guide (Hegmann *et al*. 1999), CEA Agency's Addressing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act* (CEA Agency 2013), the *CEA Act, 2012* and the NEB Filing Manual (NEB 2013c) and is similar to the methodology used in Volumes 5A and 5B.

4.4.1.1 Identify Residual Effects of Project-Related Marine Vessel Traffic

The expectation of the NEB is that each residual environmental or socio-economic effect is evaluated for potential cumulative effects (see Guide A.2.7 of the NEB Filing Manual [2013c]). Nevertheless, Table A-2 of the NEB Filing Manual (2013c) indicates that likely residual effects for the GHG emissions element need not be subject to a cumulative effects assessment. Consequently, all other likely residual environmental and socio-economic effects identified in Section 5.0 are evaluated to determine the Project's contribution to potential cumulative effects.

As per Guides A.2.6 and A.2.7 of the NEB Filing Manual, if a physical, biological and socio-economic element or indicator evaluated in the environmental and socio-economic effects assessment (Section 4.3) had no residual effects predicted or effects were not considered likely, then these were excluded from the cumulative effects assessment. Therefore, the cumulative effects assessment is limited to elements or indicators with residual effects that could act cumulatively with residual effects from other marine vessel traffic.

4.4.1.2 Spatial and Temporal Boundaries

4.4.1.2.1 Spatial Boundaries

Spatial boundaries or ZOI for the effects of increased Project-related marine vessel traffic are variable based on a consideration of local and regional environmental setting and any common connections or links that the Project-related activities possess with other marine vessel traffic along the established marine transportation shipping lanes. The spatial boundaries used in the marine transportation cumulative effects assessment were determined to be the areas where potential cumulative effects are non-trivial and have been identified. The spatial boundaries for each element as well as the rationale for the boundaries are presented in Section 4.3.

4.4.1.2.2 Temporal Boundaries

Current accepted practice for NEB applications is to use existing conditions for cumulative effects assessment. A general discussion of the historical developments and activities that have created existing conditions is included as background information (Section 4.4.1.3).

The temporal boundaries used in the cumulative effects assessment include the time period in which increased Project-related marine vessel traffic will occur (*i.e.,* the operations period or more than 50 years).

4.4.1.3 Existing Activities and Events

Existing activities that are likely to occur in the Project area will vary depending on the spatial residual effects boundaries identified for the specific environmental or socio-economic element.

4.4.1.3.1 Marine Industry and Commercial Fishing

Marine industry in the Marine RSA is concentrated in the Lower Mainland in the most populous region of BC (Chamber of Shipping 2011). PMV is Canada's busiest port and is the port authority mandated under the *Canada Marine Act* to be responsible for the safe and efficient movement of marine vessel traffic in Burrard Inlet (PMV 2013a). The port authority provides oversight for operations of 28 cargo and container terminals in the Lower Mainland (PMV 2013a). Most of the marine terminals are located in Burrard Inlet, including: cargo terminals for bulk products (*i.e.*, raw material commodities such as chemicals and petroleum products) and break-bulk products (*e.g.*, forest products); container terminals for transporting goods in intermodal containers; and two cruise ship terminals. Marine terminals along the lower Fraser River include cargo, container and automobile terminals.

Roberts Bank Superport is a twin-terminal port facility in Delta, BC that contains a coal terminal and a container terminal. Westshore Terminals exported 27.3 million tonnes of coal and coke in 2011 (Westshore Terminals 2013). The Deltaport container terminal at Roberts Bank is Canada's largest container terminal (PMV 2013a).

In 2012, PMV activities for terminals in Burrard Inlet, the Lower Fraser River, and Delta included:

- handling of approximately 123 million tonnes of cargo;
- handling over 3,000 calls by foreign vessels; and
- facilitating the transit of 191 cruise ship voyages, with over 600,000 passengers (PMV 2013a).

The City of Victoria is the major commercial centre on Vancouver Island. The port is used by deep sea ships and coastal and industrial traffic, including a cruise ship terminal at Ogden Point (Chamber of Shipping 2011).

Commercial fishing vessels employ a variety of fishing techniques for a large number of key targeted species and species groups, including salmon, herring, groundfish, crab, shrimp and prawn. Many species are fished year-round; however, the location and timing of specific commercial fishing activities depends upon the abundance and distribution of the targeted species or species assemblages, the season being fished, economic factors such as the value of the fishery, and regulations determined by DFO pursuant to the *Fisheries Act*.

Areas of the Marine RSA with the highest relative effort for certain fisheries were determined using spatial data obtained from DFO (for more detail, refer to the Marine Commercial, Recreational and Tourism Use – Marine Transportation Technical Report (Volume 8B, TR 8B-6). These areas include:

- salmon troll: Southern Gulf Islands;
- salmon seine: northwestern Juan de Fuca Strait;
- salmon gillnet: southern Strait of Georgia and northwestern Juan de Fuca Strait;
- groundfish trawl: western Juan de Fuca Strait and Southern Gulf Islands;
- groundfish hook and line (Schedule II fisheries): southern Strait of Georgia;
- rockfish hook and line (ZN fisheries): Haro Strait and western Juan de Fuca Strait;
- Dungeness crab trap: nearshore areas of Haro Strait along the Saanich Peninsula, and Southern Gulf Islands;
- prawn trap: nearshore areas of southeast Vancouver Island;
- shrimp otter trawl: Southern Gulf Islands; and
- shrimp beam trawl: Strait of Georgia along the shipping lanes west of Richmond and Delta, and southern Haro Strait.

The routes typically used by fishing vessels throughout the marine study area are summarized using information from the Marine Commercial, Recreational and Tourism Use – Marine Transportation Technical Report (Volume 8B, TR 8B-6).

Fishing vessels use the designated shipping lanes through the Strait of Georgia, Haro Strait and Juan de Fuca Strait, as well as most navigable channels in the study area. The use of travel routes depends on factors including the location of the fishing grounds, the location of the home port, weather, and navigational hazards.

In the Strait of Georgia, most fishing vessels travel in a north-south direction along Roberts Bank to access the southern straits, and east-west to access fishing grounds in Howe Sound and north of the study area. Fishing vessels must cross the shipping lanes in the Strait of Georgia to access fishing grounds in areas of the Southern Gulf Islands and southeast Vancouver Island. Fishing vessels also cross the Strait of Georgia from the west to access home ports, fishing grounds and processing facilities along the Fraser River. Fishing vessels use the shipping lanes in Juan de Fuca Strait, and seldom cross the Traffic Separation Zone down the middle of the strait. Smaller fishing vessels travel close to shore, in more sheltered waters outside of the main shipping lanes. The TMEP TERMPOL 3.2, Origin, Destination, and Marine Traffic Volume Survey (Volume 8C, TR 8C-2) provides more information on the movements of marine vessels, including fishing vessels, in the Marine RSA.

4.4.1.3.2 Marine Transportation

The Strait of Georgia is a busy and regionally important shipping route. To address the efficient navigation and safety of marine vessels, a Marine Traffic Separation Scheme is in place throughout the Strait of Georgia, Haro Strait and Juan de Fuca Strait (CCG 2013a). Traffic Separation Schemes separate opposing streams of traffic by establishing inbound and outbound shipping lanes and associated navigational aids, as well as a separation zones between lanes in some areas (IMO 2013a). Most commercial vessels use the shipping lanes, although passenger ferries follow routes that often cross the shipping lanes between terminals.

Passenger ferries operated by BC Ferry Services use the Strait of Georgia for ferry service between ports on the Lower Mainland, Vancouver Island, and the Southern Gulf Islands. Ferries transit frequently between:

- Horseshoe Bay (West Vancouver) and Nanaimo (Vancouver Island);
- Tsawwassen (Delta) and Duke Point (Nanaimo area);
- Tsawwassen and Swartz Bay (north of Victoria); and
- Tsawwassen, Swartz Bay and the main Southern Gulf Islands (Salt Spring, Pender, Mayne, Galiano, and Saturna islands) (BC Ferry Services 2013b).

Other ferry services operating in the Marine RSA include Washington State Ferries, which carry passengers between Sidney and Anacortes in Washington State (Washington State Department of Transportation 2013a). From Victoria, Black Ball Ferry Line runs regular trips between Victoria and Port Angeles (Black Ball Ferry Line 2013). The Victoria Clipper is a passenger-only ferry service that runs high-speed catamarans daily between Victoria and Seattle (Clipper Navigations 2013). The Alaska Marine Highway System includes as part of its transportation network the Alaska ferry from Bellingham via Prince Rupert into Alaska. The ferry route is in the shipping lanes through the Strait of Georgia, continuing north through Johnstone Strait and Hecate Strait (State of Alaska 2013).

Marine transportation services are provided by a large fleet of tugboats and barges that operate throughout BC coastal waters. Some of the larger operators include Seaspan Marine

Corporation, Pacific Towing Services Ltd. and SMIT Harbour Towage (Transport Canada 2013c).

Barges operated by Seaspan Coastal Intermodal Company transport truck trailers and rail cars across the shipping lanes between terminals on the Fraser River and Nanaimo and Swartz Bay, north of Victoria (Transport Canada 2006).

In 2012, tug transits (*i.e.*, all tug and barge traffic) made up approximately 49 per cent of the total sailed nautical miles in the Strait of Georgia and Vancouver Outer Harbour, with cargo and ferry traffic making up a further 18 per cent and 15 per cent, respectively (refer to the TMEP TERMPOL 3.2, Volume 8C, TR 8C-2).

Log handling occurs in Burrard Inlet and along the Fraser River, and other log handling and storage areas are located in the Southern Gulf Islands, the Saanich Peninsula north of Victoria, and near Sooke and Port Renfrew on southern Vancouver Island (BC MCA 2012, Natland pers. comm.). Logs are also stored in numerous locations along the Fraser River. Mill & Timber Products in Port Moody handles and stores logs in Port Moody Inlet (Natland pers. comm.). A log pond area is active in nearshore areas south of Point Grey in Vancouver. Many of these logs stored on the river are processed at the remaining mill sites along the river (Natland pers. comm.).

Aquaculture operations for shellfish and finfish are present in nearshore areas in Haro Strait as well as southwestern Vancouver Island. Active licenses for shellfish aquaculture operations for mussels, Manila clams, Pacific oysters and other shellfish are present in the Southern Gulf Islands, in sheltered areas near Saturna Island and Saltspring Island (DFO 2013n). Active licenses for Atlantic salmon, Manila clams and Pacific oysters are present in the Sooke Basin, west of Victoria (DFO 2013o).

4.4.1.3.3 Marine Recreation

Marine recreational use of the Marine RSA includes fishing, boating (including sailboats and powerboats), kayaking and canoeing and scuba diving. Recreational use is inherently connected to specific designated areas including marine parks and reserves, and recreational fishery areas, but marine recreational activities also occur throughout the Marine RSA.

Recreational fishing activities, including economic activity generated by tourist and non-tourist anglers, contributed over $300 million to the provincial economy in 2011 (BC Stats 2013). Recreational fishing occurs throughout the study area, including in accessible nearshore areas close to population centres, such as Burrard Inlet and Victoria Harbour; at river mouths such as the Capilano River in Burrard Inlet; and in more remote but highly productive areas such as Swiftsure Bank at the western approach to Juan de Fuca Strait (Bird pers. comm.). Recreational fishers in tidal waters must obtain a tidal waters sport fishing license from DFO (DFO 2013l). Key species for recreational fishing include Chinook and coho salmon, and Pacific halibut (Sport Fishing Institute of BC 2013). Rockfish species, lingcod, other salmon species, prawn and Dungeness crab are also popular with recreational fishers (Sport Fishing Institute of BC 2013).

The Strait of Georgia is a major access route for boaters to areas in the Southern Gulf Islands, Vancouver Island, the US San Juan Islands, and many other destinations. Commonly used boating routes cross the shipping lanes north of Roberts Bank off Delta and at several other points from the east, to access Porlier Pass between Valdes Island and Galiano Island and Active Pass between Mayne Island and Galiano Island. Recreational boaters also cross the shipping lanes from the west to access the Fraser River. Yacht racing also takes place throughout the Marine RSA. TERMPOL 3.2, Volume 8C, TR 8C-2 provides more information on the movements of vessels in the Marine RSA.

The Southern Gulf Islands and the inshore areas of southeast Vancouver Island are highly popular recreational areas in the summer months for residents and tourists. Together, Boundary Pass and Haro Strait form the eastern boundary of the Gulf Islands National Park Reserve, designated to protect terrestrial and marine areas on many of the islands in the Gulf Islands archipelago (Parks Canada 2013b). The park reserve is an international destination for activities such as kayaking, canoeing, boating, scuba diving, coastal camping, whale-watching and wildlife viewing. An extensive marine trail network of paddling routes, access points and coastal campsites throughout coastal BC provides opportunities for kayakers, canoeists and other small craft (BC Marine Trails Network Association 2013). Many of the most accessible routes are located in the Gulf Islands National Park Reserve (Gulf Islands Tourism 2013). Coastal campsites are present on South Pender Island, Sidney Island and D'Arcy Island, in marine parks that are also part of the National Park Reserve. In the Victoria area, Discovery Island Marine Park off Oak Bay is also popular for kayaking. Kayakers use the coastal campsites on the south side of the islands in Rudlin Bay, as well as other campsites in the Chatham Islands to the north in Haro Strait (BC Parks 2013b).

4.4.1.4 Reasonably Foreseeable Activities

Reasonably foreseeable developments that are likely to occur in the Project area will vary depending on the spatial residual effects boundaries identified for the specific environmental or socio-economic element.

The criteria used to determine marine vessel traffic that may act cumulatively with the Project-related marine vessel traffic are:

- the marine vessel traffic is already travelling in the vicinity of increased Project-related marine vessels (*i.e.*, certain); or
- the marine vessel traffic is associated with a development that is either proposed (public disclosure), has been approved to be developed, but is not yet being developed in the vicinity of the Project, or is included in projections of likely future marine vessel traffic (*i.e.,* reasonably foreseeable) included in the TMEP TERMPOL 3.2 (Volume 8C, TR 8C, TR 8C-2).

TERMPOL 3.2 includes projected traffic increases compiled from PMV, Fraser River Port Authority and North Fraser Port Authority. Other activities and reasonably foreseeable developments included in the assessment are summarized below, from specific expansion plans as well as general projected increases in the RSAs.

4.4.1.4.1 Specific Terminal Expansion Plans

Trans Mountain surveyed other bulk terminals in the Vancouver Harbour to determine the potential increase in vessel traffic. Pacific Coast Terminals are currently planning to increase vessel calls projecting out to 2018.

4.4.1.4.2 General Traffic Increase Projections

Table 4.4.1.1 details the projected growth rates of vessel movements in the Marine RSA by vessel type for the TERMPOL 3.2 (see Volume 8C, TR 8C-2 for more details). Table 4.4.1.2 details numbers of 2012 sailings and compares Project-related tankers and total traffic to 2012 and predicted 2030 numbers. Since vessel traffic growth rates were provided for the entire Marine RSA, projected increases that have been calculated for each cross-section are considered to be a rough estimate. Projected total traffic increases in the Marine RSA are expected to vary between Burrard Inlet, English Bay, the Strait of Georgia, Haro Strait and Juan de Fuca Strait and are provided as a reasonably foreseeable approximation.

TABLE 4.4.1.1

SUMMARY OF OTHER PROJECTED MARINE RSA VESSEL TRAFFIC GROWTH RATES

Ship Type	Projected Growth Rates in Marine RSA (% change per year)		Total Change (%)
	2012 to 2020	2020 to 2030	
Tanker < 50,000 DWT	2	2	42.8
Tanker > 50,000 DWT	2	2	42.8
Chemical tanker	2	2	42.8
Liquefied petroleum/natural gas carrier	2	2	42.8
General cargo	1	1	19.6
Bulk cargo	1	1	19.6
Container	1	1	19.6
Tug	1	1	19.6
Tug with oil barge	1	1	19.6
Tug with chemical barge	1	1	19.6
Tug with tow	1	1	19.6
Government	1	1	19.6
Fishing	0	0	0
Passenger vessel	1	1	19.6
Other vessels > 20 m	1	1	19.6
Other vessels < 20 m	1	1	19.6
Ferry movements	0	1	10.5

TABLE 4.4.1.2

SUMMARY OF EXISTING AND FUTURE VESSEL MOVEMENTS AT FIVE LOCATIONS IN THE MARINE RSA

Location of Cross Section[1]		Vessel Movements by Vessel Type in 2012 (#/yr)									Project-Related Vessel Movements[10] (#/yr)			Project-Related Tanker Contribution to 2012 Vessel Traffic (%)[11]	Project-Related Tanker and Tug Contribution to 2012 Vessel Traffic (%)[11]	Estimated Increase in Non-Project Vessel Movements by 2030 (#/yr)[12]	Estimated Total Vessel Movements in 2030 (#/yr)[13]	Project-Related Tanker Contribution to Total Projected Future Vessel Traffic (%)[14]	Project-Related Tanker and Tug Contribution to Total Projected Future Vessel Traffic (%)[14]
Name	Description	Tanker[2]	Cargo/Carrier[3]	Tug[4]	Service[5]	Passenger[6]	Fishing[7]	Other[8]	Unknown[9]	Total	Tanker	Tug	Total						
Burrard Inlet[15]	North-south across Burrard Inlet just west of the Westridge Marine Terminal	263	108	5,631	473	68	25	261	29	6,858	720	2,160	2,880	9.5	29.6	1,401	11,139	6.5	25.9
English Bay	North-south from Point Atkinson in West Vancouver to Point Grey area in Vancouver	384	3,170	5,755	682	477	192	1,244	337	12,241	720	720	1,440	5.6	10.5	2,453	16,134	4.5	8.9
Strait of Georgia	Northeast across southern Strait of Georgia, from Delta near Tsawwassen to Active Pass area	385	5,301	3,237	1,316	5,634	459	672	590	17,594	720	720	1,440	3.9	7.6	3,450	22,484	3.2	6.4

TABLE 4.4.1.2

SUMMARY OF EXISTING AND FUTURE VESSEL MOVEMENTS AT FIVE LOCATIONS IN THE MARINE RSA (continued)

Location of Cross Section[1]		Vessel Movements by Vessel Type in 2012 (#/yr)									Project-Related Vessel Movements[10] (#/yr)			Project-Related Tanker Contribution to 2012 Vessel Traffic (%)[11]	Project-Related Tanker and Tug Contribution to 2012 Vessel Traffic (%)[11]	Estimated Increase in Non-Project Vessel Movements by 2030 (#/yr)[12]	Estimated Total Vessel Movements in 2030 (#/yr)[13]	Project-Related Tanker Contribution to Total Projected Future Vessel Traffic (%)[14]	Project-Related Tanker and Tug Contribution to Total Projected Future Vessel Traffic (%)[14]
Name	Description	Tanker[2]	Cargo/Carrier[3]	Tug[4]	Service[5]	Passenger[6]	Fishing[7]	Other[8]	Unknown[9]	Total	Tanker	Tug	Total						
Haro Strait	Northeast from Victoria area east to San Juan Island	391	4,506	975	850	506	300	907	461	8,896	720	720	1,440	7.5	13.9	1,777	12,113	5.9	11.9
Juan de Fuca Strait	Southeast from Victoria to Port Angeles area	1,197	7,695	2,294	2,189	2,146	742	1,409	831	18,503	720	720	1,440	3.7	7.2	3,762	23,705	3.0	6.1

Source: ,TERMPOL 3.2 (Volume 8C, TR 8C-2)

Notes:
1 Cross sections were placed across the shipping lanes to characterize the movements of vessels in the area that may be travelling in or adjacent to the shipping lanes.
2 Tanker traffic includes all chemical and petroleum products.
3 Cargo/carrier includes bulk carriers and general cargo carriers.
4 Tug traffic includes all tug movements, such as tugs engaged in towing and barging activities and harbour assist tugs.
5 Service vessels include: law enforcement/patrol vessels, military vessels, pilot vessels, pollution control vessels, research/survey vessels, dredges, and others.
6 Passenger includes ferries and cruise ships. While cruise ships operate in the summer months, most ferry services are year round. Strait of Georgia passenger vessel movements may be biased due to placement of the cross section parallel to major ferry routes and may include more than one instance per ferry crossing. Due to the fact that the passenger vessels category combines ferry and cruise ship traffic, ferry movements were estimated as 1% per annum from 2012 to 2030.
7 Fishing: only fishing vessels greater than 24 m in length and 150 gross tonnes are required to call in to VTS. Smaller vessel movements are not captured.
8 'Other' category may include pleasure craft greater than 30 m in length (required to call into VTS).
9 'Unknown' category is likely to include private recreational vessels and all vessels smaller than 30 m that are not required to call into VTS.
10 Tanker numbers calculated as: 30 vessels/month ×12 months/yr × 2 transits/vessel (inbound + outbound). Tug numbers calculated assuming 3 escort tugs for outbound tankers in Burrard Inlet and 1 escort tug for outbound tankers along the remainder of the shipping lanes. Tug numbers include outbound trip (*i.e.,* while escorting tanker) and inbound trip (*i.e.,* returning to point of origin).

TABLE 4.4.1.2

SUMMARY OF EXISTING AND FUTURE VESSEL MOVEMENTS AT FIVE LOCATIONS IN THE MARINE RSA (continued)

11 Calculated as: Project-related vessel movements/yr / (TMEP vessel movements/yr + 2012 total vessel movements).

12 Calculated using projected growth rates from Table 4.4.1.1.

13 Includes Project-related vessel movements.

14 Calculated as: TMEP vessel movements/yr / 2030 total vessel movements.

15 Some traffic east of Second Narrows in Burrard Inlet is associated with Westridge Marine Terminal; however, Pacific Coast Terminals and other terminals operate east of Westridge Marine Terminal in Port Moody. Therefore, existing commercial and tanker traffic and projected growth in this cross-section is not entirely Project-related.

Future marine vessel movements in the Marine RSA were projected to have a growth rate of 2 per cent per annum through to 2030 for marine tankers, including oil tankers, chemical tankers and LNG carriers. Cargo carriers and container ships were projected to grow at 1 per cent per annum through to 2030. The projected growth rate for all other marine vessels (*e.g.*, tugs, barges, government vessels, passenger vessels and all other vessels) was 1 per cent per annum over the same time period, with the exception of fishing vessels, which were projected to have a 0 per cent growth rate (TERMPOL 3.2, TR 8C-2, Volume 8C). The growth of commercial marine vessel traffic in the Marine RSA is the result of development of the marine industry in the region. For example, several existing marine terminals are proposing to undergo considerable expansion to increase their shipping capacity, which will add to the commercial marine traffic in the Marine RSA.

Discussions between Trans Mountain and other bulk terminals in Burrard Inlet were held to discuss the potential increase in local vessel traffic from marine terminal developments east of the Second Narrows, around the Westridge Marine Terminal. In order to navigate through Burrard Inlet into the Strait of Georgia, deep draft marine vessels must request that the CN Rail Bridge be raised to allow transit through the Second Narrows. An increase in traffic in this area will also increase the frequency of the need to raise the rail bridge. As of 2013, at least one other marine terminal located east of the Second Narrows plans to increase vessel calls projecting out to 2018.

Developments in the Marine RSA which have planned marine terminal components or expansions include a number of proposed projects that fall under the jurisdiction of PMV. If approved, these developments are expected to contribute to the increase in commercial marine vessel traffic in Burrard Inlet, the Strait of Georgia, Haro Strait and Juan de Fuca Strait. These include the following proposed projects.

- PMV is proposing to construct and operate the Roberts Bank Terminal 2 Expansion Project. In 2011, PMV moved 2.5 million twenty-foot equivalent unit containers (TEUs), and forecasts suggest that container traffic is expected to double over the next 10 to 15 years and triple by 2030. The proposed new multi-berth container terminal at Roberts Bank in Delta would provide 2.4 million TEUs of container capacity. The project is part of PMV's Container Capacity Improvement Program, a long-term strategy to deliver projects to meet anticipated growth in demand for container capacity to 2030. The project is currently in the pre-application phase (field studies are currently underway) with construction anticipated from 2017/2018 to 2024 (PMV 2013b).

- Fraser Surrey Docks on the Fraser River is proposing a development of a direct transfer coal facility to handle up to 4 million metric tonnes of coal per year by 2014. The coal will be transferred to the terminal by rail and loaded onto barges which will be towed to a storage facility on Texada Island, before transfer to bulk carriers for overseas export. At full capacity, an estimated 640 barge tows per year or two tows a day will transit from FSD north across the Strait of Georgia to Texada Island (Det Norske Veritas 2012). The project is currently under review by PMV (PMV 2013).

- Neptune Terminals in Burrard Inlet has received a project permit from PMV to expand its coal handling capacity up to 18.5 million metric tonnes per year, which is expected to result in approximately one additional ship per week calling on the terminal following project completion (PMV 2013a).

- Richardson International Limited has received a project permit from PMV to expand their grain storage capacity at their Vancouver marine terminal by adding a new storage facility. The project is expected to take two years to complete. The increased grain storage capacity will increase the annual capacity of the terminal to handle from 3 million to 5 million metric tonnes of grains and oilseeds (PMV 2013a). No estimates of future growth in associated vessel traffic have been released as of 2013.

- Westshore Terminals in Delta recently completed an upgrade to its facilities that increased throughput capacity for coal exports to 33 million tonnes, and anticipates an increase in coal shipments to reach the new capacity over the next few years (Kirby 2013).

Additionally, proposed coal terminal expansions in Washington State will contribute to marine vessel traffic in Juan de Fuca Strait, if approved. As of 2013, two proposed coal terminals are undergoing review by state authorities, including the following.

- Gateway Pacific Terminal is a terminal proposed at Cherry Point, near Bellingham, Washington. The terminal will have the capacity to ship up to 60 million metric tonnes annually of dry bulk commodities, mostly coal. Most of the coal barges calling at the Gateway Pacific Terminal are expected to use Rosario Strait between the Strait of Georgia and Juan de Fuca Strait, with occasional use of Haro Strait. The project is under environmental review by the Washington Department of Ecology (Washington State Department of Ecology 2013c).

- Millennium Bulk Terminals is a coal terminal proposed in Longview, Washington. The completed terminal will have the capacity to ship up to 44 million metric tonnes of coal annually. The project is under environmental review by the Washington Department of Ecology (Washington State Department of Ecology 2013c).

In addition to reasonably foreseeable marine industry developments, proposed parks and other recreational areas in the Marine RSA that include marine components may also contribute to future increases in marine use by recreational and tourism users and, therefore, are considered in the cumulative effects assessment. Notably, the Southern Strait of Georgia National Marine Conservation Area is proposed for the Southern Gulf Islands and nearshore areas of southeast Vancouver Island. The proposed area includes the current Gulf Islands National Park Reserve with considerable expansion of the marine areas from Gabriola Island in the north to the middle of Haro Strait in the south, including nearshore areas of Vancouver Island out to the shipping lanes and the international border. The current national park reserve is a draw for both residents and visitors to BC. The proposed NMCA is currently in the public consultation phase of a feasibility assessment by the provincial and federal governments (Parks Canada 2013b).

4.4.1.5 Identify Potential Cumulative Effects

The potential cumulative effects of marine transportation depend on many factors, including:

- the source of the disturbance;
- resilience of the receptor or indicator of interest; and

- the way in which disturbances from multiple vessel passages interact in time and space.

The level of detail provided in the analysis reflects the extent to which a cumulative effect on an environmental or socio-economic element is probable, the likely scale or magnitude of effect, as well as the extent to which these effects can be accurately and reasonably quantified and described relative to the receptor or indicator of interest. Most residual effects were assessed qualitatively since the residual effect or indicator to be assessed did not lend itself to a quantitative assessment and given that the Marine RSA is heavily used for marine traffic under current conditions. A quantitative approach using GIS or predictive models (*e.g.,* air emissions analysis) was used to inform the assessment of marine acoustic environment and marine air emissions.

4.4.1.6 Environmental Protection Measures

Best management practices implemented to mitigate project-specific effects often limit the potential cumulative environmental effects (Finley and Revel 2002). The goal of mitigation is to attempt to avoid or reduce adverse effects to acceptable or non-significant levels by reducing the magnitude of the effect, limiting the extent of the effect and shortening the reversibility of the effect (*i.e.,* time to alleviate the residual effect) (*e.g.*, the use of additional escort tugs for navigational safety in Juan de Fuca Strait).

No additional mitigation measures beyond those listed in Section 5.0 of this marine transportation assessment were deemed warranted.

4.4.1.7 Determination of Significance

The overall cumulative effects on an element and the contribution of the effects of the Project-related marine vessel traffic to these cumulative effects (*i.e.,* cumulative effects of the Project) are described for each applicable element or indicator. The significance of the contribution of the effects of the Project-related marine vessel traffic to cumulative effects is determined in a manner similar to that used to determine the significance of Project-related residual effects as previously outlined in Section 4.3.1 and summarized in Table 4.3.1.2 with the exception of spatial boundaries, which are discussed in Sections 4.3.2 to 4.3.12.

All significance assessment criteria (*e.g.,* temporal context, magnitude, *etc*.) are considered by the assessment team for each cumulative environmental or socio-economic effect.

4.4.1.8 Cumulative Effects Assessment

Those environmental and socio-economic effects in which adverse residual effects are predicted and are analyzed in the cumulative effects assessment are:

- physical elements such as marine air emissions and marine acoustic environment;
- biological elements such as marine fish and fish habitat, marine mammals, marine birds and marine species at risk; and
- socio-economic elements such as traditional marine resource use and MCTRU.

The potential and likely residual effects associated with increased Project-related marine vessel traffic on each element are identified in the following subsections along with the identification of existing activities or reasonably foreseeable developments acting in combination with the Project, as well as the cumulative effect.

An evaluation of the significance of the contribution of Project-related marine vessel traffic to cumulative effects was conducted. Details of the significance evaluation are also discussed in each of the following subsections.

4.4.2 Marine Air Emissions

4.4.2.1 Reasonably Foreseeable Developments

Table 4.4.1.2 summarizes the current level of marine traffic within the Marine RSA as well as the anticipated marine traffic attributed to the Project and other reasonably foreseeable marine traffic. A description of existing and anticipated activities is provided in Section 4.4.1.4.

4.4.2.2 Potential Cumulative Effects

The potential and likely environmental residual effects associated with the increase in Project-related marine vessel traffic on marine air emission indicators were identified in Section 4.3 and are listed in Table 4.4.2.1 along with the identification of existing activities and reasonably foreseeable marine traffic that could act in combination with the increase in Project-related marine vessel traffic. There is no detailed inventory information available with respect to major foreseeable developments or urban emissions in the Lower Fraser Valley or in marine traffic that would permit a future scenario to be modelled. Therefore, a qualitative assessment was completed.

TABLE 4.4.2.1

POTENTIAL RESIDUAL EFFECTS OF PROJECT-RELATED MARINE TRAFFIC ON AIR EMISSIONS CONSIDERED FOR THE CUMULATIVE EFFECTS ASSESSMENT

Potential Residual Project Effect on Indicator	Spatial Boundary[1]	Temporal Boundary	Potential Cumulative Effect	Existing Activities/Reasonably Foreseeable Activities with Residual Effects Acting in Combination with Project-Related Marine Vessel Traffic
1. Combined Project effects on CACs	RSA	Operation	Project contribution to cumulative increase in CAC emissions	• Existing marine traffic • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.
2. Combined Project effects on VOCs	RSA	Operation	Project contribution to cumulative increase in VOC emissions	• Existing marine traffic • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.
3. Combined Project effect on formation of secondary PM and ozone	LFV	Operation	Project contribution to cumulative increase information of secondary PM and ozone emissions	• Existing marine traffic • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.
4. Combined Project effect on visibility	LFV	Operation	Project contribution to cumulative increase in decreased visibility during operations	• Existing marine traffic • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.

Note: 1 RSA = Air Quality RSA; LFV = Lower Fraser Valley Photochemical Model Domain

4.4.2.3 Significance Evaluation of Potential Cumulative Effects

Table 4.4.2.2 provides a summary of the significance evaluation of the contribution of Project-related marine vessel traffic to potential cumulative effects on the air emission indicators. The rationale used to evaluate the significance of each of the cumulative effects is provided below.

TABLE 4.4.2.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON AIR EMISSIONS

Potential Cumulative Effects		Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
				Duration	Frequency	Reversibility				
1	**Marine Air Emissions Indicator – Primary Emissions of CACs**									
1(a)	Project contribution to cumulative increase in CAC emissions	Negative	RSA	Long-term	Periodic	Short-term	Low	High	Moderate	Not significant
2	**Marine Air Emissions Indicator – Primary Emissions of VOCs**									
2(a)	Project contribution to cumulative increase in VOC emissions	Negative	RSA	Long-term	Periodic	Short-term	Low	High	Moderate	Not significant
3	**Marine Air Emissions Indicator – Formation of Secondary PM and Ozone**									
3(a)	Project contribution to cumulative increase in formation of secondary PM and ozone emissions	Negative	LFV	Long-term	Periodic	Short-term	Low	High	Moderate	Not significant
4	**Marine Air Emissions Indicator – Visibility**									
4(a)	Project contribution to cumulative increase in decreased visibility during operations	Negative	LFV	Long-term	Periodic	Short-term	Low	High	Moderate	Not significant
5	**Combined Cumulative Effects on Marine Air Emissions**									
5(a)	Project contribution to combined cumulative effects on marine air emissions indicators (1[a], 2[a], 3[a] and 4[a])	Negative	LFV	Long-term	Periodic	Short-term	Low	High	Moderate	Not significant

Notes: 1 RSA = Marine Air Quality RSA; LFV = Lower Fraser Valley Photochemical Model Domain

2 **Significant Residual Environmental Effect:** A high probability of occurrence of a permanent or long-term residual effect of high magnitude that cannot be technically or economically mitigated.

4.4.2.3.1 Air Emissions Indicator – Criteria Air Contaminants

Existing sources of air emissions in the Marine Air Quality RSA include marine vessels emissions arising from shipping, cruise ships, tankers, cargo ships, tugs, container ships, and smaller recreational and commercial boats.

The Project will act in combination with existing activities and reasonably foreseeable developments in the Marine Air Quality RSA to increase shipping-related air emissions. Trans Mountain has limited ability to influence third party vessel owners and operators. On March 26, 2010, the IMO officially designated the North American ECA.

For this area, all vessels within 200 nautical miles of the coast must burn low-sulphur fuel or achieve an equivalent emission reduction with exhaust gas after-treatment or other methods as follows:

- starting August 2012, the maximum fuel sulphur limit was 1 per cent;
- beginning January 2015, the maximum sulphur limit will be lowered to 0.1 per cent; and
- beginning in 2016, NO_x after-treatment emission control requirements become applicable for newly manufactured engines.

Port Metro Vancouver has joined the Northwest Ports Clean Air Strategy (formed in 2007) with the Ports of Seattle and Tacoma, and identified measures to reduce landside and marine air emissions (PMV 2013). Specifically to reduce marine emissions by year 2010, all ocean-going vessels should use distillate fuels with <0.5 per cent sulphur in their auxiliary engines during hoteling (at anchor) and <1.5 per cent sulphur in distillate fuel or equivalent particulate matter reduction measures for the main engines or diesel electric engines, when hoteling. In 2012, 40 per cent of the ocean-going vessels visiting PMV were complying with the IMO target. No PMV performance results were reported for the NO_x reduction measures; however, IMO Tier III marine engine requirements for new ships with engines over 130 kW output power must not exceed 3.4 g/kWh, which is an 80 per cent reduction relative to Tier I marine engines built after year 2000.

For reasons described more fully in Section 4.4.1.4, the Project is unlikely to act in combination with most reasonably foreseeable marine vessel traffic to cause increased air emissions in a particular area and it is unlikely that any exceedances of applicable air quality objectives would occur as a result of emissions from the increase in Project-related marine vessel traffic.

Project contribution to a cumulative increase in CAC emissions from combustion of distillate fuels in the main and auxiliary engines within the Marine Air Quality RSA during normal operations activities is considered to have a negative impact balance, is reversible immediately and of low magnitude (Table 4.4.2.2 point 1[a]). A summary of the rationale for all of the significance criteria of combined cumulative effects on increased VOC emissions is provided below.

- **Spatial Boundary** - Marine Air Quality RSA – Project contribution to cumulative increases in CAC emissions from the tanker engines would dissipate within the Air Quality RSA.
- **Duration** - long-term – emissions of CACs and subsequent changes to ambient ground-level concentrations are expected to occur for the life of the Project, and are thereforerated as long-term.
- **Frequency** - periodic – emissions of CACs will occur upon vessels transiting through the Marine Air Quality RSA, which is expected to occur intermittently and repeatedly with one to two vessels per day.
- **Reversibility** - long-term – Project contribution to cumulative effects will reverse shortly after shipping activities stop; however, Project life is more than 10 years.

- **Magnitude** - low – Project contribution to an increase in CAC emissions is expected to be low.
- **Probability** - high – Project emissions and those from other marine vessel traffic will occur on an ongoing basis.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between the Project and air emissions; however, vessel-specific data are limited.

4.4.2.3.2 Air Emissions Indicator –Volatile Organic Compounds

Project contribution to a cumulative increase in VOC emissions from combustion of distillate fuels in the main and auxiliary engines and fugitive emissions from the tanker hold within the Marine Air Quality RSA during normal operations activities is considered to have a negative impact balance, is reversible in the long term and of low magnitude (Table 4.4.2.2 point 2[a]). A summary of the rationale for all of the significance criteria of the Project contribution to cumulative effects on increased VOC emissions is provided below.

- **Spatial Boundary** - Marine Air Quality RSA – Project contribution to cumulative increases in VOC emissions from the tanker engines and fugitives from the tanker hold would dissipate within the Air Quality RSA.
- **Duration** - long-term – emissions of VOCs and subsequent changes to ambient ground-level concentrations are expected to occur for the life of the Project, and therefore are rated as long-term.
- **Frequency** - periodic – emissions of CACs will occur upon vessels transiting through the Marine Air Quality RSA, which is expected to occur intermittently and repeatedly with one to two vessels per day.
- **Reversibility** - long-term - Project contribution to cumulative effects will reverse shortly after shipping activities stop; however, Project life is more than 10 years.
- **Magnitude** - low – Project contribution to an increase in VOC emissions is expected to be low.
- **Probability** - high – Project emissions and those from other marine vessel traffic will occur on an ongoing basis.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between the Project and air emissions; however, vessel-specific data are limited.

4.4.2.3.3 Air Emissions Indicator – Formation of Secondary PM and Ozone

The Project’s contribution to an increase in ambient ground-level concentrations of secondary PM and ozone is considered to have a negative impact balance. As shown in Table 4.4.2.2 point 3(a), the increase in ambient ground-level concentrations of secondary PM and ozone is confined to the photochemical model domain or LFV. Some of the Project’s marine emissions will contribute chemical pre-cursors for secondary pollutants periodically when tanker traffic travels through the Marine Air Quality RSA. The change will be long-term in duration, reversible in the long-term and the magnitude is expected to be low. The probability of this occurring is high, and confidence in the residual effects assessment is moderate. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - LFV – changes to ambient ground-level concentrations of secondary PM and ozone are expected to occur within the LFV.
- **Duration** - long-term – emissions of pre-cursors and subsequent changes to ambient ground-level concentrations of secondary PM and ozone are expected to occur for the life of the Project and are therefore rated as long-term.
- **Frequency** - periodic – formation of secondary PM and ozone would result from intermittent but repeated release of pre-cursor emissions.
- **Reversibility** - long-term - Project contribution to cumulative effects will reverse shortly after shipping activities stop; however, Project life is more than 10 years.
- **Magnitude** - low – the increase in ambient ground-level concentrations of secondary PM and ozone is expected to be small relative to existing concentrations and regulatory limits; therefore, the magnitude of effect is rated as low.
- **Probability** - high – an increase in Project-related marine vessel traffic will result in pre-cursor emissions, which will react to form secondary PM and ozone.
- **Confidence**: - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between Project pre-cursor emissions and resultant ambient PM and ozone concentrations via atmospheric reactions; however, vessel-specific data are limited.

4.4.2.3.4 Air Emissions Indicator –Visibility

Reduced visibility is considered to have a negative impact balance. As shown in Table 4.4.2.2 point 4(a), the increase in reduced visibility is confined to the LFV. Some of the Project’s marine emissions will contribute chemical pre-cursors that could lead to the periodic formation of aerosols when tanker traffic travels through the Marine Air Quality RSA. The change will be long-term in duration, reversible in the long term, and the magnitude is expected to be low. The probability of this occurring is high and confidence in the residual effects assessment is moderate. As shown in Table 4.3.3.3 point 4(a), the reduced visibility is confined to the LFV. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - LFV – changes to visibility are expected to occur within the LFV.
- **Duration** - long-term – emissions of pre-cursors causing light absorption are expected to occur for the life of the Project, and therefore, the duration of effect is rated as being long-term.
- **Frequency** - periodic – light absorption and reduced visibility due to intermittent release of pre-cursor emissions will occur intermittently and repeatedly.

- **Reversibility** - long-term - emissions of pre-cursors will cease and any increases in ambient ground-level concentrations of secondary PM and ozone will reverse shortly after tankers exit the Marine Air Quality RSA but emissions are expected to occur in the Marine Air Quality RSA for the life of the Project which is more than 10 years.
- **Magnitude** - low – the change in light extinction and visibility is expected to be small relative to existing conditions, and in the absence of regulatory limits, the magnitude of effect is rated as being low.
- **Probability** - high – an increase in Project-related marine vessel traffic will result in an increase of pre-cursor emissions and secondary species, which will scatter light and reduce visibility.
- **Confidence** - moderate – residual effects assessment is based on a good understanding of cause-effect relationships between Project pre-cursor emissions and light absorption; however, vessel-specific data are limited.

4.4.2.3.5 Combined Cumulative Effects on Air Emissions

The Project will contribute to an increase in air emissions in the Marine Air Quality RSA along the shipping lanes in combination with existing vessels and the projected increase in marine traffic. Project contribution to a cumulative increase in emissions and decrease in visibility within the Marine Air Quality RSA and LFV is considered to have a negative impact balance, is reversible in the long term, and of low magnitude (Table 4.4.3, point 5[a]). A summary of the rationale for all of the significance criteria of the Project contribution to combined cumulative effects on marine air emissions is provided below.

- **Spatial Boundary** - Marine Air Quality RSA (or LFV) – Project contribution to combined cumulative effects from marine air emissions would dissipate within the Marine Air Quality RSA or LFV (for secondary formation products).
- **Duration** - long-term – the events causing Project contribution to combined cumulative effects from marine air emissions are from normal operations.
- **Frequency** - periodic – the events causing Project contribution to cumulative increases in air emissions will occur intermittently and repeatedly over the assessment period.
- **Reversibility** - long-term - Project contribution to cumulative effects will reverse shortly after shipping activities stop; however, Project life is more than 10 years.
- **Magnitude** - low – Project contribution to cumulative effects from marine air emissions is expected to be low.
- **Probability** - high – Project emissions and those from other marine vessel traffic will occur on an ongoing basis.
- **Confidence** - moderate – cumulative effects assessment is based on a good understanding of cause-effect relationships between the Project and air emissions; however, vessel-specific data are limited.

4.4.2.4 Potential US Effects

Project effects on air emissions in US waters are expected to be similar to Canadian waters. The same vessels will travel through both Canadian and US waters and will emit the same emissions along the shipping lanes. Residual effects on land (*i.e.,* the Olympic Peninsula) may be similar to residual effects at the coastline along shipping lanes in Canadian waters. The dispersion climate and important factors such as wind direction will materially affect the extent and magnitude of the predicted impacts and effects.

4.4.2.5 Summary

As identified in Table 4.4.2.2, there are no situations where there is a high probability of occurrence of a permanent or long-term cumulative effect of high magnitude that cannot be technically or economically mitigated. Consequently, the Project's contribution to cumulative effects on air emissions within the Marine Air Quality RSA will be not significant.

4.4.3 Marine Acoustic Environment

4.4.3.1 Reasonably Foreseeable Developments

Table 4.4.1.2 summarizes the current level of marine traffic within the Marine RSA as well as the anticipated marine traffic attributed to the Project and other reasonably foreseeable marine traffic. A description of existing and anticipated activities is provided in Section 4.4.1.4.

4.4.3.2 Potential Cumulative Effects

The potential and likely environmental residual effects associated with increased Project-related marine vessel traffic on the marine acoustic environment indicator were identified in Section 4.3.5 and are listed in Table 4.4.3.1 along with the associated existing and reasonably foreseeable regional marine traffic that could act in combination with the effects of increased Project-related marine vessel traffic to cause a cumulative effect on the marine acoustic environment.

TABLE 4.4.3.1

POTENTIAL RESIDUAL EFFECTS OF PROJECT-RELATED MARINE TRAFFIC ON MARINE ACOUSTIC ENVIRONMENT CONSIDERED FOR THE CUMULATIVE EFFECTS ASSESSMENT

Potential Residual Effect on Marine Acoustic Environment Indicator	Spatial Boundary[1]	Temporal Boundary	Potential Cumulative Effect	Existing Activities/Reasonably Foreseeable Activities with Residual Effects Acting in Combination with Project-Related Marine Vessel Traffic
1. Combined Project effects on atmospheric sound levels.	RSA	Operations	Project contribution to cumulative atmospheric sound levels.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).

Note: 1 RSA = Marine RSA.

4.4.3.3 Significance Evaluation of Potential Cumulative Effects

Table 4.4.3.2 provides a summary of the significance evaluation of the contribution of the effects of Project-related marine vessel traffic to potential cumulative effects on the marine acoustic environment indicator. The rationale used to evaluate the significance of each of the cumulative effects is provided below.

TABLE 4.4.3.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON MARINE ACOUSTIC ENVIRONMENT

Potential Cumulative Effects		Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
				Duration	Frequency	Reversibility				
1.	**Marine Acoustic Environment Indicator – Atmospheric Sound Levels**									
1(a)	Project contribution to cumulative atmospheric sound levels.	Negative	RSA	Long-term	Periodic	Immediate	Low to medium	High	Moderate	Not significant
2.	**Combined Cumulative Effects on Marine Acoustic Environment**									
2(a)	Project contribution to combined cumulative effects on marine acoustic environment indicator (1[a]).	Negative	RSA	Long-term	Periodic	Immediate	Low to medium	High	Moderate	Not significant

Notes: 1 RSA = Marine RSA.

2 **Significant Contribution to a Cumulative Environmental Effect:** A high probability of occurrence of a permanent or long-term cumulative effect of high magnitude that cannot be technically or economically mitigated.

4.4.3.3.1 Marine Acoustic Environment Indicator – Atmospheric Sound Levels

The primary effect evaluated in Section 4.3.5.6 was the potential change in day/night atmospheric sound levels due to increased vessel traffic in the shipping lanes. Individual noise events from shipping would increase due to the tankers and associated tugs, resulting in increased average sound levels over the time periods indicated. The analysis was based on pass-by events, where a combination of tanker and tugs was taken as a single event or ‘trip’.

Projected future traffic summarized in Table 4.4.1.2 lists the total numbers for vessel movements based on the number of individual ships. As the marine acoustic environment assessment uses the number of events, not the number of individual vessels as the basis for the analysis, the cumulative effect of changes to atmospheric sound levels from future vessel traffic can be discussed by looking at the relative changes that may occur.

Increased Project-related marine vessel traffic day/night sound levels were estimated to increase by between 0 to 1 dBA and singular sound level events could increase sufficiently in Burrard Inlet to be noticeable, resulting in a combined magnitude rating of low to medium for the effects on existing sound levels. Table 4.4.1.1 indicates there is approximately a 20 per cent increase of non-Project related vessel movements along the shipping lanes in the absence of the Project. Atmospheric sound from singular sound level events from other future vessel traffic (*i.e.*, the 2030 case not including Project-related traffic) may change within a day or night period when Project-related marine vessels are active, proportionally to the amount of increased traffic. When combined with Project-related marine traffic, the total increase in vessel traffic is not expected to result in substantially different sound levels as demonstrated in Table 4.3.5.4 of Section 4.3.5. Therefore, the magnitude of the Project’s contribution to cumulative effects on atmospheric sound levels is expected to be low to medium (Table 4.4.3.2, point 1[a]), consistent with the results of Section 4.3.5.

A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative effects is assessed within the regional context of the Marine RSA.
- **Duration** - long-term – the sound emissions and singular sound level events from Project-related marine vessels contributing to cumulative effects on sound levels will occur for the duration of operation of the Project-related marine vessel traffic.
- **Frequency** - periodic – sound level increases from Project-related marine vessel pass-bys, anchors or horns contributing to cumulative effects on sound levels will occur intermittently but repeatedly over the duration of operation of the Project-related marine vessel traffic.
- **Reversibility** - immediate – day/night noise levels return to ambient shortly after pass-bys of Project-related marine vessels.
- **Magnitude** - low to medium – the Project's contribution to cumulative effects on atmospheric sound levels from Project vessel pass-bys are expected to be detectable but remain within the BC OGC Guideline PSL values. When combined with future marine traffic, the total increase in vessel traffic is not expected to result in substantially different sound levels.
- **Probability** - high – the Project and other future vessels will generate sound and more vessel passages will occur.
- **Confidence** - moderate – the confidence in the evaluation of the combined cumulative effects is based on data relevant to the Project area as well as good understanding of noise propagation.

4.4.3.3.2 Combined Cumulative Effects on Marine Acoustic Environment

Atmospheric sound levels are the only marine acoustic environment indicator likely to be affected by increased Project-related vessel traffic, therefore, combined cumulative effects on marine acoustic environment are the same as cumulative effects on atmospheric sound levels (see subsection above and Table 4.4.3.2, point 2[a]).

4.4.3.4 Potential United States Effects

The Project's contribution to cumulative sound levels in US waters, specifically the various shoreline areas in US waters are expected to be similar to those in Canadian waters at the same distances from the shipping lanes. No differences in acoustic environment conditions in the US and Canadian portions of the Marine RSA were identified that would change the nature of the cumulative effects assessment.

4.4.3.5 Summary

As identified in Table 4.4.3.2, there are no situations where there is a high probability of occurrence of a permanent or long-term cumulative effect of high magnitude that cannot be technically or economically mitigated. Consequently, it is concluded that the Project's contribution to cumulative effects on the acoustic environment within the Marine RSA will be not significant.

4.4.4 Marine Fish and Fish Habitat

4.4.4.1 Reasonably Foreseeable Developments

Table 4.4.1.2 summarizes the current level of marine traffic within the Marine RSA as well as the anticipated marine traffic attributed to the Project and other reasonably foreseeable marine traffic. A description of existing and anticipated activities is provided in Section 4.4.1.4.

4.4.4.2 Potential Cumulative Effects

The potential and likely environmental residual effects associated with increased Project-related marine vessel traffic on marine fish and fish habitat indicators were identified in Section 4.3.6 and are listed in Table 4.4.4.1 along with the associated existing and reasonably foreseeable regional marine traffic that could act in combination with the effects of increased Project-related marine vessel traffic to cause a cumulative effect on marine fish and fish habitat. Residual effects on the Pacific salmon and Pacific herring indicators (*i.e.*, injury or mortality due to vessel wake) are considered unlikely (see Section 4.3.6) and are, therefore, not considered in the context of cumulative effects.

TABLE 4.4.4.1

POTENTIAL RESIDUAL EFFECTS OF PROJECT-RELATED MARINE TRAFFIC ON MARINE FISH AND FISH HABITAT CONSIDERED FOR THE CUMULATIVE EFFECTS ASSESSMENT

Potential Residual Effect on Marine Fish and Fish Habitat Indicator	Spatial Boundary[1]	Temporal Boundary	Potential Cumulative Effect	Existing Activities/Reasonably Foreseeable Activities with Residual Effects Acting in Combination with Project-Related Marine Vessel Traffic
1. Combined Project effects on intertidal habitat.	RSA	Operations	Project contribution to cumulative disturbance to intertidal habitat.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).

Note: 1 RSA = Marine RSA

4.4.4.3 Significance Evaluation of Potential Cumulative Effects

Table 4.4.4.2 provides a summary of the significance evaluation of the contribution of the effects of Project-related marine vessel traffic to potential cumulative effects on the marine fish and fish habitat indicator. The rationale used to evaluate the significance of each of the cumulative effects is provided below.

TABLE 4.4.4.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON MARINE FISH AND FISH HABITAT

Potential Cumulative Effects		Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
				Duration	Frequency	Reversibility				
1.	**Marine Fish and Fish Habitat Indicator – Intertidal Habitat**									
1(a)	Project contribution to cumulative disturbance to intertidal habitat.	Negative	RSA	Long-term	Periodic	Immediate	Low	High	High	Not significant
2.	**Combined Cumulative Effects on Marine Fish and Fish Habitat**									
2(a)	Project contribution to combined cumulative effects on marine fish and fish habitat indicator (1[a]).	Negative	RSA	Long-term	Periodic	Immediate	Low	High	High	Not significant

Notes: 1 RSA = Marine RSA

2 Significant Contribution to a Cumulative Environmental Effect: A high probability of occurrence of a permanent or long-term cumulative effect of high magnitude that cannot be technically or economically mitigated.

4.4.4.3.1 Marine Fish and Fish Habitat Indicator – Intertidal Habitat

Intertidal habitats within the Marine RSA are constantly exposed to natural wind-generated waves. In general, wave heights are greater during the winter months when storm events are more frequent and at locations with greater fetch (*i.e.*, distance to nearest landmass). Local landscape and seascape features such as headlands, embayments, bathymetric contours, shoreline slope, intertidal and subtidal substrates, and currents also influence site-specific wave heights. Although there is limited data available on wave heights within the Marine RSA, regional buoy data indicates that average significant wave heights range from as low as 0.06 m in Saanich Inlet (Patricia Bay buoy) to as high as 2.66 m on the west coast of Vancouver Island (La Perouse Bank buoy; DFO 2013a).

Due to the large number of vessels that transit the shipping lanes and adjacent waters, intertidal habitats throughout the Marine RSA are routinely exposed to wake waves generated by passing vessels. The height of a wake wave at the shoreline depends on a number of factors, including vessel size, vessel speed, hull shape, vessel distance from shore, bathymetry, shoreline slope, and shoreline substrate. In general, large vessels traveling at high speeds produce the largest wake waves; however, smaller vessels such as pleasure craft often travel at high speeds close to shore and are capable of producing larger waves that interact with intertidal habitats.

Due to the average channel width of 22 to 28 km in the Strait of Georgia and Juan de Fuca Strait (Thompson 1981) and the relatively rapid rate at which wake waves decrease in height away from transiting Project-related tankers and tugs, wakes are not expected to be detectable from existing wave conditions along most of the shoreline in the Marine RSA. In Burrard Inlet, Haro Strait and near the southern end of Vancouver Island where the shipping lanes pass within 2 km of land, wake waves from Project-related vessels are predicted to be less than 0.1 m in height at the shoreline (see Section 4.3.6.5). In these areas, wake waves from existing vessel traffic, Project-related vessel traffic, and reasonably foreseeable future vessel traffic may act cumulatively to affect intertidal habitats. In 2012, approximately 6,900 vessel movements were recorded in Burrard Inlet and 8,900 movements were recorded in Haro Strait (Table 4.4.1.2).

If approved, the Project would add up to approximately 2,880 vessel movements in Burrard Inlet and 1,440 movements in Haro Strait, which would represent 29.6 per cent and 13.9 per cent of the total traffic in these areas (Table 4.4.1.2). Based on the anticipated growth rates presented in Table 4.4.1.2, the total number of annual vessel movements in Burrard Inlet and Haro Strait are predicted to increase by approximately 1,401 and 1,777, respectively, by the year 2030. The Project's contribution to total vessel traffic would then be 25.9 per cent in Burrard Inlet and 11.9 per cent in Haro Strait (Table 4.4.1.2).

Wake waves have the potential to disturb intertidal habitats, primarily through the erosion of fine-grained sediments. Large waves can also dislodge sessile marine organisms (*e.g.*, algae and invertebrates), leading to reduced habitat complexity and productivity. These effects are more likely to occur in soft-sediment habitats that are sheltered from wind-driven waves. As discussed in Section 4.3.6.5, most shoreline habitats within the Marine RSA are dominated by rocky substrates. These habitats are routinely exposed to natural waves that can be considerably larger than wake waves produced by passing vessels. As a result, marine organisms inhabiting the intertidal zone are adapted to the physical forces imparted by incoming waves, and are unlikely to be affected by wake waves that are within the range of natural wave heights. Although the heights of wake waves from existing vessel traffic and reasonably foreseeable future vessel traffic have not been calculated, it is expected that other large, deep draft vessels transiting the shipping lanes will produce similar wake waves. Smaller, faster vessels such as recreational fishing boats and pleasure craft may produce larger wake waves, but these would still be within the range of natural wave heights.

While the combination of existing vessel traffic, Project-related vessel traffic and reasonably foreseeable vessel traffic will increase the frequency of wake waves interacting with the shoreline, wake heights are predicted to be within the range of natural wave conditions and are unlikely to result in any measurable changes to the biophysical characteristics of intertidal habitats. With one inbound and one outbound transit per day, the Project's contribution to the cumulative effect will be periodic over the life of the Project. Wake waves from Project-related vessels will be detectable at the shoreline for only several minutes per day, and any temporary disturbance to intertidal habitats (*e.g.*, localized re-suspension of sediment) will be reversible within minutes following the passing of the vessel. Considering the large number of vessels that currently transit the shipping lanes and adjacent waters, the Project's contribution to the cumulative effect of disturbance to intertidal habitats is predicted to be of low magnitude (Table 4.4.4.2, point 1[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to potential cumulative effects on intertidal habitat could extend to the Marine RSA.
- **Duration** - long-term – wake waves from Project-related vessels will occur throughout the operations phase.
- **Frequency** - periodic – on average, wake waves from Project-related vessels will be generated twice per day during one inbound and one outbound transit.
- **Reversibility** - immediate – the temporary disturbance of intertidal habitats by vessel wake will not be detectable within minutes following each passing vessel.

- **Magnitude** - low – while Project-related vessel traffic will account for an estimated 25.9 per cent and 11.9 per cent of total vessel traffic in Burrard Inlet and Haro Strait by 2030, the predicted wake wave heights are well within the range of natural wave conditions and are not expected to result in measurable changes to the biophysical characteristics of intertidal habitats.
- **Probability** - high – vessel wake from Project-related vessels will be detectable along shorelines within the Marine RSA and will act cumulatively with wake waves from existing and future vessel traffic.
- **Confidence** - high – based on a good understanding of the wave heights generated by Project-related vessels, a reasonable understanding of the natural wave conditions within the Marine RSA, a good understanding of the shoreline types within the Marine RSA, and a good understanding of the sensitivity of intertidal biota to wave exposure.

4.4.4.3.2 Combined Cumulative Effects on Marine Fish and Fish Habitat

Intertidal habitat is the only marine fish and fish habitat indicator likely to be affected by increased Project-related vessel traffic, therefore, combined cumulative effects on marine fish and fish habitat are the same as cumulative effects on intertidal habitat (see subsection above and Table 4.4.4.2, point 2[a]).

4.4.4.4 Potential United States Effects

Cumulative effects of vessel wake on intertidal habitats in US waters are expected to be very similar to those described for Canadian waters. In the US, only about 10 km of shoreline falls within 2 km of the shipping lanes (the area within which wake waves from Project-related vessels are expected to be detectable), and this area is limited to the west side of the San Juan Islands in Haro Strait. Shoreline habitat types and natural wave conditions are very similar on the east and west sides of Haro Strait and all vessels transiting this area will generate wake waves that interact with Canadian and US intertidal habitats in a similar fashion. Therefore, the significance evaluation for cumulative disturbance to intertidal habitats due to vessel wake (Table 4.4.4.2) applies to both Canadian and US waters.

4.4.4.5 Summary

As identified in Table 4.4.4.2, there are no situations where there is a high probability of occurrence of a permanent or long-term cumulative effect of high magnitude that cannot be technically or economically mitigated. Consequently, it is concluded that the Project's contribution to cumulative effects on marine fish and fish habitat within the Marine RSA will be not significant.

4.4.5 Marine Mammals

4.4.5.1 Reasonably Foreseeable Developments

Table 4.4.1.2 summarizes the current level of marine traffic within the Marine RSA as well as the anticipated marine traffic attributed to the Project and other reasonably foreseeable marine traffic. A description of existing and anticipated activities is provided in Section 4.4.1.4.

4.4.5.2 Potential Cumulative Effects

The potential and likely environmental residual effects associated with increased Project-related marine vessel traffic on marine mammals are identified for each indicator in Section 4.3.7. The assessed combined effect of those potential residual effects on each of the marine mammal indicators is listed in Table 4.4.5.1 along with the associated existing and reasonably foreseeable regional marine traffic that could act in combination with the effects of increased Project-related marine vessel traffic to cause a cumulative effect on marine mammals.

TABLE 4.4.5.1

POTENTIAL RESIDUAL EFFECTS OF PROJECT-RELATED MARINE TRAFFIC ON MARINE MAMMALS CONSIDERED FOR THE CUMULATIVE EFFECTS ASSESSMENT

Potential Residual Effect on Marine Mammal Indicator	Spatial Boundary[1]	Temporal Boundary	Potential Cumulative Effect	Existing Activities/Reasonably Foreseeable Activities with Residual Effects Acting in Combination with Project-Related Marine Vessel Traffic
1. Combined Project effects on southern resident killer whale.	RSA	Operations	Project contribution to cumulative increase in sensory disturbance due to underwater noise.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).
2. Combined Project effects on humpback whale.	RSA	Operations	Project contribution to cumulative increase in sensory disturbance due to underwater noise.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).
3. Combined Project effects on Steller sea lion.	RSA	Operations	Project contribution to cumulative increase in sensory disturbance due to underwater noise.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).

Note: 1 RSA = Marine RSA.

Marine mammals may be affected by increased sensory disturbance due to the cumulative effects of underwater noise from existing marine vessel traffic acting in combination with noise from the increase in Project-related and reasonably foreseeable marine vessel traffic within the Marine RSA. Residual effects associated with permanent or temporary auditory injury (PTS or TTS) due to underwater noise from marine vessel traffic are considered unlikely (see Section 4.3.7). Cumulative broadband SELs associated with Project-related vessels are not predicted to exceed the Southall *et al.* (2007) PTS-onset thresholds for pinnipeds or cetaceans (*i.e.,* 203 and 215 dB re: 1 μPa^2-s, respectively) under any of the four modelled scenarios (*i.e.*, Strait of Georgia, Haro Strait, Juan de Fuca Strait and North of Cape Flattery) (see Appendix A of the Marine Resources – Marine Transportation Technical Report (Volume 8B, TR 8B-1). For TTS, cumulative SELs are only predicted to exceed the Southall *et al.* thresholds at distances of less than 30 and 15 m from the vessel's propeller (*i.e.,* for pinnipeds and cetaceans, respectively; see Table 4.3.7.7). Threshold values for continuous noises capable of causing PTS or TTS are not addressed by the NOAA criteria (NOAA Fisheries 2013).

Although the SPLs and cumulative broadband SELs from existing and reasonably foreseeable future vessel traffic are not known, it is generally expected that other large, deep draft vessels transiting the shipping lanes will produce similar sound levels to Project-related vessels. Smaller, faster vessels such as recreational fishing boats and pleasure craft will also contribute to underwater noise, and noise from all vessels may act additively to increase overall underwater ambient sound levels in the marine environment. However, based on acoustic modelling done for the Project, SPLs higher than 130 dB re: 1 μPa are expected to attenuate quickly with distance from the vessels (see Table 8 in Appendix A of the Marine Resources – Marine Transportation Technical Report (Volume 8B, TR 8B-1). It is unlikely that the potential interaction of existing, Project-related, and reasonably foreseeable future vessel traffic noise (*i.e.,* during close vessel passes) will lead to underwater sound levels capable of causing PTS or TTS for distances that exceed much beyond (if at all) those predicted for residual effects (*i.e.,* within 30 m of the tug or tanker propellers). As noted for residual effects, it is also unlikely that a marine mammal would approach this close to the vessels' operating propellers, and exposure to cumulative SELs capable of causing PTT or TTS is considered similarly unlikely.

Based on the above, no permanent or temporary auditory injury to marine mammals is expected as the result of the combination of underwater noise from existing vessel traffic and the increase in Project-related and reasonably foreseeable vessel traffic. The potential for PTS and TTS is, therefore, not considered further in the context of cumulative effects. The assessed combined Project residual effects on the marine mammals indicators listed in Table 4.4.5.1; therefore include only the potential for cumulative effects of sensory disturbance due to underwater noise.

4.4.5.3 Significance Evaluation of Potential Cumulative Effects

Table 4.4.5.2 provides a summary of the significance evaluation of the contribution of Project-related marine vessel traffic to potential cumulative effects on the marine mammals indicators. The rationale used to evaluate the significance of each of the cumulative effects is provided below. The assessment follows a qualitative approach (*i.e.,* based primarily on professional judgment) due to a lack of quantitative measures of underwater noise levels associated with existing and reasonably foreseeable marine vessel traffic in the Marine RSA and current levels of sensory disturbance to marine mammal species within the Marine RSA.

TABLE 4.4.5.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON MARINE MAMMALS

Potential Cumulative Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
1. Marine Mammals Indicator – Southern Resident Killer Whale									
1(a) Project contribution to cumulative increase in sensory disturbance due to underwater noise.	Negative	RSA	Long-term	Periodic	Immediate	High	High	Low	Significant[3]
2. Marine Mammals Indicator – Humpback Whale									
2(a) Project contribution to cumulative increase in sensory disturbance due to underwater noise.	Negative	RSA	Long-term	Periodic	Immediate	Medium	High	Low	Not Significant

TABLE 4.4.5.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON MARINE MAMMALS (continued)

Potential Cumulative Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
3. Marine Mammals Indicator – Steller Sea Lion									
3(a) Project contribution to cumulative increase in sensory disturbance due to underwater noise.	Negative	RSA	Long-term	Periodic	Immediate	Low	High	High	Not Significant
4. Combined Cumulative Effects on Marine Mammals									
4(a) Project contribution to combined cumulative effects on marine mammals indicators (1[a], 2[a] and 3[a]).	Negative	RSA	Long-term	Periodic	Immediate	High	High	Low	Not Significant to Significant

Notes: 1 RSA = Marine RSA.

2 **Significant Contribution to a Cumulative Environmental Effect:** A high probability of occurrence of a permanent or long-term cumulative effect of high magnitude that cannot be technically or economically mitigated.

3 Refer to the discussion on Southern Resident Killer Whales below for the rationale for the evaluation.

The Project's contribution to cumulative effects of underwater noise is considered in the context of the contribution of existing marine transportation activities and reasonably foreseeable projects to overall ambient underwater noise levels in the Marine RSA. The potential for increase in underwater ambient noise levels and sensory disturbance from overall growth in marine traffic (including effects from Project-related and reasonably foreseeable future vessels) is much greater in Burrard Inlet compared to other areas of the shipping lanes. By the year 2030 and accounting for projected future growth (Table 4.4.1.2), the Project contribution to total vessel traffic would be 25.9 per cent in Burrard Inlet, 8.9 per cent in English Bay, 6.4 per cent in the Strait of Georgia, 11.9 per cent in Haro Strait, and 6.1 per cent in Juan de Fuca Strait (Table 4.4.1.2). These numbers account for Project contribution to tug and tanker traffic.

4.4.5.3.1 Marine Mammals Indicator – Southern Resident Killer Whale

The following subsection provides the evaluation of significance of the potential cumulative effect and Project contribution to cumulative effect on the southern resident killer whale indicator.

Sensory Disturbance of Southern Resident Killer Whales Due to Underwater Noise Resulting from the Cumulative Effects of Existing Marine Vessel Traffic and the Increase in Project-Related and Reasonably Foreseeable Marine Vessel Traffic

As discussed in the assessment of residual effects (see Section 4.3.7.6), based on available scientific knowledge, it is concluded that past and current activities (including all forms of mortality, high contaminant loads, reduced prey, and sensory and physical disturbance) have resulted in significant adverse cumulative effects to the southern resident killer whale population. The recent historical decline of the southern resident killer whale population and its current status (*i.e.,* Endangered) support this conclusion. However, given the current state of knowledge, and the ability of threats to interact with one another, it is not possible to completely partition how each threat may be affecting the population.

While the Endangered status of southern resident killer whales is assumed to represent a currently-existing significant adverse cumulative effect, there are currently no quantitative Canadian thresholds with respect to assessing sensory disturbance for marine mammals associated with underwater noise, nor are there recommended Canadian standards or guidelines with respect to what would be appropriate ambient SPLs or SELs for southern resident killer whale critical habitat. Trans Mountain has little direct control over the operating practices of the tankers or tugs, as Project-related vessels are owned and operated by a third party. Operation of Project-related vessels and other marine traffic in Canadian waters is authorized and regulated through the *Canada Shipping Act, 2001* and related legislation, and regulations are administered by Transport Canada and the CCG. Despite operating legally, the Project will contribute additional underwater noise that could affect the southern resident killer whale population and this noise will act cumulatively with noise from existing and reasonably foreseeable marine vessel traffic. As such, even though the Project contribution to overall underwater noise represents only one component of current and future marine transportation sources for underwater noise, the Project's contribution to potential cumulative effects of sensory disturbance is determined to be significant for southern resident killer whales.

A summary of the rationale for all of the significance criteria is provided below (Table 4.4.5.2, point 1[a]).

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative increase in sensory disturbance due to underwater noise on southern resident killer whales will be concentrated along the shipping lanes in the Marine RSA and will decrease with distance from the sound source (*i.e.*, tankers and tugs).
- **Duration** - long-term – the Project's contribution to increased tanker transits and the associated production of underwater noise along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.
- **Frequency** - periodic – Project-related marine vessel traffic will increase by approximately 30 Aframax tanker calls to the Westridge Marine Terminal per month (*i.e.,* an additional 720 tanker transits each year). It will take Project-related vessels approximately 12 hours to complete one transit of the Marine RSA, and on average, there will be two transits every 24 hours. Southern resident killer whale exposure to Project-related vessels will likely be limited to a maximum of two exposures per transit per day (*i.e.,* periodic).
- **Reversibility** - immediate – the Project's contribution to underwater noise in the Marine RSA will exceed NOAA thresholds for sensory disturbance at any given location for approximately half an hour per transit, and any temporary disturbance to individual southern resident killer whales at this location will likely be reversible shortly thereafter (*i.e.,* in less than 2 days).
- **Magnitude** - high – the Project's contribution to underwater noise within the Marine RSA will exceed NOAA's regulatory standards for sensory disturbance.

While there are no Canadian regulatory standards with respect to this effect, the NOAA thresholds are used as commonly-applied environmental standards. Southern resident killer whales within 4 to 7 km of the shipping lanes are expected to be exposed to noise from Project-related vessel traffic capable of causing sensory disturbance. This effect will occur throughout the Canadian designated critical habitat for this endangered population. For these population status reasons, the magnitude for southern resident killer whales is rated as high.

- **Probability** - high – underwater noise produced by Project-related vessels is expected to exceed the current NOAA standards for sensory disturbance within 4 to 7 km of the transiting vessels and will act cumulatively with noise from existing and reasonably foreseeable future vessel traffic. As such, there is a high probability that southern resident killer whales in the Marine RSA will experience some degree of sensory disturbance as a result of cumulative effects associated with increased Project-related marine vessel traffic.
- **Confidence** - low – there is no precedent (*e.g.,* other project EAs) for attempting to assess significance of the effects of sensory disturbance from underwater noise associated with marine shipping on southern resident killer whales. Things that are known with certainty concerning this population are its small size, recent population trends, Endangered status, and relative importance of this area (*i.e.,* critical habitat). Recent ambient noise measurement studies have been conducted in the Marine RSA and results are available in the literature (Williams *et al.* 2013; see also Appendix A of the Marine Resources – Marine Transportation Technical Report of Volume 8B, TR 8B-1). Project-related vessel source levels and ambient conditions were not directly measured and underwater noise associated with reasonably foreseeable future traffic is unknown; however, the vessel source levels from the literature are deemed appropriate surrogates and acoustic modeling used in the residual effects assessment followed standard practices. Disturbance from vessels and underwater noise have been shown through numerous studies to alter behaviour, cause compensatory responses, and interfere with normal activity patterns, but the greatest source of uncertainty is the linkage of sensory disturbance effects to population-level consequences and the degree to which such effects can be attributed to underwater noise from Project-related vessels and other ships and boats.

4.4.5.3.2 Marine Mammals Indicator – Humpback Whale

The following subsection provides the evaluation of significance of the potential cumulative effect and Project contribution to cumulative effect on the humpback whale indicator.

Sensory Disturbance of Humpback Whales Due to Underwater Noise Resulting from the Cumulative Effects of Existing Marine Vessel Traffic and the Increase in Project-Related and Reasonably Foreseeable Marine Vessel Traffic

As discussed in the assessment of residual effects (see Section 4.3.7.6), while the acoustic environment in many areas of the humpback whale's range may currently exceed environmental standards for sensory disturbance, the North Pacific population is not only stable, but has been growing at an annual rate of approximately 4.9 per cent since 1993 (Cascadia Research 2008). Unlike southern resident killer whales, DFO has identified critical habitat for humpback whales in other areas of BC, and humpback whales in Canada belong to a much larger population (*i.e.,* 2008 estimate of 18,302 individuals in the North Pacific) (Cascadia Research 2008). Based on photo-identification studies (from 1992 to 2006) and a minimum number alive (MNA) estimate of the 2006 BC humpback whale population size of 1,620 individuals, 208 humpback whales have been identified in the southwest Vancouver Island critical habitat area; this represents approximately 13 per cent of the BC coast-wide MNA (DFO 2010b).

The increase in Project-related vessel traffic will contribute additional underwater noise to the Marine RSA and this noise will act cumulatively with noise from existing and reasonably foreseeable marine vessel traffic. However, the Project contribution to overall underwater noise represents only one component of current and future marine transportation sources for underwater noise. The Project contribution to cumulative effects will affect a relatively small, localized component of the overall North Pacific (or Canadian) humpback whale population, and only during periods of the year when they are present in the Marine RSA. As such, while the assessment recognizes the importance of maintaining functional acoustic habitats for humpback whales or any marine mammal species, the Project's contribution to potential cumulative effects of sensory disturbance is determined to be adverse, but not significant for humpback whales.

A summary of the rationale for all of the significance criteria is provided below (Table 4.4.5.2, point 2[a]).

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative increase in sensory disturbance due to underwater noise on humpback whales will be concentrated along the shipping lanes in the Marine RSA and will decrease with distance from the sound source (*i.e.,* tankers and tugs).
- **Duration** - long-term – the Project's contribution to increased tanker transits and the associated production of underwater noise along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.
- **Frequency** - periodic – Project-related marine vessel traffic will increase by approximately 30 Aframax tanker calls to the Westridge Marine Terminal per month (*i.e.,* an additional 720 tanker transits each year). It will take Project-related vessels approximately 12 hours to complete one transit of the Marine RSA, and on average, there will be two transits every 24 hours. Humpback whale exposure to Project-related vessels will likely be limited to a maximum of one exposure per transit per day during the months when humpback whales are present in the Marine RSA.
- **Reversibility** - immediate – the Project's contribution to underwater noise in the Marine RSA will exceed NOAA thresholds for sensory disturbance at any given location for approximately half an hour per transit, and any temporary disturbance to individual humpback whales at this location will likely be reversible shortly thereafter (*i.e.,* in less than 2 days).
- **Magnitude** - medium – the Project's contribution to underwater noise within the Marine RSA will exceed NOAA's regulatory standards for sensory disturbance. While there are no Canadian regulatory standards with respect to this effect, the NOAA thresholds are used as commonly-applied environmental standards. Humpback whales within 4 to 7 km of the shipping lanes are expected to be

exposed to noise from Project-related vessel traffic capable of causing sensory disturbance. The Marine RSA overlaps a small portion of the proposed Canadian critical habitat for this species and only a small proportion of the much larger North Pacific population of humpback whales occurs seasonally in the Marine RSA. For these population status reasons, the magnitude for humpback whales is rated as medium.

- **Probability** - high – underwater noise produced by Project-related vessels is expected to exceed the current NOAA standards for sensory disturbance within 4 to 7 km of the transiting vessels and will act cumulatively with noise from existing and reasonably foreseeable future vessel traffic. As such, there is a high probability that humpback whales in the Marine RSA will experience some degree of sensory disturbance as a result of cumulative effects associated with increased Project-related marine vessel traffic.
- **Confidence** - low – Recent ambient noise measurement studies have been conducted in the Marine RSA and results are available in the literature (Williams *et al.* 2013; see also Appendix A of the Marine Resources – Marine Transportation Technical Report (Volume 8B, TR 8B-1). Project-related vessel source levels and ambient conditions were not directly measured and underwater noise associated with reasonably foreseeable future traffic is unknown; however, the vessel source levels from the literature are deemed appropriate surrogates and acoustic modeling used in the residual effects assessment followed standard practices. Disturbance from vessels and underwater noise have been shown through numerous studies to alter behaviour, cause compensatory responses, and interfere with normal activity patterns, but the greatest source of uncertainty is the linkage of sensory disturbance effects to population-level consequences and the degree to which such effects can be attributed to underwater noise from Project-related vessels and other ships and boats. The primary rationale for the difference in significance determination between humpback whales and southern resident killer whales is the marked difference in status, population size, distribution, and relative use and importance of the Marine RSA.

4.4.5.3.3 Marine Mammals Indicator – Steller Sea Lion

The following subsection provides the evaluation of significance of the potential cumulative effect and Project contribution to cumulative effect on the Steller sea lion indicator.

Sensory Disturbance of Steller Sea Lion Due to Underwater Noise Resulting from the Cumulative Effects of Existing Marine Vessel Traffic and the Increase in Project-Related and Reasonably Foreseeable Marine Vessel Traffic

The increase in Project-related vessel traffic will contribute additional underwater noise to the Marine RSA and this noise will act cumulatively with noise from existing and reasonably foreseeable marine vessel traffic. The Project contribution to overall underwater noise will be most detectable directly along the shipping lane during a vessel transit. However, as discussed in the assessment of residual effects (see Section 4.3.7.6), Steller sea lions in the Marine RSA are expected for the most part to be habituated to regular traffic movements along the shipping lanes and a large part of the acoustic energy produced by Project-related (and other large commercial vessels) is expected to be inaudible to sea lions and within the predicted range of current ambient conditions. While individuals in the water are expected to move away from vessels, large-scale disturbance around the haulouts is not expected, and individuals are likely to recover from any direct effects of sensory disturbance immediately. There are no rookeries, critical habitat or DFO-identified important areas for pinnipeds in the Marine RSA and the DFO Steller Sea Lion Management Plan lists acoustic disturbance when in aquatic habitat as low concern (DFO 2010a). As such, while the assessment recognizes the importance of maintaining functional acoustic habitats for Steller sea lions and all marine mammal species, the Project's contribution to potential cumulative effects of sensory disturbance on Steller sea lions is determined to be not significant.

A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative increase in sensory disturbance due to underwater noise on Steller sea lions will be concentrated along the shipping lanes in the Marine RSA and will decrease with distance from the sound source (*i.e.,* tankers and tugs).
- **Duration** - long-term – the Project's contribution to increased tanker transits and the associated production of underwater noise along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.
- **Frequency** - periodic – Project-related marine vessel traffic will increase by approximately 30 Aframax tanker calls to the Westridge Marine Terminal per month (*i.e.,* an additional 720 tanker transits each year). It will take Project-related vessels approximately 12 hours to complete one transit of the Marine RSA, and on average, there will be two transits every 24 hours. Steller sea lion exposure to Project-related vessels will likely be limited to a maximum of one exposure per transit per day.
- **Reversibility** - immediate – the Project's contribution to underwater noise in the Marine RSA will exceed NOAA thresholds for sensory disturbance at any given location for approximately half an hour per transit, and any temporary disturbance to individual Steller sea lions at this location will likely be reversible shortly thereafter (*i.e.,* in less than 2 days).
- **Magnitude** - low – the Project's contribution to underwater noise within the Marine RSA will exceed NOAA's regulatory standards for sensory disturbance. While there are no Canadian regulatory standards with respect to this effect, the NOAA thresholds are used as commonly-applied environmental standards. Steller sea lions within 4 to 7 km of the shipping lanes are expected to be exposed to noise from Project-related vessel traffic capable of causing sensory disturbance. However, the Project contribution to introduced underwater noise (relative to Steller sea lion hearing) is expected to mostly be within the range of current ambient conditions. Steller sea lions in the Marine RSA are expected for the most part to be habituated to regular traffic movements along the shipping lanes. There are no rookeries, critical habitat or DFO identified important areas for pinnipeds in the Marine RSA and little if any detectable effects are predicted as a result of the increase over current traffic conditions, which will remain concentrated along the shipping lanes. For these species-specific and population status reasons, the magnitude for Steller sea lions is rated as low.

- **Probability** - high – underwater noise produced by Project-related vessels is expected to exceed the current NOAA standards for sensory disturbance within 4 to 7 km of the transiting vessels and will act cumulatively with noise from existing and reasonably foreseeable future vessel traffic. As such, there is a high probability that Steller sea lions in the Marine RSA will experience some degree of sensory disturbance as a result of cumulative effects associated with increased Project-related marine vessel traffic. However, the NOAA thresholds do not factor in species-specific hearing abilities, and based on audiogram-weighted analyses, Project-related vessels will for the most part be undetectable to Steller sea lions outside of current ambient conditions.

- **Confidence** - high – pinnipeds in water and away from rookeries are known to be fairly tolerant of even close vessel approaches and the Marine RSA does not include any habitat identified as being of particular importance to Steller sea lions. The DFO Steller Sea Lion Management Plan lists acoustic disturbance when in aquatic habitat as low concern (DFO 2010a).

4.4.5.3.4 Combined Cumulative Effects on Marine Mammals

The evaluation of the Project's contribution to the combined cumulative effects of sensory disturbance due to increased Project-related marine vessel traffic on the marine mammals element considers collectively the assessment of the likely potential cumulative effects on the following indicators: southern resident killer whale, humpback whale, and Steller sea lion. The assessment of these indicator species for the selected effects is considered to adequately represent the Project's contribution to the combined cumulative effects on all marine mammals within the Marine RSA.

A summary of the assessment conclusions for combined cumulative effects is provided below and presented in Table 4.4.5.2 (point 4[a]). Where two indicators had different criterion conclusions, the more conservative assessment was carried forward to the combined effects assessment.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative increase in sensory disturbance due to underwater noise on marine mammals will be concentrated along the shipping lanes in the Marine RSA and will decrease with distance from the sound source (*i.e.*, tankers and tugs).

- **Duration** - long-term – the Project's contribution to increased tanker transits and the associated production of underwater noise along the shipping lanes will be initiated during the operations phase and will extend for the life of the Project.

- **Frequency** - periodic – Project-related marine vessel traffic will increase by approximately 30 Aframax tanker calls to the Westridge Marine Terminal per month (*i.e.*, an additional 720 tanker transits each year). It will take Project-related vessels approximately 12 hours to complete one transit of the Marine RSA, and on average, there will be two transits every 24 hours. Marine mammal exposure to Project-related vessels will likely be limited to a maximum of one exposure per transit per day.

- **Reversibilit** - immediate – the Project's contribution to underwater noise in the Marine RSA will exceed NOAA thresholds for sensory disturbance at any given location for approximately half an hour per transit, and any temporary disturbance to individual marine mammals will likely be reversible shortly thereafter (*i.e.*, in less than 2 days).

- **Magnitude** - high – the Project's contribution to underwater noise within the Marine RSA will exceed NOAA's regulatory standards for sensory disturbance. While there are no Canadian regulatory standards with respect to this effect, the NOAA thresholds are used as commonly-applied environmental standards. Marine mammals within 4 to 7 km of the shipping lanes are expected to be exposed to noise from Project-related vessel traffic capable of causing sensory disturbance.
- **Probability** - high – underwater noise produced by Project-related vessels is expected to exceed the current NOAA standards for sensory disturbance within 4 to 7 km of the transiting vessels and will act cumulatively with noise from existing and reasonably foreseeable future vessel traffic. As such, there is a high probability that marine mammals in the Marine RSA will experience some degree of sensory disturbance as a result of cumulative effects associated with increased Project-related marine vessel traffic.
- **Confidence** - low - disturbance from vessels and underwater noise have been shown through numerous studies to alter behaviour, cause compensatory responses, and interfere with normal activity patterns, but the greatest source of uncertainty is the linkage of sensory disturbance effects to population-level consequences and the degree to which such effects can be attributed to underwater noise from Project-related vessels and other existing and future marine vessel traffic.

Given that past and current activities are considered to have caused significant adverse effects on the southern resident killer whale population, the Project's contribution to cumulative effects associated with the increase in Project-related marine vessel activity on this species was considered to be significant. The Project's contribution to cumulative effects on humpback whale and Steller sea lion populations in the Marine RSA are considered to be not significant.

PMV is in the midst of developing a program to look at the current levels of underwater noise in the Strait of Georgia and surrounding waters and to consider options for reducing potential environmental effects of noise from marine traffic on marine mammals. This program will be a collaborative effort, led by PMV, and supported by TC, DFO, and the CCG. It will involve the Chamber of Shipping and the PPA as key stakeholders, as well as other major marine shipping industry representatives. The program will involve the deployment of a network of hydrophones in the Strait of Georgia and Haro Strait that will be used to measure the acoustic signatures of vessels and to monitor the activities of southern resident killer whales and other cetaceans. Data collected through the program will contribute to the development of mitigation measures aimed at reducing acoustic disturbance to marine mammals. PMV is expected to release more details on the program in early 2014.

Trans Mountain is strongly supportive of this regionally-based collaborative industry-government approach to developing viable solutions that could be applied to the marine transportation industry as a whole. Trans Mountain met with PMV in late 2013 and expressed its interest in contributing in a meaningful capacity to the development and implementation of the proposed program. Trans Mountain is also willing to support the outcomes (*i.e.*, research findings and recommended mitigations) that result from the PMV program or a similar government-industry effort. Trans Mountain will be furthering conversation with PMV in early 2014 to establish how to best support and participate in current and future endeavours on this topic.

4.4.5.4 Potential United States Effects

No differences in the indicators or acoustic conditions in the US and Canadian portions of the Marine RSA were identified that would change the nature of the effects assessment. Therefore, the effects are expected to be similar in Canadian and US waters.

4.4.5.5 Summary

As identified in Table 4.4.5.2, given the current endangered status of the southern resident killer whale population, the Project's contribution to cumulative effects associated with increased Project-related marine vessel traffic on marine mammals are considered to be significant.

4.4.6 Marine Birds

4.4.6.1 Reasonably Foreseeable Developments

Table 4.4.1.2 summarizes the current level of marine traffic within the Marine RSA, the anticipated marine traffic attributed to the Project, and other reasonably foreseeable marine traffic. A description of existing and anticipated activities is provided in Section 4.4.1.4.

4.4.6.2 Potential Cumulative Effects

The potential and likely environmental residual effects associated with the increase in Project-related marine vessel traffic on marine birds are identified for each indicator in Section 4.3.8. The assessed combined effect of those potential residual effects on each of the marine bird indicators is listed in Table 4.4.6.1 along with the associated existing and reasonably foreseeable regional marine traffic that could act in combination with the effects of increased Project-related marine vessel traffic to cause a cumulative effect on marine birds.

Marine birds are likely to be affected by sensory disturbances from Project-related marine shipping activities that disrupt marine bird foraging behaviours and can cause birds to flush from preferred or important feeding habitats. Repeated vessel disturbances, such as those which may affect some species of marine birds within the transportation route, can eventually cause a level of stress, especially during the sensitive breeding season when energetic costs are high. The consequent alterations in behaviour are indirect effects that have implications for their energy budgets and survivorship. Marine birds are present in the shipping lanes throughout the year, with various species using these habitats for migration, overwintering, moulting and foraging during the breeding period. The effect of Project-related sensory disturbances will be localized and recurrent with the regular transiting of two vessels per day within the shipping lanes. Individual encounters will be temporary and not expected to be detrimental to the viability, stability and overall well-being of the diverse populations of marine birds.

The current context of marine traffic can be represented as the total number recorded in 2012, ranging from 6,858 vessels (Burrard Inlet) to 18,503 vessels (Juan de Fuca Strait), depending on the location along the shipping lanes (Table 4.4.1.2), and also includes English Bay, Strait of Georgia and Haro Strait. The Project's projected percent contribution to existing traffic is highest in Burrard Inlet (25.9 per cent) and Haro Strait (11.9 per cent), and is lowest in Juan de Fuca Strait (6.1 per cent). The total number of vessels from the present time to the year 2030 in Burrard Inlet increases from 6,858 to 11,139 (38 per cent), and in Haro Strait from 8,896 to

12,113 vessels (27 per cent). The potential for the increase in noise and visual disturbances from overall traffic is much greater in Burrard Inlet, which also includes effects from Project-related vessels, compared to other components of the shipping lanes.

TABLE 4.4.6.1

POTENTIAL RESIDUAL EFFECTS OF PROJECT-RELATED MARINE TRAFFIC ON MARINE BIRDS CONSIDERED FOR THE CUMULATIVE EFFECTS ASSESSMENT

Potential Residual Effect on Marine Bird Indicator	Spatial Boundary[1]	Temporal Boundary	Potential Cumulative Effect	Existing Activities/Reasonably Foreseeable Activities with Residual Effects Acting in Combination with Project-Related Marine Vessel Traffic
1. Combined Project effects on fork-tailed storm-petrel.	RSA	Operations	Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).
2. Combined Project effects on Cassin's auklet.	RSA	Operations	Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).
3. Combined Project effects on surf scoter.	RSA	Operations	Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).
4. Combined Project effects on pelagic cormorant.	RSA	Operations	Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).
5. Combined Project effects on glaucous-winged gull.	RSA	Operations	Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	• Existing marine vessel traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine vessel traffic within the Marine RSA (Table 4.4.1.2).

Note: 1 RSA = Marine RSA

4.4.6.3 Significance Evaluation of Potential Cumulative Effects

Table 4.4.6.2 provides a summary of the significance evaluation of the contribution of Project-related marine vessel traffic to potential cumulative effects on the marine bird indicators. The rationale used to evaluate the significance of each of the cumulative effects is provided below. The assessment follows a qualitative approach due to a lack of quantitative measures of thresholds of disturbance to marine bird species within the Marine RSA. The evaluation of significance was based primarily on professional judgment, which is the product of a strong body of knowledge about indicator species life-history in the Marine RSA and experience gained on environmental assessments of other similar marine transportation projects in BC.

TABLE 4.4.6.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON MARINE BIRDS

Potential Cumulative Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
1. Marine Birds Indicator – Fork-tailed Storm-Petrel									
1(a) Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	Negative	RSA	Long-term	Periodic	Short-term	Low	High	High	Not significant
2. Marine Birds Indicator – Cassin's auklet									
2(a) Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	Negative	RSA	Long-term	Periodic	Short-term	Medium	High	High	Not significant
3. Marine Birds Indicator – Surf Scoter									
3(a) Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	Negative	RSA	Long-term	Periodic	Short-term	Medium	High	High	Not significant
4. Marine Birds Indicator – Pelagic Cormorant									
4(a) Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	Negative	RSA	Long-term	Periodic	Short-term	Medium	High	High	Not significant
5. Marine Birds Indicator – Glaucous-winged Gull									
5(a) Project contribution to the cumulative increase in behavioural alteration or sensory disturbance.	Negative	RSA	Long-term	Periodic	Short-term	Low	High	High	Not significant
6. Combined Cumulative Effects on Marine Birds									
6(a) Project contribution to combined cumulative effects on marine birds indicators (1[a], 2[a], 3[a], 4[a] and 5[a]).	Negative	RSA	Long-term	Periodic	Short-term	Medium	High	High	Not significant

Notes: 1 RSA = Marine RSA

2 **Significant Contribution to a Cumulative Environmental Effect:** A high probability of occurrence of a permanent or long-term cumulative effect of high magnitude that cannot be technically or economically mitigated.

4.4.6.3.1 Marine Bird Indicator – Fork-Tailed Storm-Petrel

The fork-tailed storm-petrel is a pelagic species spending most of its life in open waters on the continental shelf and beyond, making irregular visits to the Marine RSA during the breeding season and during long-distance flights to forage. Observations of individuals within the Marine RSA primarily take place during summer and fall seasons, somewhat distant from the shipping lanes. The fork-tailed storm-petrel rarely lands, soaring low over waves, capturing prey from the water's surface. Therefore, there is a lower likelihood of sensory disturbance responses that might characterize surface or diving foragers, such as flushing from moving vessels in close proximity due to in-air and underwater noise. The Project's contribution to cumulative effects with respect to the fork-tailed storm-petrel is primarily of concern in the area of overlap with the species distribution which is greatest in the western passages of the shipping lanes from Haro Strait to the 12 nautical mile boundary of the territorial sea. This is where the contribution of Project-related vessel movements to overall vessel traffic is approximately 6 to 12 per cent (Table 4.4.1.2). Sensory disturbance (*i.e.*, vessel-related in-air noise and activity) is considered to have a negative impact balance through marine bird avoidance of important habitats. The potential periodic disturbances will affect a small number of individuals that intermittently use the Marine RSA, but are unlikely to have more than a marginal to low adverse effect to the regional population, considering the wide-ranging and highly pelagic nature of this species. The physical presence of vessels and vessel-generated noise is anticipated to result in localized, repetitive, temporary disturbances. The recovery (return to normal behaviours) of individuals or groups of birds from vessel disturbances may be interrupted and somewhat delayed by the subsequent disturbances from other vessel and marine activities. The effects from sensory disturbances (stress, changes in energy budgets over time and reduced fitness) could be more persistent than the immediate recovery that might be expected after isolated disturbance events, given the frequency of overall vessel movements along the shipping lanes. Consequently, taking into account the high volume of vessel traffic within the Marine RSA, and with the professional judgment of the assessment team, the Project's contribution to cumulative effects on fork-tailed storm-petrel is considered to have a high probability of being long-term in duration with a low magnitude and short-term reversibility (Table 4.4.6.2, point 1[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative effects is assessed within the regional context of the Marine RSA with consideration for the highly pelagic, wide-ranging and agile flight behaviour of fork-tailed storm-petrels.
- **Duration** - long-term – the event causing sensory disturbance to fork-tailed storm-petrel is the contribution of Project-related vessels to cumulative effects during operations for the life of the Project.
- **Frequency** - periodic – the Project's contribution to the cumulative effects on fork-tailed storm-petrels is intermittent but repeated sensory disturbance, with regular transits potentially twice per day, for the life of the Project.
- **Reversibility** - short-term – the reversibility of the event of the Project's contribution to the cumulative effect of vessel-related sensory disturbances to fork-tailed storm-petrel will be short-term considering the potential for other subsequent vessel disturbances after the passage of Project-related marine vessels.
- **Magnitude** - low – the Project's contribution to cumulative effects will be detectable at the individual level, but marginal to negligible on the population level with consideration for the context of existing and anticipated high volume vessel traffic within the Marine RSA, the highly pelagic nature of the species, and the relatively lower contribution of Project-related vessels to cumulative effects in this western portion of the shipping lanes.
- **Probability** - high – the Project is likely to contribute to the cumulative effect of sensory disturbances to fork-tailed storm-petrel.

- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and fork-tailed storm-petrel, and data pertinent to the coastal region.

4.4.6.3.2 Marine Bird Indicator – Cassin's Auklet

Cassin's auklets breed at colonies within the western portion of the Marine RSA near Juan de Fuca Strait. During the non-breeding season, they spend most of their time at sea upwellings and on the continental shelf. Recent literature documents the sensitivities of these and other alcid species to various sources of disturbance (Carney and Sydeman 1999, 2000). Considering the sensitive nature of auklets, the cumulative effects of the increased Project-related and reasonably foreseeable future vessel traffic may potentially result in a minimal adverse impact on the population. Auklets are unlikely to become habituated to marine shipping activities. Outside the breeding season, large groups resting on the water surface or diving to forage are vulnerable to disturbances and exhibit flushing and other stress responses when disrupted. The events relevant to the Cassin's auklet primarily take place in narrow and physically sheltered passages during the breeding season, and where their foraging range in open waters overlaps the shipping lanes from the Strait of Georgia to the 12 nautical mile territorial boundary, in which the percent contribution to overall traffic is approximately 6 to 12 per cent (Table 4.4.1.2). Taking into account the existing vessel traffic within the Marine RSA, and the professional judgment of the assessment team, the increased Project-related and reasonably foreseeable future vessel traffic is anticipated to result in regular, temporary disturbances, resulting in cumulative effects of medium magnitude. Sensory disturbance (*i.e.*, vessel-related in-air noise and the avoidance of important habitats) is considered to have a negative impact balance. The recovery of individuals or groups of auklets from vessel disturbances may be interrupted and subsequently delayed by subsequent disturbances from other vessel activity. Auklets, as a group, are more sensitive to various types of human disturbance than other bird species groups, therefore, direct and indirect effects (stress, changes in energy budgets over time and reduced fitness) could be more persistent. The Project's contribution to cumulative effects on Cassin's auklet is determined to have a high probability of being long-term in duration with a medium magnitude and short-term reversibility (Table 4.4.6.2, point 2[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative effects is assessed within the regional context of the Marine RSA with consideration for the wide-ranging and seasonal changes in behaviour and habitat use of Cassin's auklet.

- **Duration** - long-term – the event causing sensory disturbance to Cassin's auklet is the contribution of Project-related vessels to cumulative effects during operations for the life of the Project.

- **Frequency** - periodic – the Project's contribution to the cumulative effect on Cassin's Auklet is intermittent but repeated sensory disturbance, with regular transits potentially twice per day, for the life of the Project.

- **Reversibility** - short-term – the reversibility of the event of the Project's contribution to the cumulative effect of vessel-related sensory disturbances to Cassin's auklet will be short-term considering the potential for other subsequent vessel disturbances after the passage of Project-related marine vessels.

- **Magnitude** - medium – the Project's contribution to cumulative effects will be detectable at the individual level but low to medium on the population level with consideration for the context of existing and anticipated high-volume large-vessel traffic within the Marine RSA, the seasonal sensitivity of the species during breeding, their seasonal tendency to forage in large aggregations, and the relatively lower contribution of Project-related vessels to cumulative effects in this western component of the shipping lanes.

- **Probability** - high – the Project is likely to contribute to the cumulative effect of sensory disturbances to Cassin's auklet.

- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and Cassin's auklet, and data pertinent to the coastal region.

4.4.6.3.3 Marine Bird Indicator – Surf Scoter

Surf scoters are seasonally present within the Marine RSA and effects would be limited to wintering, migrating and moulting periods (late summer to late spring). During these periods, large foraging aggregations of surf scoters are present in nearshore areas, while smaller groups are found in open waters. The presence of vessels and vessel-generated noise is anticipated to result in regular, temporary disturbances, primarily in narrower portions of the shipping lanes, such as in Haro Strait. Depending on the time of year, these disturbances could adversely affect large numbers of surf scoters (*e.g.*, thousands in spring when foraging on Pacific herring spawn) or when energetic costs are already high for individuals (during moulting periods). However, birds are expected to move away from vessels and resume normal behaviors and activities within a relatively short time frame, depending on the potential for subsequent disturbance events. The increase in Project-related large vessel traffic will continue over the long-term; however, it is unlikely that there would be substantial adverse effects to the relatively large regional population of surf scoters. The cumulative effect of sensory disturbance (*i.e.*, the avoidance of important habitats) is considered to have a negative impact balance. The Project's contribution to cumulative effects that is relevant to the surf scoter takes place primarily in nearshore and sheltered passages of the shipping lanes from Burrard Inlet to the 12 nautical mile boundary of the territorial sea. The percent contribution of the Project to overall traffic in these areas will range from approximately 6 to 26 per cent (Table 4.4.1.2). The recovery of individuals or groups of birds from vessel disturbances may be interrupted by subsequent disturbances due to other marine vessel activity. The effects (stress, changes in energy budgets over time and reduced fitness) could last longer than the immediate recovery expected after isolated events, given the frequency of vessel movements in the shipping lanes. Consequently, the professional judgment of the assessment team has determined that the Project's contribution to cumulative effects on surf scoter will have a high probability of being long-term in duration with a low magnitude and an short-term reversibility (Table 4.4.6.2, point 3[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative effects is assessed within the regional context of the Marine RSA with consideration for the seasonal presence and nearshore congregational foraging behaviour of surf scoters.

- **Duration** - long-term – the event causing sensory disturbance to surf scoters is the contribution of Project-related vessels to cumulative effects during operations for the life of the Project.
- **Frequency** - periodic – the Project's contribution to the cumulative effect on surf scoter is intermittent but repeated sensory disturbance, with regular transits potentially twice per day, for the life of the Project.
- **Reversibility** - short-term – the reversibility of the event of the Project's contribution to the cumulative effect of vessel-related sensory disturbances to surf scoter will be short-term considering the context of other subsequent vessel disturbances after the passage of Project-related marine vessels.
- **Magnitude** - medium – the Project's contribution to cumulative effects will be detectable at the individual level, but marginal to negligible on the population level with consideration for the context of high-volume vessel traffic existing and anticipated within the Marine RSA, and the potential for large aggregations of birds during overwintering moulting and overwintering seasons in channels and nearshore habitats.
- **Probability** - high – the Project is likely to contribute to the cumulative effect of sensory disturbances to surf scoters.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and surf scoters, and data pertinent to the coastal region.

4.4.6.3.4 Marine Bird Indicator – Pelagic Cormorant

The regional population of pelagic cormorants is abundant year-round and habitat use is primarily focused in nearshore areas. This species has one of the largest flushing distances among marine birds (*i.e.,* low disturbance threshold). The Project's contribution to cumulative effects that is relevant to the pelagic cormorant takes place in the nearshore and narrow passages from Burrard Inlet to the 12 nautical mile boundary of the territorial sea where the Project's contribution to overall vessel traffic ranges from 6 to 26 per cent (Table 4.4.1.2). Many of these areas have cormorant breeding colonies, including Burrard Inlet, where marine activity will be the highest in the shipping lanes. The recovery from vessel disturbance for individuals or groups of cormorants, primarily in narrow channels, may be somewhat delayed by the potential for continuous subsequent disturbances from other marine activity. The effects could be more persistent given the proximity of the shipping lanes to birds at shorelines and marine structures. Although the sensitivity of pelagic cormorants to human disturbances is well documented (Carney and Sydeman 1999, 2000), they sometimes use marine and commercial structures for perching and resting. Habituation to the presence and activity of marine traffic has not previously been assessed in the Marine RSA. It is unlikely that there will be cumulative effects at the scale of the relatively abundant regional population of pelagic cormorants. Consequently, considering the existing high volume of large vessel traffic within the Marine RSA, and the professional judgment of the assessment team, the Project's contribution to cumulative effects on pelagic cormorant is considered to have a high probability of being long-term in duration with a medium magnitude and short-term reversibility (Table 4.4.6.2, point 4[a]). Sensory disturbance (*i.e.*, vessel-related in-air noise) is considered to have a negative impact balance through the avoidance of important habitats. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative effects are assessed within the Marine RSA with consideration for the sensitivity of pelagic cormorant, weather conditions and the location of local breeding colonies.
- **Duration** - long-term – the event causing sensory disturbance to pelagic cormorant is the contribution of Project-related vessels to cumulative effects during operations for the life of the Project.
- **Frequency** - periodic – the Project's contribution to the cumulative effect on pelagic cormorant is intermittent but repeated sensory disturbance, with regular transits potentially twice per day, for the life of the Project.
- **Reversibility** - short-term – the reversibility of the event of the Project's contribution to the cumulative effect of vessel-related sensory disturbances to pelagic cormorant will be short-term considering the potential for other subsequent vessel disturbances after the passage of Project-related marine vessels
- **Magnitude** - medium – the Project's contribution to cumulative effects will be detectable at the individual level but low to moderate on the population level with consideration for the context of existing and anticipated high-volume vessel traffic within the Marine Birds LSA, the sensitive foraging and breeding behaviour of the species, and the relatively moderate contribution of Project-related vessels to cumulative effects in narrower channels of the shipping lanes, especially in Burrard Inlet.
- **Probability** - high – the Project is likely to contribute to the cumulative effects of sensory disturbances to pelagic cormorant.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and pelagic cormorants, and data pertinent to the coastal region.

4.4.6.3.5 Marine Bird Indicator – Glaucous-Winged Gull

Glaucous-winged gulls are abundant and ever-present within the Marine RSA. Although generally an inshore species, it does forage at sea as far as the continental shelf. The Project's contribution to cumulative effects that is relevant to the glaucous-winged gulls takes place primarily in nearshore and sheltered passages of the shipping lanes and from Burrard Inlet to the 12 nautical mile boundary of the territorial sea. Glaucous-winged gulls breed at colonies located on islets near the shipping lanes, including in Burrard Inlet. One active breeding colony is located within 1 km of the Westridge Marine Terminal. The percent contribution of the Project to overall traffic ranges from approximately 6 to 26 per cent throughout the full extent of shipping lanes; however, the largest contribution is in Burrard Inlet (Table 4.4.1.2). While the increase in large vessel traffic due to the Project is likely to be long-term in duration, it is unlikely that any associated effects will be detectable at the scale of the regionally high-density population of glaucous-winged gulls. Habituation to the current presence and activity of marine vessels is likely; however, birds are most sensitive to disturbances during the breeding season (Carney and Sydeman 1999, 2000) and the additional traffic is likely to contribute increased disturbance effects on seasonal colonial breeders. The recovery of individuals or groups of birds from vessel disturbance may be somewhat delayed by subsequent disturbances from other marine activity. The adverse effects, primarily at breeding colonies, could be more pronounced in these narrow channel areas. Considering gulls are well-adapted to human-influenced environments, adverse effects are less likely for glaucous-winged gulls than other species outside of the breeding season; however, there is a lack of information and studies to document the species-specific threshold of continuous disturbances for birds that commonly use these areas. Consequently, considering the existing high volume of large vessel traffic within the Marine RSA, and the professional judgment of the assessment team, the Project's contribution to cumulative effects on glaucous-winged gulls is considered to have a high probability of being long-term in duration with a low magnitude and short-term reversibility (Table 4.4.6.2, point 5[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative effects are assessed within the Marine RSA with consideration for the seasonal sensitivity of local breeding colonies of glaucous-winged gulls.
- **Duration** - long-term – the event causing sensory disturbance to glaucous-winged gulls is the contribution of Project-related vessels to cumulative effects during operations for the life of the Project.
- **Frequency** - periodic – the Project's contribution to the cumulative effect on glaucous-winged gulls is intermittent but repeated sensory disturbance, with regular transits potentially twice per day, for the life of the Project.
- **Reversibility** - short-term – the reversibility of the event of the Project's contribution to the cumulative effects of vessel-related sensory disturbances to glaucous-winged gull will be short-term considering the potential for other subsequent vessel disturbances after the passage of Project-related marine vessels.
- **Magnitude** - low – the Project's contribution to cumulative effects will be detectable at the individual level, but low on the population level with consideration for the context of existing and anticipated high-volume large-vessel traffic within the Marine RSA, the sensitivity of local breeding colonies, especially in Burrard Inlet, and the relatively moderate contribution of Project-related vessels to cumulative effects in narrower channels of the shipping lanes, most apparent in Burrard Inlet.
- **Probability** - high – the Project is likely to contribute to the cumulative effect of sensory disturbances to glaucous-winged gulls.
- **Confidence** - high – based on a good understanding by the assessment team of cause-effect relationships between the Project activities and marine birds, and data pertinent to the coastal region.

4.4.6.3.6 Combined Cumulative Effects on Marine Birds

The evaluation of the Project's contribution to the cumulative effect of increased sensory disturbance to marine birds considers collectively the likelihood of potential residual effects on the following indicator species: fork-tailed storm-petrel; Cassin's auklet; surf scoter; pelagic cormorant; glaucous-winged gull; and the larger diverse assemblage of marine bird species they represent. Increased Project-related marine vessel traffic may act cumulatively with existing and reasonably foreseeable future vessel traffic to adversely affect marine birds in the Marine Birds LSA and Marine RSA, as described above for the marine birds indicator species. The Marine RSA is one of the busiest waterways on the Pacific Coast and the assessment of combined effects has been considered in this context. Effects are considered within a setting of predicted future high-volume vessel activity within the Marine RSA, the Project's modest contribution to that activity, and standards set within an existing regulatory framework. The impact balance is considered negative. The implementation of mitigation measures will reduce the severity of cumulative effects arising from the Project and reasonably foreseeable increases in vessel traffic. There is a high probability that the combined cumulative effect of the Project on marine birds is long-term in duration, of medium magnitude and reversible in the short-term (Table 4.4.6.2, point 6[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative effects to marine birds from sensory disturbance is assessed within the regional context of existing and projected future marine activities in the Marine RSA interacting with Project-related activities.
- **Duration** - long-term – the event causing the Project's contribution to cumulative effects on marine birds will be initiated during operations and continue for the life of the Project.
- **Frequency** - periodic – the Project's contribution to the cumulative effect on marine birds is intermittent but repeated sensory disturbance, with regular transits potentially twice per day, for the life of the Project.
- **Reversibility** - short-term – the reversibility of the event of Project's contribution to the cumulative effect of vessel-related sensory disturbances to marine birds will be short-term considering the potential for other subsequent vessel disturbances after the passage of Project-related marine vessels.
- **Magnitude** - medium – the Project's contribution to cumulative effects will be detectable at the individual level and may have low to moderate effects on the populations of some sensitive colonial breeding species in narrow channel areas with consideration for the context of high volume large vessel traffic that currently exists within the Marine RSA and the relatively moderate contribution of Project-related vessels to cumulative effects.
- **Probability** - high – the Project is likely to contribute to the cumulative adverse effects to varying degrees, and under some conditions, on marine birds.
- **Confidence** - high – based on a good understanding by the assessment team on pathways of effect between the increased Project-related vessel activities and marine birds, and with baseline data relevant to the coastal region.

4.4.6.4 Potential United States Effects

During various seasons, seabirds cross terrestrial/marine ecological and political boundaries regularly to forage, stage during migration, overwinter in large congregations and breed, often in large colonies. Individual birds and seabird populations are exposed to similar environmental conditions in open water or intertidal habitats, from vessel activity or natural wave conditions in the US and Canadian portions of the Marine RSA. The same types of effects from shipping assessed in Canadian waters are expected to be present in US waters since the marine bird species compositions and the volume of large marine vessel traffic is similar or greater in US waters. However, federal and state management policies may be slightly different than provincial policies. Considering the jurisdiction of agencies does not cross the land-sea boundary in the same manner as the seabirds they are managing, these management efforts are often facilitated by multi-agency communication and collaboration. The cumulative effects from marine vessel traffic on marine birds are expected to be similar in Canadian and US waters.

4.4.6.5 Summary

As identified in Table 4.4.6.2, there are no situations where there is a high probability of occurrence of the Project's contribution to a permanent or long-term cumulative effect of high magnitude that cannot be technically or economically mitigated. Consequently, it is concluded that the Project's contribution to cumulative effects on marine birds within the Marine RSA will be not significant.

4.4.7 Marine Species at Risk

Potential cumulative effects of the increased Project-related marine vessel traffic on marine species at risk are assessed through the use of indicators in Section 4.4.4, Section 4.4.5 and Section 4.4.6. Therefore, although not all marine species at risk are discussed explicitly under each indicator, the Project's contribution to potential cumulative effects was assessed in consideration of all species at risk. Since the cumulative effects assessment considers only likely residual effects, low probability potential effects to fish, bird and mammal species were not assessed for cumulative effects. For a discussion on how indicators were selected to ensure consideration of species at risk, the reader is referred to Section 4.3.9.

4.4.8 Traditional Marine Resource Use

This subsection discusses how existing marine traffic and reasonably foreseeable marine traffic within the Marine RSA may interface with increased Project-related marine vessel traffic to cumulatively affect traditional marine resource use indicators including subsistence activities and sites, and cultural sites.

4.4.8.1 Reasonably Foreseeable Developments

Table 4.4.1.2 summarizes the current level of marine traffic within the Marine RSA as well as the anticipated marine traffic attributed to the Project and other reasonably foreseeable marine traffic. A description of existing and anticipated activities is provided in Section 4.4.1.4.

4.4.8.2 Potential Cumulative Effects

The potential and likely socio-economic residual effects associated with increased Project-related marine vessel traffic on traditional marine resource use indicators were identified in Section 4.3.10 and are listed in Table 4.4.8.1 along with the associated existing and reasonably foreseeable regional marine traffic that could act in combination with the effects of increased Project-related marine vessel traffic to cause a cumulative effect on TMRU.

The significance evaluation considers the effect of Project-related marine vessel traffic as a proportion of the total amount of existing and future marine vessel traffic. The potential cumulative effects for each indicator are then discussed in the context of the total foreseeable increased marine vessel traffic in the region.

TABLE 4.4.8.1

POTENTIAL RESIDUAL EFFECTS OF PROJECT-RELATED MARINE TRAFFIC ON TRADITIONAL MARINE RESOURCE USE CONSIDERED FOR THE CUMULATIVE EFFECTS ASSESSMENT

Potential Residual Effect on TMRU Indicator	Spatial Boundary[1]	Temporal Boundary	Potential Cumulative Effect	Existing Activities/Reasonably Foreseeable Activities with Residual Effects Acting in Combination with Project-Related Marine Vessel Traffic
1. Combined effects on subsistence activities and sites.	RSA	Operations	Project contribution to cumulative effects on subsistence activities and sites.	• Existing marine traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.
2. Combined effects on cultural sites.	RSA	Operations	Project contribution to cumulative effects on cultural sites.	• Existing marine traffic within the Marine RSA (Table 4.4.1.2). • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.

Note: 1 RSA = Marine RSA

4.4.8.3 Significance Evaluation of Potential Cumulative Effects

The combined Project effects on subsistence activities and sites as well as on cultural sites from Table 4.3.10.4 were assessed in terms of the Project contribution to cumulative effects in each indicator category. Table 4.4.8.2 provides a summary of the significance evaluation of the contribution of Project-related marine vessel traffic to the potential cumulative effects. The rationale used to evaluate the significance of each of the cumulative effects is provided below.

TABLE 4.4.8.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON TRADITIONAL MARINE RESOURCE USE

Potential Cumulative Effects	Impact Balance	Spatial Boundary[1]	Temporal Context: Duration	Temporal Context: Frequency	Temporal Context: Reversibility	Magnitude	Probability	Confidence	Significance[2]
1. Traditional Marine Resource Use Indicator – Subsistence Activities and Sites									
1(a) Project contribution to cumulative effects on subsistence activities and sites.	Negative	RSA	Long-term	Periodic	Short to long-term	Low to high	High	High	Significant

TABLE 4.4.8.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON TRADITIONAL MARINE RESOURCE USE (continued)

Potential Cumulative Effects		Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
				Duration	Frequency	Reversibility				
2.	**Traditional Marine Resource Use Indicator – Cultural Sites**									
2(a)	Project contribution to cumulative effects on cultural sites.	Negative	RSA	Long-term	Continuous	Long-term	Medium	High	High	Not significant
3.	**Combined Cumulative Effects on Traditional Marine Resource Use**									
3(a)	Combined Project contribution to cumulative effects on traditional marine resource use indicators (1[a] and 2[a]).	Negative	RSA	Long-term	Continuous	Long-term	High	High	High	Significant

Notes: 1 RSA = Marine RSA

2 **Significant Contribution to a Cumulative Socio-Economic Effect:** The Project's contribution to a cumulative socio-economic effect is considered significant if the contribution is predicted to be:

- high magnitude, high probability, short to medium-term reversibility and regional, provincial or national in extent that cannot be technically or economically mitigated; or
- high magnitude, high probability, long-term or permanent reversibility and any spatial boundary that cannot be technically or economically mitigated.

4.4.8.3.1 Traditional Marine Resource Use Indicator – Subsistence Activities and Sites

As noted Section 4.3.10.5, all components of the marine environment are understood to support the marine resource base and habitat conditions essential to the practice of traditional activities. As such, the potential cumulative effects on subsistence activities and sites are assessed in consideration of all pertinent biophysical resources known or assumed to be of importance to Aboriginal communities for traditional use, as well as in consideration of the existing high volume of large vessel traffic within the Marine RSA. As described in Section 4.3.7.6, southern resident killer whales within 4 to 7 km of the shipping lanes are expected to be disturbed by vessel traffic and this effect will occur throughout the Canadian designated critical habitat for this endangered population. The assessment of marine mammals has determined the magnitude of this effect on southern resident killer whales is expected to be high; this determination takes into consideration past and current activities resulting in a currently existing significant adverse cumulative effect on this population. While future harvesting of the southern resident killer whale population is unlikely given the recent historical decline of this population (as described in Section 4.3.10.6), significant changes in the availability of a single traditionally harvested resource may also be reflected throughout the broader ecological system and the availability of marine resources overall. Effects to subsistence activities and sites are not expected to be of high magnitude except for effects relating to southern resident killer whale. The overall contribution of the Project to cumulative effects on the subsistence activities and sites indicator is of low to high magnitude, reversible in the short-term to long-term and of high probability (Table 4.4.8.2, point 1[a]).

A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative change in subsistence activities and sites is assessed within the regional context of the Marine RSA to include wide-ranging marine species.
- **Duration** - long-term – the contribution of Project-related vessels to cumulative effects on traditionally harvested marine resources will extend for the operational life of the Project.
- **Frequency** - periodic – the Project's contribution to the cumulative effect on subsistence activities and sites will occur whenever a Project-related tanker is in transit.
- **Reversibility** - short to long-term – the Project's contribution to cumulative effects on subsistence activities such as delays or disruptions are expected to extend throughout the operational life of the Project; however, disturbances to marine resources will be short-term considering the context of other subsequent vessel disturbances after the passage of Project-related marine vessels.
- **Magnitude** - low to high – the cumulative effects assessment results for marine fish and fish habitat, marine mammals and marine birds indicates that contribution of Project-related vessels to cumulative effects on marine resources may be detectable and is dependent on each target species' sensitivities, with the exception of the southern resident killer whale population, whereby cumulative changes are beyond environmental and regulatory standards.
- **Probability** - high – the Project's contribution to cumulative effects on subsistence sites and activities is considered to be likely.
- **Confidence** - high – there is a good understanding of general cause-effect relationships that result in the Project contribution to cumulative effects on subsistence activities and sites.

4.4.8.3.2 Traditional Marine Resource Use Indicator – Cultural Sites

The Project contribution to cumulative effects on the cultural sites indicator consists of increased sensory disturbance to marine users and negative user perspectives of increased Project-related marine vessel traffic (Table 4.4.8.2, point 2[a]). If approved, future developments such as those described in Section 4.4.1.4 and Project-related marine vessel traffic will add to the existing marine vessel traffic in the Marine RSA. Increased marine vessel traffic is likely to increase congestion in areas that are geographically constrained and already experience high marine traffic volumes. Increased marine vessel traffic in such areas may potentially cause some traditional marine users to avoid these areas or to alter their preferred routes due to sensory disturbance from transiting marine vessels. Mitigation measures for the potential residual effects of increased Project-related marine vessel traffic on cultural site use are proposed in Table 4.3.10.3 in Section 4.3.

A detailed assessment discussion of this cumulative effect, including an explanation of the rationale of the significance criteria related to the marine recreational use indicator of MCRTU, is provided in Section 4.4.9.3, which includes traditional marine resource users.

4.4.8.3.3 Combined Cumulative Effects on Traditional Marine Resource Use

The potential effects of the Project (*i.e.*, combined Project effects on subsistence activities and sites, and cultural sites) are anticipated to act in combination with other existing marine vessels and reasonably foreseeable developments to affect traditional marine resource use in the Marine RSA. The impact balance of the combined cumulative effects is considered negative, though the implementation of mitigation measures described in Table 4.3.10.3 in Section 4.3 will reduce the severity of cumulative effects associated specifically with the Project and other reasonably foreseeable developments. The overall contribution of the Project to the cumulative effects on traditional marine resource use is of high magnitude given the cumulative effects assessment of marine mammals, reversible in the long-term and of high probability (Table 4.4.8.2, point 3[a]). A summary of the rationale for all the significance criteria is provided below. Effects are considered in the context of existing high-volume vessel activity within the Marine RSA, the existing regulatory framework and the relatively moderate contribution of Project-related vessels to cumulative effects.

- **Spatial Boundary** - Marine RSA – the Project's contribution to cumulative combined effects on traditional marine resource use indicators are assessed within the regional context of existing activities and reasonable foreseeable marine developments and activities in the Marine RSA interacting with Project-related activities.
- **Duration** - long-term – the presence of Project-related marine vessels will extend through the operational life of the Project.
- **Frequency** - continuous - Project-related marine vessels will be present in the Marine RSA continually over the assessment period.
- **Reversibility** - long-term – the Project contribution to cumulative change for all traditional marine resource use indicators is expected to extend throughout the operational life of the Project.
- **Magnitude** - high – the effects on marine resources are beyond environmental and regulatory standards.
- **Probability** - high – the Project contribution to cumulative effects on traditional marine resource use indicators is likely.
- **Confidence** - high – there is a good understanding of general cause-effect relationships that result in the Project contribution to cumulative effects on traditional marine resource use indicators.

4.4.8.4 Potential United States Effects

The potential cumulative effects evaluated in this assessment are considered to apply equally in Canadian and US waters, primarily due to the location of the shipping lanes being along the international boundary throughout much of the Marine RSA.

4.4.8.5 Summary

As identified in Table 4.4.8.2, the Project's contribution to adverse cumulative effects on traditional marine resource use within the Marine RSA is considered not significant, with the exception of the Project's contribution to cumulative effects on the southern resident killer whale population, which is considered to be significant (see Section 4.3.7).

4.4.9 Marine Commercial, Recreational and Tourism Use

This subsection discusses how existing marine traffic and reasonably foreseeable marine traffic within the Marine RSA may interface with additional Project marine traffic to cumulatively affect MCRTU indicators including commercial fisheries and aquaculture, marine transportation, marine recreational use and marine tourism use.

4.4.9.1 Reasonably Foreseeable Developments

Table 4.4.1.2 summarizes the current level of marine traffic within the Marine RSA as well as the anticipated marine traffic attributed to the Project and other reasonably foreseeable marine traffic. A description of existing and anticipated activities is provided in Section 4.4.1.4.

4.4.9.2 Potential Cumulative Effects

The potential and likely socio-economic residual effects associated with increased Project-related marine vessel traffic on MCRTU indicators were identified in Section 4.3.11 and are listed in Table 4.4.9.1 along with the associated existing and reasonably foreseeable regional marine traffic that could act in combination with the effects of increased Project-related marine vessel traffic to cause a cumulative effect on MCRTU.

The significance evaluation considers the effect of Project-related marine vessel traffic as a proportion of the total amount of existing and future marine vessel traffic. The potential cumulative effects for each indicator are then discussed in the context of the total foreseeable increased marine vessel traffic in the region.

TABLE 4.4.9.1

POTENTIAL RESIDUAL EFFECTS OF PROJECT-RELATED MARINE TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE CONSIDERED FOR THE CUMULATIVE EFFECTS ASSESSMENT

Potential Residual Effect on MCRTU Indicator	Spatial Boundary[1]	Temporal Boundary	Potential Cumulative Effect	Existing Activities/Reasonably Foreseeable Activities with Residual Effects Acting in Combination with Project-Related Marine Vessel Traffic
1. Combined Project effects on commercial fisheries and aquaculture.	LSA to RSA	Operations	Project contribution to cumulative effects on commercial fishing.	• Existing marine traffic. • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.
2. Combined Project effects on marine transportation.	LSA to RSA	Operations	Project contribution to cumulative effects on marine transportation.	• Existing marine traffic. • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.

TABLE 4.4.9.1

POTENTIAL RESIDUAL EFFECTS OF PROJECT-RELATED MARINE TRAFFIC ON MARINE COMMERCIAL, RECREATIONAL AND TOURISM USE CONSIDERED FOR THE CUMULATIVE EFFECTS ASSESSMENT (continued)

Potential Residual Effect on MCRTU Indicator	Spatial Boundary[1]	Temporal Boundary	Potential Cumulative Effect	Existing Activities/Reasonably Foreseeable Activities with Residual Effects Acting in Combination with Project-Related Marine Vessel Traffic
3. Combined Project effects on marine recreational use.	LSA to RSA	Operations	Project contribution to cumulative effects on marine recreational use.	• Existing marine traffic. • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.
4. Combined Project effects on marine tourism use.	LSA to RSA	Operations	Project contribution to cumulative effects on marine tourism use.	• Existing marine traffic. • Reasonably foreseeable marine traffic within the RSA listed in Table 4.4.1.2.

Note: 1 RSA = Marine RSA

4.4.9.3 Significance Evaluation of Potential Cumulative Effects

The combined Project effects on marine transportation, marine recreational use and marine tourism use from Table 4.3.11.3 were assessed in terms of the Project contribution to cumulative effects in each indicator category. Table 4.4.9.2 provides a summary of the significance evaluation of the contribution of Project-related marine vessel traffic to the potential cumulative effects. The rationale used to evaluate the significance of each of the cumulative effects is provided below.

TABLE 4.4.9.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON MCRTU

Potential Cumulative Effects	Impact Balance	Spatial Boundary[1]	Temporal Context: Duration	Temporal Context: Frequency	Temporal Context: Reversibility	Magnitude	Probability	Confidence	Significance[2]
1. MCRTU Indicator – Commercial Fisheries and Aquaculture									
1(a) Project contribution to cumulative effects on commercial fishing.	Negative	LSA to RSA	Long-term	Periodic	Long-term	Low to medium	High	High	Not significant
2. MCRTU Indicator – Marine Transportation									
2(a) Project contribution to cumulative effects on marine transportation.	Negative	LSA to RSA	Long-term	Periodic	Long-term	Low to medium	High	High	Not significant

TABLE 4.4.9.2

SIGNIFICANCE EVALUATION OF THE CONTRIBUTION OF PROJECT-RELATED MARINE TRAFFIC TO CUMULATIVE EFFECTS ON MCRTU (continued)

Potential Cumulative Effects	Impact Balance	Spatial Boundary[1]	Temporal Context			Magnitude	Probability	Confidence	Significance[2]
			Duration	Frequency	Reversibility				
3. MCRTU Indicator – Marine Recreational Use									
3(a) Project contribution to cumulative effects on marine recreational use.	Negative	LSA to RSA	Long-term	Periodic to continuous	Long-term	Low to medium	High	High	Not significant
4. MCRTU Indicator – Marine Tourism Use									
4(a) Project contribution to cumulative effects on marine tourism use.	Negative	LSA to RSA	Long-term	Periodic	Long-term	Low to medium	High	High	Not significant
5. Combined Cumulative Effects on MCRTU									
5(a) Combined Project contribution to cumulative effects on MCRTU indicators (1[a], 2[a] 3[a], and 4[a]).	Negative	LSA to RSA	Long-term	Periodic	Long-term	Low to medium	High	High	Not significant

Notes: 1 RSA = Marine RSA

2 **Significant Contribution to a Cumulative Socio-Economic Effect:** The Project's contribution to a cumulative socio-economic effect is considered significant if the contribution is predicted to be:

- high magnitude, high probability, short to medium-term reversibility and regional, provincial or national in extent that cannot be technically or economically mitigated; or
- high magnitude, high probability, long-term or permanent reversibility and any spatial boundary that cannot be technically or economically mitigated.

4.4.9.3.1 Marine Commercial, Recreational and Tourism Use Indicator – Commercial Fisheries and Aquaculture

Commercial fishing takes place throughout the Marine RSA, including areas of Burrard Inlet, the southern Strait of Georgia, Boundary Pass, Haro Strait and Juan de Fuca Strait. Commercial fishing vessels employ a variety of fishing techniques for a large number of key targeted species and species groups, including salmon, herring, groundfish, crab, shrimp and prawn. Desktop analysis determined that no active aquaculture operations are present within the Marine LSA in Canadian waters; it was determined that the effects of vessel wake from Project-related marine vessels on fish and fish habitat would be negligible at a distance of approximately 2 km.

Existing activities that affect commercial fishing in the Marine RSA include any use that displaces fishing activities. Fishing vessels can be physically displaced by the presence of other vessels or marine infrastructure, or fishing may be prohibited in areas that are reserved for other types of use. Marine shipping activities of deep draft vessels (including Project-related marine vessels) may affect commercial fishing activities if fishing is taking place within the designated shipping lanes, or if fishing vessels use the shipping lanes on route to fishing grounds or processing facilities.

Preferred fishing areas coincide with the designated shipping lanes in many areas of the Marine RSA. Fishing grounds are likely to have existed for many years prior to the imposition of the shipping lanes. In addition, fishers may specifically target shipping lanes or other frequently used routes because such areas may not be fished regularly and, therefore, can be de facto recovery areas for target species. For example, conflicts between crab fishers and ferry operators have recently been documented near both Prince Rupert and Mayne Island, where crab traps have become entangled in ferry propellers (Vancouver Sun 2010).

Commercial fishing vessels may choose to fish in the shipping lanes during fishery openings; for example, fishery openings for species such as roe herring or salmon can be very brief and may occur only once in a fishing season, with fishing vessels sometimes congregating for the duration of the opening over a key fishing area (CCG 2013b, DFO 2012d, DFO 2013l).

The Project contribution to the cumulative effects on commercial fishing is most likely to occur in areas where productive fishing grounds coincide with the designated shipping lanes in the Marine RSA. Several locations along the shipping lanes are highly productive undersea banks that are important fishing locations for many fisheries, including Sturgeon Bank and Roberts Bank in the southern Strait of Georgia, Constance Bank south of Victoria in Juan de Fuca Strait, and Swiftsure Bank near the western entrance to Juan de Fuca Strait. Preferred fishing locations depend upon the species being fished, and many of these fishing "hotspots" are situated along or near the shipping lanes. Another example occurs near Stuart Island around the shipping lanes in Haro Strait which is higher effort area for the prawn trap fishery. A final example is the salmon gillnet fishery which can occur in short and intense openings around the mouth of the Fraser River, in the Roberts Bank area of the shipping lanes outside Tsawwassen (CCG 2013a). Smaller marine vessels including many fishing vessels are not required to register with the CCG Marine Communications and Traffic Services, and these vessels may also not be fully visible on ship's radar, making them difficult to detect by large ships in poor weather (CCG 2013a).

The impact balance of the Project contribution to cumulative effects on the commercial fishing indicator is considered to be negative. The spatial boundary ranges from the Marine LSA to the Marine RSA. Although fishing vessels will only be directly affected by Project-related marine vessels in the area of the shipping lanes (Marine LSA), the cumulative effect of the increase in marine vessel traffic may be that displaced fishing vessels select other fishing areas, which could increase fishing effort in other areas of the Marine RSA. The duration is considered to be long-term, extending through the operational life of the Project. The frequency of the Project contribution is considered to be periodic. Project-related marine vessels will be transiting daily through the Marine RSA, with the potential to contribute to the combined effects on fishing activities intermittently and repeatedly over the operational life of the Project.

The reversibility of the Project contribution to cumulative effects on commercial fishing is considered to be long-term, since the residual effects attributable to the Project-related increase in vessel traffic will occur for the operational life of the Project. The magnitude of the Project contribution to the cumulative effect is low to medium. The Project contribution to cumulative effects on commercial fishing activities may cause commercial fishing vessels be temporarily inconvenienced by the presence of Project-related marine vessels (low), but delays may have business implications for some commercial fishing operators at select times (medium). The overall probability of a Project contribution to cumulative change in commercial fishing activities is considered to be high, for some operators (Table 4.4.9.2, point 1[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA to RSA - the Project contribution to cumulative effects on commercial fishing could occur at any point along the shipping lanes

(LSA), and may cause displacement of vessels to other regions of the Marine RSA.

- **Duration** - long-term - the event causing the cumulative change in commercial fishing (*i.e.* presence of Project-related marine vessels) will begin during the operations phase and extend for the operational life of the Project.
- **Frequency** - periodic –the Project contribution to the cumulative effects on commercial fishing activities have the potential to occur intermittently but repeatedly over the operational life of the Project.
- **Reversibility** - long-term – the Project contribution to cumulative effects on commercial fishing is expected to extend throughout the operational life of the Project.
- **Magnitude** - low to medium - the Project contribution to cumulative effects on commercial fishing activities may cause commercial fishing vessels be temporarily inconvenienced by the presence of Project-related marine vessels (low), but delays may have business implications for some commercial fishing operators at select times (medium).
- **Probability** - high – it is likely that the Project contribution to the cumulative effects on commercial fishing vessels, as characterized, will occur for some operators.
- **Confidence** - high - there is a good understanding of general cause-effect relationships that characterize the Project contribution to cumulative change in commercial fishing.

4.4.9.3.2 Marine Commercial, Recreational and Tourism Use Indicator – Marine Transportation

Marine transportation use in the Marine RSA includes: deep draft marine vessels for long distance shipping of goods; (*i.e.*, cargo carriers, container ships and tankers); passenger vessels such as cruise ships and passenger ferries, and tugs engaged in barging activities. Marine terminals import and export goods including automobiles, bulk products (*i.e.*, raw material commodities such as chemicals and petroleum products) break-bulk products (*e.g.*, forest products); and intermodal containers with consumer goods (PMV 2013a).

A large portion of the current commercial vessel movements in areas of the Marine RSA consists of tug traffic, while assisting ships, engaging in short sea (*i.e.*, short distance) shipping activities, or in transit. In eastern Burrard Inlet, tug traffic comprises 82 per cent of the total current marine vessel movements. Cargo and container ships make up significant portions of the total vessel movements in the Strait of Georgia (30 per cent), Haro Strait (50 per cent), and other areas. Ferry movements are responsible for a large proportion of the total vessel activity in the Strait of Georgia (32 per cent) (refer to Table 4.4.1.2).The Project contribution to the cumulative effects on marine transportation is considered to be most likely to occur in Burrard Inlet in the area of the Second Narrows. Table 4.4.1.2 shows the annual number of Project-related marine tanker movements to be 720, assuming an average increase of 30 vessels per month above the current vessel traffic associated with the Westridge Marine Terminal, which accounts for both inbound and outbound tankers calling at Westridge Marine Terminal. The increase constitutes an increase of 9.5 per cent in eastern Burrard Inlet, not counting the associated increase in escort tugs that will be required (Table 4.4.1.2). The total Project-related contribution to marine vessel traffic in Burrard Inlet is estimated to be 29.6 per cent, including escort tugs (Table 4.4.1.2).

Assuming daily transits of Project-related marine vessels, the CN Rail Bridge will need to be raised twice daily to accommodate Project-related vessels. The PMV requirement for all other vessels to remain clear of the shipping channels while deep draft vessels are in transit will also apply twice daily, on average. Marine traffic requiring access to areas east of the Second Narrows and rail traffic both have the potential to be delayed by the increase in Project-related marine vessel traffic. The demand for anchorages may also increase if commercial vessels miss the appropriate tidal window for transiting through Burrard Inlet. Including Westridge Marine Terminal, six active marine terminals are located east of the Second Narrows in Burrard InletThe use of the CN Rail Bridge will further increase in frequency if capacities are increased at other marine terminals in the eastern portions of Burrard Inlet. .

The relative contribution of Project-related marine vessels (tankers and escort tugs) to total vessel traffic in other areas of the Marine RSA is lower, ranging from 7.2 per cent to 13.9 per cent, due to the increased traffic from other ports and terminals in Canada and the US (Table 4.4.1.2). If approved, future developments such as those described in Section 4.4.1.4 and Project-related marine vessel traffic will add to the existing marine vessel traffic in the Marine RSA. Increased marine vessel traffic from all sources is likely to increase congestion in areas that are constrained geographically and already experience high marine traffic volumes. Mitigation measures for the potential residual effects of increased Project-related marine vessel traffic on marine transportation are proposed in Table 4.3.11.2.

The impact balance of the Project contribution to cumulative effects on the marine transportation indicator is considered to be negative. The spatial boundary where these effects are considered to be likely is the Marine LSA to the Marine RSA; since the zone of influence of Project-related marine vessels could overlap with other future traffic and extend beyond the Marine LSA. The duration of the Project contribution to cumulative effects on marine transportation is considered to be long-term, extending through the operational life of the Project.

The Project contribution to cumulative effects on marine transportation is considered to be periodic in frequency. Project-related marine vessels will be transiting through the Marine RSA twice daily over the operational life of the Project. The reversibility of the Project contribution to cumulative effects on marine transportation is considered to be long-term, since the effect on marine transportation and rail traffic will potentially occur for the operational life of the Project.

The magnitude is low to medium. Although the Project contribution to cumulative change in marine transportation use may be perceived only as a nuisance to some users (low), the activities of other commercial marine users may be interrupted as a result of interactions with Project-related marine vessel traffic which could have business implications (medium) (Table 4.4.9.2, point 2[a]).

The Project contribution to cumulative change in marine transportation use is considered to be likely, due to the navigational constraints present in Burrard Inlet, the requirement for raising the lift span of the CN Rail Bridge to allow vessel transits, the PMV Clear Narrows requirement for deep draft vessel transits and the location of other active marine terminals east of the Second Narrows which also experience regular vessel calls. Confidence in the significance evaluation is high, and is based on a good understanding of data from within the RSA. A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA to RSA – the Project contribution to cumulative effects on marine transportation use since the zone of influence of Project-related marine vessels could overlap with other future traffic and contribute to cumulative effects extending beyond the Marine LSA.
- **Duration** - long-term – the presence of Project-related marine vessels will extend for the operational life of the Project.
- **Frequency** - periodic – the Project contribution to the cumulative effect on marine transportation will occur whenever a Project-related tanker is in transit.
- **Reversibility** - long-term – the Project contribution to cumulative effects on marine transportation such as delays or disruptions are expected to extend throughout the operational life of the Project.
- **Magnitude** - low to medium - the Project contribution to cumulative effects on marine transportation activities may contribute to commercial vessels to be temporarily inconvenienced by the presence of Project-related marine vessels (low), but delays may have business implications for some commercial operators at select times (medium).
- **Probability** - high – the Project contribution to cumulative effects on marine transportation is considered to be likely.
- **Confidence** - high – there is a good understanding of general cause-effect relationships that result in the Project contribution to cumulative effects on marine transportation use.

4.4.9.3.3 Marine Commercial, Recreational and Tourism Use Indicator – Marine Recreational Use

Marine recreational use in the Marine RSA includes: kayaking; boating; fishing; and scuba diving. Many easily accessible areas within the Marine RSA are popular destinations for both residents and visitors, including Indian Arm and False Creek in the Lower Mainland and marine areas around Victoria on Vancouver Island. In the southern Strait of Georgia, fishers and boaters use the strait to access destinations in the Gulf Islands, Vancouver Island and other locations. Recreational fishing occurs all over the Marine RSA, in particular for salmon, halibut, rockfish and crab. Marinas and yacht clubs are located in communities throughout the Marine RSA. Most recreational activities including boating, kayaking and diving take place in accessible nearshore areas which are outside of the shipping lanes. Fishing may be the most likely recreational activity to occur in or near the shipping lanes, due to the overlap with key fishing grounds at several locations in the Marine RSA.

The Project contribution to the cumulative effects on marine recreational use is likely to affect recreational vessel traffic in Burrard Inlet, where concern has been noted at marinas east of the Second Narrows regarding the increased frequency of CN Rail Bridge openings and related “Clear Narrows” procedures that will be attributable to the Project. In other areas of the Marine RSA that are near the shipping lanes such as Juan de Fuca Strait south of Victoria, recreational users may experience sensory disturbance due to noise, odour or other irritants associated with passage of large marine vessels. A further potential residual effect that was considered to have a high probability of occurrence is negative user perspectives of the Project. This effect addresses feedback from stakeholders and other sources about the negative perspective on the increased presence of oil tankers in the Marine RSA. The effect is applicable to recreational users.

If approved, future developments such as those described in Section 4.4.1.4 and Project-related marine vessel traffic will add to the existing marine vessel traffic in the Marine RSA. Increased marine vessel traffic is likely to increase congestion in areas that are constrained geographically and already experience high marine traffic volumes. Increased marine vessel traffic in such areas may cause recreational users to avoid the area or delay travel, ultimately affecting the quality of the recreational experience.

The impact balance of the Project contribution to cumulative effects on the marine recreational use indicator is considered to be negative. The spatial boundary considered to range from the Marine LSA to the Marine RSA. Recreational vessels are only likely to be directly affected by Project-related marine vessels in the immediate vicinity of the shipping lanes (LSA); however, the negative perspective of the Project is not contingent on the proximity of Project-related marine vessel traffic. The duration is considered to be long-term, extending through the operational life of the Project. The frequency is considered to be periodic to continuous. The Project contribution to the cumulative effects on marine recreational users will occur intermittently, however, repeatedly over the life of the Project. The overall presence of Project-related marine vessels in the Marine RSA may be viewed as continuously affecting negative user perspectives.

The reversibility of the Project contribution to cumulative effects on marine recreational use is considered to be long-term, since the increased Project-related marine vessel traffic will occur for the operational life of the Project. The magnitude is low to medium. Although the effect of one daily tanker transit on a recreational user at a specific location in the shipping lanes is not considered to be significant in the context of the total daily marine vessel traffic (Table 4.4.9.2, point 3[a]), the Project contribution to cumulative effects on marine recreational use will be detectable by marine recreational users. In most cases the Project contribution to effects are likely to represent only an inconvenience to those affected (low), however, if marine recreational users alter preferred routes the magnitude may be considered to be medium.

The overall probability of the Project contribution to cumulative effects on marine recreational users is considered to be high. Sensory disturbance to recreational users is likely, and may contribute to some users avoiding areas near the shipping lanes. Confidence in the significance evaluation is high and is based on a good understanding of data from within the RSA.

A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA to RSA – the event causing the Project contribution to cumulative effects on marine recreational use (*i.e.,* presence of Project-related marine vessels) could occur at any point in the shipping lanes in the Marine LSA. Contributions to potential effects related to alteration of movement patterns could occur at any point in the Marine RSA and may also affect the distribution of vessels in areas of the Marine RSA.

- **Duration** - long-term – the event causing the the Project's contribution to cumulative effects on marine recreational use (*i.e.,* presence of Project-related marine vessels) will extend for the operational life of the Project.

- **Frequency** - periodic to continuous – the Project contribution to the cumulative effects on marine recreational users will occur intermittently, however, repeatedly over the life of the Project. The overall presence of Project-related marine vessels in the Marine RSA may be viewed as continuously contributing to negative user perspectives some marine users.

- **Reversibility** - long-term – the Project contribution to cumulative effects on marine recreational use is expected to extend throughout the operational life of the Project.
- **Magnitude** - low to medium – the Project contribution to cumulative effects on marine recreational use will be detectable by marine recreational users. In most cases the effects are likely to represent only an inconvenience to those affected (low), however, if marine recreational users alter their preferred routes or activities the magnitude may be considered to be medium.
- **Probability** - high – the Project contribution to cumulative effects on marine recreational use is likely.
- **Confidence** - high – there is a good understanding of general cause-effect relationships that result in the Project contribution to cumulative effects on marine recreational use.

4.4.9.3.4 Marine Commercial, Recreational and Tourism Use Indicator – Marine Tourism Use

Marine tourism uses of the Marine RSA are diverse, and include: cruise ships; yacht charters; fishing charter companies; and whale-watching. Cruise terminals in Vancouver and Victoria are points of call for the Alaska cruise industry. Cruise ships are required to use the shipping lanes and also must use the services of a marine pilot in BC coastal waters. Small vessels are also involved in marine tourism. Commercial sportfishing guides take clients fishing for salmon, halibut and other fish and invertebrates around the Vancouver area, the Gulf Islands and Juan de Fuca Strait. Whale-watching operators operate throughout the Strait of Georgia, and spend the most time around the southern Gulf Islands and the US San Juan Islands where killer whales are most likely to be present (Towers pers. comm.). Other tourism operations include day cruises in Burrard Inlet and other areas of the Marine RSA, and yacht charters. Passenger ferries are considered to be commercial marine operators in this assessment, but also can be considered as a marine tourism use.

The Project contribution to cumulative effects on the marine tourism use indicator is related to the increased sensory disturbance to marine tourism users as well as existing marine vessel movement patterns.

If approved, future developments such as those described in Section 4.4.1.4 and Project-related marine vessel traffic will add to the existing marine vessel traffic in the Marine RSA. Increased marine vessel traffic is likely to increase congestion in areas that are constrained geographically and already experience high marine traffic volumes. Increased marine vessel traffic in such areas may potentially cause some smaller tourism users to avoid these areas or alter their preferred routes due to sensory disturbance from transiting marine vessels. Mitigation measures for the potential residual effects of increased Project-related marine vessel traffic on marine recreational use are proposed in Table 4.3.11.3 in Section 4.3.

The impact balance of the Project contribution to cumulative effects to marine tourism users is considered to be negative. The spatial boundary is the Marine LSA to RSA, since the zone of influence of Project-related marine vessels could overlap with other future traffic and extend beyond the Marine LSA. Marine tourism vessels are only likely to be directly affected by Project-related marine vessels in the area of the shipping lanes. The duration is considered to be long-term, extending through the operational life of the Project. The frequency is considered to be periodic. Project-related marine vessel traffic is likely to affect marine tourism users intermittently and repeatedly over the operational life of the Project.

The reversibility of the Project contribution to cumulative effects on marine tourism use is long-term, because the Project-specific effects will occur for the operational life of the Project. The magnitude is low to medium. The Project may contribute to commercial tourism operators being temporarily inconvenienced by the presence of Project-related marine vessels (low), but contributions to vessel delays or required alternation of marine routes may have business implications for some commercial tour operators at select times (medium).

The overall probability of the Project contribution to cumulative effects on marine tourism use is considered to be high. Generally, the potential for a Project contribution to cumulative effects on marine tourism users is considered likely to occur and thus of high probability. Confidence in the significance evaluation is high, and is based on a good understanding of data from within the RSA (Table 4.4.4.2, point 4[a]). A summary of the rationale for all of the significance criteria is provided below.

- **Spatial Boundary** - Marine LSA to RSA – Project contribution to sensory disturbance (*e.g.*, visual effects, noise, and air quality) from increased large marine vessel traffic could occur at any point in the shipping lanes in the Marine LSA. Contribution to potential effects related to alteration of movement patterns could occur at any point in the Marine RSA and may also affect the distribution of vessels in areas of the Marine RSA.
- **Duration** - long-term – the event causing the Project contribution to cumulative effects on in marine tourism use (*i.e.*, presence of *Proj*ect-related marine vessels) will extend for the operational life of the Project.
- **Frequency** - periodic – Project-related marine vessels will be transiting through the Marine RSA intermittently but repeatedly over the operational life of the Project.
- **Reversibility** - long-term – the Project contribution to cumulative effects on marine tourism use is expected to extend throughout the operational life of the Project.
- **Magnitude** - low to medium - the Project contribution to cumulative effects on marine tourism activities may cause commercial tourism operators to be temporarily inconvenienced by the presence of Project-related marine vessels (low), but delays or required alteration of marine routes may have business implications for some commercial tourism operators at select times (medium).
- **Probability** - high – a Project contribution to cumulative effects on marine tourism use is likely.
- **Confidence** - high – there is a good understanding of general cause-effect relationships that result in the Project contribution to cumulative effects on marine tourism use.

4.4.9.3.5 Combined Cumulative Effects on Marine Commercial, Recreational and Tourism Use

The potential effects of the Project (*i.e.*, combined Project effects on marine transportation, marine recreation use and marine tourism use) are anticipated to act in combination with other existing marine vessels and projected future increases in vessel traffic to affect MCRTU in the Marine RSA. The impact balance of the Project's contribution to the combined cumulative effects is considered negative, though the implementation of mitigation measures described in Table 4.3.11.2 in Section 4.3 will reduce the severity of cumulative effects associated specifically with the Project and other reasonably foreseeable developments. The overall contribution of the Project to the cumulative effects on MCRTU is of low to medium magnitude, reversible in the long-term and high probability (Table 4.4.9.2, point 4[a]). A summary of the rationale for all the significance criteria is provided below.

- **Spatial Boundary** - Marine RSA - the Project's contribution to cumulative effects is assessed within the regional context of the Marine RSA.
- **Duration** - long-term – the presence of Project-related marine vessels will extend through the operational life of the Project.
- **Frequency** - periodic – Project-related marine vessels will be transiting through the Marine RSA intermittently, but repeatedly over the operational life of the Project.
- **Reversibility** - long-term – the Project contribution to cumulative change in all MCRTU indicators is expected to extend throughout the operational life of the Project.
- **Magnitude** - low to medium – the Project contribution to cumulative effects on MCTRU indicators due to increased Project-related marine vessel traffic is detectable but in most cases does not contribute more than that of an inconvenience or nuisance (low); however, contribution to cumulative effects resulting in delays or alteration of marine routes may have business implications for some commercial operators at select times (medium).
- **Probability** - high – the Project contribution to cumulative effects on MCRTU indicators is likely.
- **Confidence** - high – there is a good understanding of general cause-effect relationships that result in the Project contribution to cumulative effects in MCRTU indicators.

4.4.9.4 Potential United States Effects

The potential cumulative effects evaluated in this assessment are considered to apply equally in Canadian and US waters, primarily due to the location of the shipping lanes being along the international boundary throughout much of the Marine RSA.

4.4.9.5 Summary

As identified in Table 4.4.11.3, there are no situations where the Project's contribution to cumulative socio-economic effects will be significant. Consequently, the Project's contribution to adverse cumulative effects on MCRTU within the Marine RSA will be not significant.

4.4.10 Human Health Risk Assessment

This subsection outlines the nature of potential health risks to people within the screening level HHRA LSA associated with short-term and long-term exposures to the chemical emissions from the increased Project-related marine vessel traffic in combination with chemical exposures associated with existing activities as well as all other reasonably foreseeable developments within the Marine Air Quality RSA (referred to as the "combined chemical exposures" for the purposes of this subsection). The HHRA evaluated the potential health risks to people associated with more than 100 chemicals, including CACs, metals, PAHs, petroleum hydrocarbons (PHCs), sulphur-containing chemicals and VOCs. The HHRA was completed using a series of conservative assumptions reflecting 'worst-case' circumstances, which collectively contributed to an exposure event being strictly hypothetical in nature, with a low probability of occurrence. In particular, the HHRA assumed that people would be found on both a short-term and long-term basis at the location within the HHRA LSA corresponding to the MPOI. The MPOI refers to the location at which the highest ground-level air concentrations of each of the COPC would be expected to occur, and at which the exposures received by the people within the HHRA LSA would be greatest. The choice of the MPOI location was meant to ensure that any potential impacts that could result from exposure to the chemical emissions associated with the Project on the health of the people, regardless of where they might be found, would not be underestimated. The decision to use the MPOI to represent the location at which people would be found was made by default; that is, consideration was not given as to whether or not the MPOI location was suitable for a permanent residence and/or for residents to obtain their entire complement of locally grown or harvested foodstuffs, including garden vegetables, beef, chicken, dairy, eggs, game meat, fish, beach-foods and wild plants, from the local area.

4.4.10.1 Reasonably Foreseeable Developments

Table 4.4.1.2 summarizes the current level of marine traffic within the Marine RSA as well as the anticipated marine traffic attributed to the Project and other reasonably foreseeable marine traffic. A description of existing and anticipated activities is provided in Section 4.4.1.4.

4.4.10.2 Potential Cumulative Effects

Consistent with the Project effects assessment (Section 4.3.12), the assessment indicators for the cumulative effects assessment are people within the HHRA LSA whose health might be adversely impacted as a result of the combined chemical exposures. The assessment indicators included both permanent residents living within the HHRA LSA, as well as area users who might frequent the area for recreation or other purposes. The permanent residents were separated into Aboriginal peoples and non-Aboriginal peoples, with the latter residents further separated into urban and non-urban dwellers. Additional details are available in Section 4.3.12.1.

The results of the HHRA revealed that, despite the conservative assumptions employed, with very few exceptions, the maximum predicted levels of exposure to the COPC (acting either singly or in combination) remained below the levels of exposure that would be expected to cause health effects. In the majority of cases, the exposure levels were well below those associated with health effects. The exceedances revealed by the HHRA were very few in number and in virtually all cases were modest in magnitude. The high degree of conservatism incorporated into both the exposure estimates and the exposure limits used for comparison as part of the HHRA must be considered in the interpretation of the exceedances. Based on the weight of evidence, it is unlikely that people would experience health effects from exposure to the potential increase in marine vessel traffic under the cumulative effects assessment. A detailed quantitative HHRA will be completed to expand on the findings and conclusions of the screening level HHRA; the report discussing the detailed HHRA will be submitted to the NEB in early 2014.

4.4.11 Summary of the Assessment of Potential Cumulative Effects

The cumulative environmental and socio-economic effects associated with the Project are similar to those routinely encountered during existing marine transportation operations associated with the Project.

The potential cumulative environmental and socio-economic effects associated with the Project were identified through: engagement with Aboriginal communities, government agencies, other stakeholders and the general public; a review of existing literature; and the professional judgment of the assessment team. These potential cumulative effects were related to environmental and socio-economic elements including:

- physical elements such as marine air emissions and marine acoustic environment;
- biological elements such as marine fish and fish habitat, marine mammals, marine birds, and marine species at risk; and
- socio-economic elements such as traditional marine resource use, marine commercial, recreational and tourism use, and human health.

As per the NEB Filing Manual (2013c), a cumulative effects assessment of GHG emissions is not required for the Project. No likely residual effects were identified in association with the Project for marine sediment or water quality and, consequently, a cumulative effects assessment was not warranted for this element.

Accidental events, such as the venting of an over-pressurized tanker, were considered to have a low probability of occurrence and, therefore, they were not assessed for cumulative effects.

For the purposes of the marine transportation assessment, since Trans Mountain does not have any direct control over the actions of vessel owners and operators, mitigation is considered to include existing legislation and shipping standards that are monitored by federal and international authorities (*e.g.*, PMV, PPA, CCG, Transport Canada, USCG and IMO).

Through the implementation of the mitigation measures, the residual cumulative effects associated with the increase in marine transportation on the environmental and socio-economic elements were considered to be not significant in all cases except one. Given that past and current activities are considered to have caused significant adverse effects on the southern resident killer whale population, the Project's contribution to cumulative effects associated with the increased Project-related marine vessel traffic on this species is considered to be significant.

4.5 Supplemental Studies

4.5.1 Introduction

A comprehensive assessment of potential environmental and socio-economic effects was conducted in 2012 and 2013 to complete the following objectives for normal operations of the marine transportation in accordance with the NEB's direction from their *List of Issues* (July 29, 2013) (NEB 2013a).

- Characterise the environmental and human use setting for the proposed increase in Project-related marine vessel traffic, including the following elements:
  - marine sediment and water quality;
  - marine fish and fish habitat;
  - marine birds;
  - marine species at risk;
  - traditional marine resource use;
  - MCRTU; and
  - human health risk assessment.
- Identify sensitive or unique features through consultation.
- Identify environmental mitigation measures (including existing marine transportation industry regulations and standards) to avoid or reduce potential effects.
- Assess the potential environmental and socio-economic effects (including the Project's contribution to cumulative effects) that might be caused by or otherwise affect the Project.

The environmental and socio-economic program was designed to support the highest standards of environmental and socio-economic assessment in recognition of the large scale and many environments the Project is located in.

Due to the timelines involved in collecting knowledge through consultation and facilitating studies such as TMRU studies, an update to the information is proposed to refine and augment site-specific environmental and socio-economic information gathering. A description of these updates and other detailed plans that are proposed are provided in Sections 4.5.2 and 4.5.3.

The objective of the updates is to confirm our current predictions based on desktop review, literature reviews, professional judgment and 60 years of operation of tankers associated with the Westridge Marine Terminal.

For clarity, no supplemental studies relating to the following elements are anticipated:

- marine sediment and water quality;
- marine air emissions;
- marine GHG emissions;
- marine acoustic environment;
- marine fish and fish habitat;
- marine mammals;

- marine birds;
- marine species at risk; and
- MCRTU.

As consultation and engagement continues, the information will be reviewed for any potential changes to the settings, effects assessments and significance conclusions. A supplemental filing based on the updated consultation and engagement activities may be submitted, if deemed warranted.

4.5.2 Traditional Marine Resource Use

TMRU studies for increased Project-related marine vessel traffic were initiated in 2013 for the Project and are ongoing. The initiation of community directed TMRU studies (using third-party consultants) was discussed with Aboriginal communities based on an indicated interest in participating in these studies, their proximity to the Project or their assertion of traditional and cultural rights of the land and waters. Trans Mountain continues to provide funding to assist Aboriginal communities that elected to conduct their own community-directed TMRU studies.

TMRU studies are intended to describe the current use of land and water by Aboriginal communities for traditional purposes and the spatial and temporal extent of use (*i.e.*, frequency, duration and seasonal aspects) potentially affected by the Project, in addition to identification of issues and concerns relating to traditional marine resource use. The methodology for ongoing TMRU studies as well as the qualifications of the personnel designing and conducting the studies is described in the Traditional Marine Resource Use – Marine Transportation Technical Report (Volume 8B, TR 8B-5).

On August 29, 2013, Esquimalt Nation elected to conduct a TERA-facilitated TMRU study. The TMRU study included a map review and community interviews that focused on the Crown lands and waters within the asserted traditional territory of Esquimalt Nation crossed by the Marine RSA. The results of Esquimalt Nation TMRU study completed to date for the Project are provided in the Traditional Marine Resource Use – Marine Transportation Technical Report (Volume 8B, TR 8B-5). Each phase of the TERA-facilitated TMRU study is described in further detail in the following subsections. TERA has implemented proper record keeping practices for information obtained during the TMRU study to ensure that study results are accessible for future reference and confidential information is protected.

Trans Mountain provided funding to assist Aboriginal communities that elected to conduct their own independent, community-led TMRU studies (*i.e.*, third-party). These communities often engaged other consultants to provide technical support and assistance with their TMRU studies for the Project. The following communities have elected to conduct independent, community-led TMRU studies:

- Cowichan Tribes;
- Halalt First Nation;
- Hwlitsum First Nation;
- Lyackson First Nation;
- Pacheedaht First Nation;

- Penelakut First Nation;
- Semiahmoo First Nation; and
- Stz'uminus First Nation.

To date, preliminary interests specific to the ESA have been identified to Trans Mountain by by Esquimalt Nation, Semiahmoo First Nation and by Cowichan Nation Alliance on behalf of Penelakut First Nation, Halalt First Nation, Hwlitsum First Nation, Stz'uminus First Nation and Cowichan Tribes. These interests and the progress of each participating community's TMRU study at the time of application filing is described in detail in the Traditional Marine Resource Use - Marine Transportation Technical Report (Volume 8B, TR 8B-5).. Additional TMRU study work with participating Aboriginal communities is scheduled for completion prior to construction of the Project. Information gathered during ongoing TMRU studies will be considered for incorporation into Project planning under the guidance of existing marine transport regulations and mitigation recommendations made to date. The results of these ongoing engagement efforts will be provided to the NEB.

Katzie First Nation, Kwikwetlem First Nation, Musqueam Indian Band, Malahat First Nation, Pauquachin First Nation, Scia'new Indian Band, Squamish Nation, Tsartlip First Nation, Tsawout First Nation, Tsawwassen First Nation, Tseycum First Nation and Tsleil Waututh Nation have also identified a potential interest in the Project. To date, Trans Mountain has shared Project information and invited each of these communities to participate in the development of a TMRU study and identification of interests. Trans Mountain will continue to support the participation of Katzie First Nation, Kwikwetlem First Nation, Musqueam Indian Band, Squamish Nation and Tsleil-Waututh Nation in Project activities and interest in a TMRU study will be determined by each individual community.

A detailed summary of Trans Mountain's engagement activities with each potentially affected Aboriginal community is provided in Volume 3B and Appendix A of Volume 3B.

4.5.3 Update to the Environmental and Socio Economic Assessment

An update to Section 4.0 will be provided to the NEB in Q2 2014. The update will contain the following information.

- An update to consultation and engagement conducted pertaining to Section 4.0, since the cut-off for consultation and engagement information for submission of the application.
- An update to the environmental and socio-economic setting (Section 4.2), effects assessment, including any new mitigation (Section 4.3) and cumulative effects assessment (Section 4.4) based on additional TMRU study information collected as well as consultation and engagement conducted as necessary.

After initiation of the marine air and GHG emissions, marine acoustic environment and marine mammals modelling, and as a result of the quantitative risk assessment, Trans Mountain decided to consider the use of additional tug escort as a navigational safety measure to reduce the risk of an accidental spill from a laden Project-related tanker. Tug escort would be added for the entire route between the Westridge Marine Terminal and Buoy J, as identified in Figure 5.4.2 and discussed in more detail in Section 5.4.2.1. Marine air and GHG emissions, marine acoustic environment and marine mammals modelling numbers will be updated based on extended escort tug usage. Modeling results will be provided to the NEB in a supplemental filing in Q2 2014. Based on the professional judgment of the assessment team, the addition of the escort tug is not likely to change any of the significance conclusions presented for marine air and GHG emissions, marine acoustic environment and marine mammals.

Development of HHRA for marine transportation proceeded step-wise, beginning with the screening (preliminary) level HHRA that was completed for the filing of the application. The second step of the process will be the completion and submission of the comprehensive HHRA to the NEB in early 2014.

The screening level HHRA and the comprehensive HHRA represent either end of the scale of complexity in human health risk assessment. The screening level HHRA due, in part, to its more simplistic nature is associated with a higher level of uncertainty than its comprehensive counterpart. However, this uncertainty is accommodated through the use of assumptions based on existing literature and scientific data as well as the professional judgment and experience of the assessment team. Using this approach, any health risks identified by the screening level HHRA are unlikely to be understated, but may be considerably overstated. The increased detail and complexity of the comprehensive HHRA will serve reduce the uncertainty associated with the screening level HHRA.

4.6 Conclusion

This marine transportation component of the ESA was completed in support of the proposed TMEP. The pipeline and facilities component of the ESA is found in Volumes 5A and 5B.

Application is being made by Trans Mountain, a Canadian corporation with its head office located in Calgary, Alberta, pursuant to Section 52 of the *NEB Act* for the TMEP.

As a result of the Project, marine traffic volume calling at the Westridge Marine Terminal will increase. The expanded system will be capable of serving 34 Aframax class vessels per month, with actual demand driven by market conditions. The maximum size of vessels (Aframax class) served at the terminal will not change as part of the Project. In addition, the vessels calling at the Westridge Marine Terminal (after the Project is in operation) will continue to use the existing marine shipping lanes.

The Project will require a NEB CPCN pursuant to Section 52 of the *NEB Act*. In addition, according to the *Regulations Designating Physical Activities,* the Project is a designated project under the *CEA Act, 2012*. The ESA considers the mandatory factors listed in Section 19(1) of the *CEA Act, 2012*, the factors listed in the NEB Filing Manual (NEB 2013c), and pertinent issues and concerns identified through consultation and engagement with Aboriginal communities, landowners, regulatory authorities, stakeholders and the general public. The ESA also considers the NEB's Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Increased Marine Shipping Activities, Trans Mountain Expansion Project (September 10, 2013) (NEB 2013b), effectively determining the scope of the ESA and the factors to be assessed.

In addition, the ESA addresses the NEB's *List of Issues* (July 29, 2013) for the Project (NEB 2013a) provided below. Issue 5 of this list specifically informed the marine transportation ESA.

- "The need for the proposed project;

- the economic feasibility of the proposed project;
- the potential commercial impacts of the proposed project;
- the potential environmental and socio-economic effects of the proposed project, including any cumulative environmental effects that are likely to result from the project, including those required to be considered by the NEB's Filing Manual;
- the potential environmental and socio-economic effects of marine shipping activities that would result from the proposed project, including the potential effects of accidents or malfunctions that may occur (addressed in Volume 8A);
- the appropriateness of the general route and land requirements for the proposed project;
- the suitability of the design of the proposed project;
- the terms and conditions to be included in any approval the Board may issue;
- potential impacts of the project on Aboriginal interests;
- potential impacts of the project on landowners and land use;
- contingency planning for spills, accidents or malfunctions, during construction and operation of the project;
- safety and security during construction of the proposed project and operation of the project, including emergency response planning and third-party damage prevention; and
- the NEB does not intend to consider the environmental and socio-economic effects associated with upstream activities, the development of oil sands, or the downstream use of the oil transported by the pipeline."

The scope and methodology of the ESA is more fully described in Section 4.1. In summary, the ESA includes a description of the following:

- the environmental and socio-economic baseline setting;
- the predicted adverse effects of the proposed Project on the biophysical and socio-economic environment over the life of the Project;
- the methods used for effects analysis, and the rationale for selecting the methods chosen;
- the relevant industry standards and any proposed mitigation measures; and
- the predicted significance of residual Project effects and residual cumulative effects.

Table 4.6.1 provides the companies that assisted with the preparation of Section 4.0.

TABLE 4.6.1

PROJECT TEAM

Application Component	Team
Overview of Marine Transportation and Shipping Activities	Trans Mountain
Air Emissions and Greenhouse Gas Emissions Assessment Noise Impact Assessment	Rowan Williams Davies and Irwin Inc. (RWDI)
Marine Resources Assessment (Marine Fish and Marine Mammals) Marine Bird Assessment Marine Sediment and Water Quality Assessment Species At Risk Assessment Accidents and Malfunctions Assessment	Stantec Consulting Ltd. (Stantec)
Traditional Marine Resource Use Assessment	TERA
Human Health Risk Assessment for Normal Operations	Intrinsik
Marine Commercial, Recreational and Tourism Use Assessment	Vista Strategy TERA

Environmental and socio-economic elements potentially interacting with the increased Project-related marine vessel traffic include marine sediment and water quality, marine air emissions, marine GHG emissions, marine acoustic environment, marine fish and fish habitat, marine mammals, marine birds, marine species at risk, traditional marine resource use, marine commercial, recreational, and tourism use, and human health risk assessment. The description of the environmental and socio-economic setting of the marine transportation component of the Project (current state of the biophysical and socio-economic environment) in the vicinity of the marine shipping lanes was compared against the Project description to assess potential environmental and socio-economic effects of increased Project-related marine vessel traffic. For this assessment, one or more indicators were selected and used to describe the present and predicted future condition of an element. One or more measurement endpoints (measurable parameters) were identified for each indicator to allow quantitative or qualitative measurement of potential Project effects.

Most of the environmental and socio-economic issues have been identified through engagement with Aboriginal communities, regulatory authorities, stakeholders and the general public, as well as through literature reviews and the professional experience of the assessment team. Most of the associated potential effects on environmental and socio-economic indicators arising from the Project can be readily mitigated by industry standards and federal legislation for marine vessel traffic in Juan de Fuca Strait, Haro Strait, Georgia Strait, and Burrard Inlet.

Most of the potential environmental and socio-economic residual effects that could arise from increased Project-related marine vessel traffic are considered to be long-term in duration (*i.e.*, lasting for the operational life of the Project), generally of low to medium magnitude and periodic or accidental in nature. There are no situations that would result in a significant environmental or socio-economic effect, as defined in Section 4.3, except the following:

- the potential effect of sensory disturbance of southern resident killer whales, which is determined to be high magnitude, high probability and significant but immediately reversible; and
- the potential effects of the Project on TMRU as it relates to southern resident killer whales.

The Project may act cumulatively with existing activities and reasonably foreseeable developments in the vicinity of the marine shipping lanes including other current or likely marine vessel traffic in the element-specific RSA (*i.e.*, Marine RSA or Marine Air Emissions RSA). Cumulative effects associated with the Project were evaluated conservatively using assumptions relevant to the element under consideration. Most of the cumulative effects within the element-specific RSAs are anticipated to be long-term in duration and generally of low to medium magnitude. There are no situations that would result in a significant cumulative environmental or socio-economic effect, as defined in Section 4.4, except the following:

- the potential Project contribution to the cumulative effect of sensory disturbance of southern resident killer whales, which is determined to be high magnitude, high probability and significant but immediately reversible; and
- the potential Project contribution to cumulative effects on TMRU as it relates to southern resident killer whales.

Industry and regulatory standards anticipate and address many of the Project's potential effects on the biophysical and socio-economic environment. Though Trans Mountain has little direct control over the actions of the vessel owners and operators, mitigation measures have been developed to further reduce the severity of some potential environmental and socio-economic residual effects (*e.g.*, Trans Mountain would be interested in acting as an active participant in a joint industry-government advisory group that would be charged with determining and/or developing effective mitigation measures to reduce potential effects of underwater noise on marine mammals in the region). The implementation of the proposed mitigation measures and adherence by vessel owners and operators to marine shipping regulations will reduce the severity of the adverse residual environmental and socio-economic effects associated with increased Project-related marine vessel traffic.

5.0 RISK ASSESSMENT AND SPILL MANAGEMENT

5.1 Purpose and Background

A spill of oil into the marine environment, arising from an incident involving a Project-related tanker, is a key concern for Trans Mountain, Aboriginal communities, government agencies, the public, and the maritime community. Trans Mountain recognizes that an unmitigated oil spill from a tanker could have immediate to long-term effects on the biophysical and human environment of the West Coast of BC.

Given the existing measures in place to prevent shipping and tanker accidents and tanker-related oil spills, Trans Mountain expects that a Project-related spill from a tanker will continue to be an unlikely event. Regardless, Trans Mountain is committed to continuing to work with Aboriginal communities, the public, pipeline shippers, parties in the maritime community, regulatory authorities and others to ensure that spill prevention, emergency preparedness and response measures are reviewed in a systematic and risk-based manner as part of continual improvement and as a commitment to tanker and shipping safety in this region. Such risk-based measures have been evaluated and improvements have been identified with respect to the Project-related increase in marine transportation, which will ensure that any increase in risk as a result of the Project is mitigated to the extent possible and comparable with the current level of risk of a tanker-related oil spill in this region.

Although Trans Mountain is not directly responsible for the operation of tankers and barges calling at the Westridge Marine Terminal, it is an active member in the maritime community and works with maritime agencies to promote best practices and facilitate improvements focusing on the safety, efficiency, and environmental standards of tanker traffic in the Salish Sea. Trans Mountain is a shareholder of WCMRC and works closely with WCMRC and other members to ensure that WCMRC remains capable of responding to any hydrocarbon spills from vessels transferring product or transporting it within their area of jurisdiction.

The purpose of Section 5.0 is to provide an overview of the probability and consequences of an oil spill from a tanker on the biophysical and human environments, and is organized in the following way:

Section 5.2 provides a summary of the quantitative risk assessment conducted by Det Norske Veritas (DNV) (TERMPOL 3.15, Volume 8C, TR 8C-12). The risk assessment considered regional traffic growth, navigational hazards, vessel construction, and risk controls provided under the existing safety regime. Based on an assessment of the tanker transit route the report identified potential locations for accidents. The report quantified the probability of oil spill incidents and the potential consequence of these incidents in terms of spill volume. These probabilities and consequences were combined to define credible worst case and mean case risks based on spill volume.

Section 5.3 is also a summary of the DNV quantitative risk assessment but focuses on spill prevention measures. This section provides a summary of the risk controls that are currently in place and included in the risk assessment. DNV found that existing risk controls are considered to be state of the art compared to other coastal sailing routes worldwide and in line with global best practices. However, to mitigate the effect of increased tanker traffic a number of enhancements are recommended which, if implemented, will raise the level of care and safety in the Salish Sea to well above globally accepted shipping standards. The primary recommendations include extending tug escorts for laden tankers throughout Strait of Georgia and Juan de Fuca Strait and implementing a moving exclusion zone around laden tankers.

Section 5.4 provides a summary of technical reports that describe the fate and behavior of oil spilled in the marine environment. This section includes a discussion of oil properties in general as well as the results of weathering tests conducted for Trans Mountain on diluted bitumen. Results from these tests along with spill volumes and potential locations identified in the DNV risk assessment were used to conduct stochastic modelling for selected locations. Stochastic modelling generates a probability map for oil exposure for the study area. A different map is generated for each combination of spill volume, location, and season. The stochastic modelling was implemented by executing the spill model, for the specific release, every six hours over a full calendar year, to capture the effects of tides, winds, estuarine flow and forcing from the open Pacific. The resulting probability maps do not provide information on a specific spill, but indicate the area that is at risk. An actual spill would only affect a small part of this area, but all parts are at risk. Section 5.4 concludes with a discussion of the results of testing conducted for Trans Mountain on recovery techniques for diluted bitumen.

Section 5.5 provides a summary of oil spill response capacity in the Salish Sea. Trans Mountain engaged WCMRC to review the risk assessment and fate and behavior studies and to describe enhancements to the existing planning standards that would better accommodate the tanker traffic resulting from the Project. The WCRMC study includes an equipment plan that serves as a practical example of how response capacity could be enhanced.

Section 5.6 discusses potential environmental and socio-economic effects of credible worst case and smaller oil spills described in Section 5.4

Section 5.7 provides an assessment of the spill response enhancements presented in Section 5.5. In this case the results for a single spill event at Arachne Reef in the Turn Point Special Operating Area are compared with and without spill response mitigation to assess the effectiveness of the enhanced response capacity described in Section 5.5.

Pursuant to the CEA Act, 2012 s. 19 (1) (a), the NEB's List of Issues for the Project, and the NEB's Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Increase Marine Shipping Activities, Trans Mountain Project (10 September 2013), Trans Mountain is required to consider the environmental effects of potential malfunctions and accidents that might occur related to the Project. Section 4.0 provided an assessment of higher probability and lower consequence potential accidents and malfunctions, excluding the credible worst case and smaller oil spills. Section 5.0 provides an assessment of a lower probability, high consequence incidents resulting in the unplanned release of oil from several locations along the shipping route. Assessments of credible worst case and smaller spill scenarios at the Westridge Marine Terminal are provided in Volume 7, Section 8.0. Together, these sections meet the NEB and CEA Act, 2012 requirements for the consideration of accidents and malfunctions.

5.2 Probability of an Oil Spill from a Tanker in a Marine Environment

The existing Westridge Marine Terminal typically loads five tankers and two or three barges per month. With approval of the Project only the number of tankers is expected to increase with the typical number of tanker loadings increasing up to 34 Aframax tankers per month (Table 2.2.1). An increase in barge traffic as a result of the Project is not expected. As a result of the increase in tanker traffic, the probability of an oil spill will increase. The following sub-sections describe the historical information about oil spills from tankers into the marine environment and discuss the incremental risk of a spill from an oil tanker once the Project is operating.

5.2.1 Historical Casualty Data

As part of the TERMPOL process, Trans Mountain contracted DNV to complete a survey of the available historical casualty data related to marine vessel incidents worldwide and oil spills resulting from those incidents. The complete study is provided in Volume 8C (TERMPOL 3.8, TR 8C-6) and a summary of the results of the study is provided in this section.

5.2.1.1 Background

Det Norske Veritas used data on the following types of incidents related to marine transportation in the casualty data survey:

- collisions and grounding, referred to as wrecking/stranding in the survey;
- fire/explosion; and
- foundering and contact (*i.e.*, an equipment or electrical malfunction resulting in a loss of power).

Det Norske Veritas used multiple sources of data including:

- IHS Fairplay database of worldwide casualty data;
- oil spills recorded by the International Tanker Owners Pollution Federation Limited;
- incidents in Canadian waters collected and published by the Transportation Safety Board of Canada and the CCG;
- incidents on the West Coast of Canada reported in the PPA incident database; and
- incidents in US waters published by the US Department of Homeland Security.

The results of the casualty study provide estimates of incident frequencies per year, where the information is available; however, the casualty data provided does not describe other relevant factors such as weather, local navigational conditions, and other vessel traffic.

5.2.1.2 Global Trend in Maritime Shipping Safety

Det Norske Veritas notes that the global safety record in the marine industry has improved continuously over the past 40 years due to regulatory changes and improved safety procedures taken from the lessons learned from past incidents. In addition, the shift from single-hulled to double-hulled tanker design since 1990 has significantly reduced the number of oil spills from tankers.

Det Norske Veritas reviewed recent studies on the effect of double-hulled tankers compared to single-hulled tankers and concluded that a double-hulled tanker design plays an important role in reducing the number of oil spills that could result from a tanker incident such as a collision or grounding. However, if the double hull of the tanker were fully breached, one of the studies referenced by DNV concluded that the incident would result in the same spill volume from a double-hulled *vs.* a single-hulled tanker given the same cargo tank volume and the same oil type. The benefit of the double-hulled tanker design appears to be the decrease in incidents resulting in a full breach of a double-hulled tanker.

DNV illustrates the positive outcome resulting from a double hull *vs.* single hull design by comparing the groundings of the Exxon Valdez in 1989 and the HS Elektra in 2009. The single hull Exxon Valdez spilled 37,000 tonnes of oil in the Prince William Sound, Alaska, as a result of a hard grounding on Bligh Reef. In comparison, when the double-hulled HS Elektra hit an uncharted rock close to the Chilean Coast in 2009, the collision did not result in any release of cargo oil.

While improved navigational management and safety procedures have resulted in fewer collisions and groundings of marine vessels, and in particular for oil tankers, the double hull design of oil tankers has resulted in fewer releases of oil when a collision or grounding occurs.

5.2.1.3 Global Oil Tanker Incidents and Oil Spills

DNV indicates that the global safety record for oil tankers has improved in step with the global safety record for the maritime industry. Based on the available data, DNV shows that the worldwide incident frequency involving oil tankers is among the lowest of all marine vessels for the period 2002 to 2011 and that only a fraction of the incidents reported for oil tankers resulted in the release of oil. As well, DNV shows that, despite the steady increase in the volume of oil being transported globally, the number of oil spills has decreased in the period 1970 to 2012.

DNV cautions that the global incident data for oil tankers is not directly comparable to the Salish Sea region because the global data does not take into consideration local weather conditions, the navigability of the sailing route, as well as local risk controls implemented that would reduce the likelihood for an incident. However, the global incident data for oil tankers between 2002 to 2011 supports the conclusion that the global safety record for the marine industry continues to improve, in particular for oil tankers. DNV indicated that the change from a single hull to double hull design of tankers, the segregation of oil cargo tanks, improved reliability of machinery, improved navigational aids, and improved risk management are all factors contributing to the reduction of oil spill incidents worldwide.

5.2.1.4 Shipping Incidents in Canadian Waters

Det Norske Veritas collected data from the Transportation Safety Board on shipping incidents in Canadian waters, including the East (Maritimes and Newfoundland regions), Central (Laurentian and Central regions), West, and Arctic Regions. The most recent incident data from the Transportation Safety Board was for the period 2002 to 2011.

Det Norske Veritas indicated that shipping incidents reported in Canadian waters totalled 285 in 2011, which was a 5 per cent decline from 2010 and a 22 per cent reduction compared to the 2006 to 2010 average of 364 incidents. Overall there has been a downward trend in the number of shipping incidents in Canadian waters since 2002, in keeping with the international trend of improved maritime safety.

The vessel type involved in incidents in Canadian waters most frequently reported is fishing vessels. DNV noted since 2002, 45 per cent of vessels involved in shipping incidents in Canadian waters were fishing vessels. With respect to oil tankers, in 2011, DNV notes there were 11 tankers involved in incidents in Canadian waters, the lowest number of all vessel types. No records could be found of any of these incidents resulting in an oil spill.

5.2.1.5 Shipping Incidents and Oil Spills on the West Coast of Canada

Of the 285 shipping incidents in Canadian waters in 2011, DNV reported that 31 per cent of these occurred on the West Coast (89), which was the highest concentration of incidents reported compared to other regions in Canada, likely due to the size of the region and number of vessels. In keeping with global trends, all regions in Canada reported a drop in the number of incidents in 2011, compared to the 2002 to 2010 average. With respect to the West Coast, there were 89 incidents in 2011 and an average of 119 incidents from 2002 to 2010. Of particular note, DNV indicated that the majority of incidents on the West Coast involved fishing vessels, tugs, and barges, not oil tankers.

During the 2002 to 2011 period, there was one incident on the West Coast involving an oil tanker and DNV indicates that this incident did not lead to damage of the tanker's hull or a release of oil to the marine environment.

Det Norske Veritas notes that there is no traffic density data correlated to the Transportation Safety Board data, therefore it is impossible to derive incident frequencies. However, the data published by the Transportation Safety Board gives an indication of the low number of vessel incidents on the West Coast, particularly for oil tankers.

The PPA collects incident data for the types of vessels for which they license pilots, which includes the types of oil tankers calling at the Westridge Marine Terminal. From 1993 to 2012, the PPA data reports 6 incidents with tankers, with an average of 0.3 incidents per year within the region that is the PPA's jurisdiction. DNV emphasized that the type of incidents reported by the PPA varied in severity from minor incidents, such as breaking a fender, to more serious incidents, such as collision or grounding. DNV noted that the PPA's data does not report the environmental consequence of any incidentsand therefore the portion of the reported incidents that might have resulted in an oil spill is unknown.

Det Norske Veritas noted that the majority of the incidents reported to the PPA database for all vessels including oil tankers were the result of contact damage (*i.e.,* contact with the dock while berthing). DNV noted that, on average for the period 1993 to 2012, over 60 per cent of incidents reported involved contact damage and other dock-related incidents.

With respect to oil spills on the West Coast, DNV accessed the most recent and available CCG statistics, which were for the period 2001 to 2009. DNV notes there is no updated data available for 2010 to 2012. Of particular interest, DNV noted that during the 2001 to 2009 period there were no oil spill accidents from tankers on the West Coast.

5.2.1.6 Shipping Incidents in the US Salish Sea

Det Norske Veritas accessed casualty data on incidents in US waters within North America from the Department of Homeland Security's Homeport database. DNV notes that the data is reliable for the period 2006 to 2010; some data before 2006 appears to be missing so the data is questionable, while some incidents reported after 2010 are still under investigation.

Det Norske Veritas notes that the 2006 to 2010 data from the US suggests an increase in the number of all types of vessel incidents on the US West Coast, likely due to the increase in traffic volume.

With respect to tankers in the US waters of the Salish Sea region, DNV noted that the annual number of incidents ranged from eight in 2006 to three in 2007/2008. Most of these incidents occurred in the vicinity of terminals at Cherry Point and Anacortes, Washington. DNV indicated since the data reported covers only five years and the number of vessels is relatively low in the US waters of the Salish Sea, the validity of frequency estimates is low. The data does suggest;

however, that the existing navigational risk controls have had a positive effect on the level of navigational safety in the Salish Sea region, where TMEP-related tankers would transit.

5.2.1.7 Conclusion

The data investigated by DNV from a number of different sources confirms that globally, there has been an increase in marine safety and subsequent decline in the number of marine vessel incidents, in particular those related to oil tankers and those incidents resulting in the release of oil in a marine environment.

With respect to accidental oil spills from tankers transiting the West Coast there were no reported spills from oil tankers in the 2001-2009 period of CCG collecting this type of data. The low number of incidents involving oil tankers on the West Coast may suggest the current scheme to manage navigation and marine traffic on the West Coast is effective.

5.2.2 Probability of a Spill in the Marine Environment Related to the Project

To understand the incremental risk related to the increase in oil tanker traffic created by TMEP, Trans Mountain contracted DNV to conduct a quantitative risk assessment. The quantitative risk assessment is one of the studies carried out for the TERMPOL process and the entire study is provided in TERMPOL 3.15, Volume 8C, TR 8C-12. A summary of the results of the risk assessment is provided in this section.

Det Norske Veritas evaluated the existing marine and shipping network of the Burrard Inlet and Salish Sea to identify:

- the possible types of incidents that could result in an oil spill from a laden tanker;
- the navigational hazards along the route a laden oil tanker would transit between the Westridge Marine Terminal and the Pacific Ocean;
- the navigational risk controls currently that are in use in the Salish Sea region and which have been effective at reducing the frequency of navigational incidents;
- the possible types of incidents that could result in an oil spill from a laden tanker;
- the hypothetical accident locations along the previously mentioned tanker route that could result in an oil spill from a laden tanker;
- the potential for enhanced navigational risk controls to reduce the probability of an oil spill from a laden tanker; and
- the probability and consequences of a credible worst case and smaller accidental oil spill (*i.e.,* a “mean-case” oil spill) from a laden tanker.

Based on an examination of casualty data and TERMPOL requirements, DNV selected five accidents types that could result in an accidental oil spill from a laden oil tanker:

- collision;
- powered grounding;
- drift grounding;
- structural failure; and
- fire/explosion.

As a result of the navigational hazard assessment, DNV defined a study area that included the route a laden oil tanker would transit from the Westridge Marine Terminal to the Pacific Ocean as well as directly adjacent areas, and divided the study area into twelve segments. DNV estimated both the accident and the frequency an accident might result in an accidental oil spill by a laden oil tanker from the Westridge Marine Terminal for each segment, taking into consideration these factors:

- existing and future marine traffic density;
- navigational difficulty;
- existing and proposed additional navigational risk controls; and
- meteorological and oceanographic conditions along the shipping route.

Det Norske Veritas considered existing navigational risk controls that are currently used in the study area to effectively manage marine vessel traffic and reduce the frequency of marine vessel incidents. The existing navigational risk controls DNV considered, and which were previously described in Section 1.4.3, in the quantitative risk assessment included:

- traffic separation scheme and one-way traffic;
- communication systems and oversight such as MCTS;
- mandatory pilotage for oil tankers;
- ship vetting procedures; and
- escort tugs, both tethered and non-tethered.

Det Norske Veritas also recommended two additional navigational risk controls to address the Project-related increase in tanker traffic. The additional navigational risk controls are described in greater detail in Section 5.4.2 and include:

- additional tug escort for laden oil tankers, including both tethered and non-tethered tugs; and
- a moving safety zone around laden oil tankers.

5.2.3 Volume of a Spill in the Marine Environment Related to the Project

To determine the risk of oil spills resulting from Project tankers DNV applied the probability of oil spill accidents, discussed above, to an estimate the consequences discussed here. For the purpose of DNV's analysis the quantification of consequences was limited to oil spill volume.

Expected oil spill volumes were derived from a ship damage model based on International Marine Organization Resolution for Marine Environmental Protection Program methods (IMO 2013c) for collision and grounding events. DNV applied a Monte Carlo simulation to this model to calculate the extent of uncontrolled outflow volume from a partially laden Aframax tanker. The results of the simulation provide a cumulative probability of outflow volume for an oil cargo spill accident. DNV recommended that a credible worst case spill be based on the 90th percentile volume, this is shown along with the mean (50th percentile spill volume) in Table 5.2.1.

TABLE 5.2.1

SIZE OF POSSIBLE ACCIDENTAL CARGO OIL SPILLS FROM A PROJECT-RELATED TANKER

Cases	Volume of Oil Spilled
Credible worst-case spill	16,500 m^3/104,000 bbl
Mean-case spill	8,250 m^3/52,000 bbl

Source: TERMPOL 3.15 (Volume 8C, TR 8C-12)

It is important to note that the credible worst-case spill does not reflect the complete loss of the contents of an oil tanker. DNV noted that, given the current design of an oil tanker with a double hull and segregated cargo compartments, the complete loss of the contents of a tanker leaving the Westridge Marine Terminal (*i.e.*, an Aframax vessel filled to 85 per cent capacity) is so unlikely that it is not a credible event for the purposes of the quantitative risk assessment.

5.2.4 Potential Locations for a Spill in the Marine Environment Related to the Project

As part of the quantitative risk assessment DNV completed a hazard identification exercise to identify locations where there is a higher degree of navigation complexity and probability of an incident due to a navigation issue involving collision or grounding of the tanker due to vessel traffic and/or the narrowness of the passage. The locations along the tanker route identified in the hazard identification exercise are summarized in Table 5.2.2. Five of the eight locations were modelled to develop hypothetical spill scenarios. One of the modelled locations is at the Westridge Marine Terminal and the results of modelling at this location are provided in Volume 7, Section 8.0, leaving four locations which are discussed in this Section 5. Three locations in Table 5.2.2 were not modelled for the reasons provided in the table.

TABLE 5.2.2

POSSIBLE LOCATIONS FOR AN ACCIDENT INVOLVING A PROJECT-RELATED TANKER

ID[1]	Possible location of Accident with Possibility of Oil Spill	Representative Hypothetical Incident	Identified Hypothetical Spill Scenario (Latitude/Longitude: North/West)
A	Westridge Terminal[2]	Oil spill from loading operation or flow line damage.	160 m^3 spill at berth with 20% escaping the pre-deployed oil spill boom (Lat/Long: 49.29150/ -122.95050)
B	English Bay	Possible collision with ships at anchor in English Bay and traffic from Fraser river is low probability	Not considered as viable spill location due to relatively low frequency for an accidental oil cargo spill
C	Roberts Bank	Possible collision with crossing traffic from Fraser river and other crossing traffic is low probability	Not considered as viable spill location due to relatively low frequency for an accidental oil cargo spill
D	Strait of Georgia (main ferry route crossing)	Possible collision with crossing traffic from Fraser River and ferries is a low probability event, but considered because of higher number of crossings per day	Collision (Lat/Long: 48.94303/ -123.21739)
E	Arachne Reef (Turn Point Special Operating Area)[3]	Possible powered grounding is a low probability event due to pilots and tethered tug but this location is rated with greatest level of navigation complexity for the entire passage. Location also has high environmental values.	Powered grounding (Lat/Long: 48.6850/ -123.2930)
F	Brotchie Pilot Boarding Area	Possible collision with other vessel is a low probability event.	Similar to Location G. Chose Location G.
G	Juan de Fuca Strait – (south of Race Rocks)	Possible collision with crossing traffic from Puget Sound and Rosario Strait or grounding at Race Rock is a low probability event, but considered because not all vessels in this location would have pilot onboard.	Collision (Lat/Long: 48.25257/ -123.52687)
H	Buoy J	Possible collision between vessels approaching the confluence of the traffic separation scheme (TSS) at the entrance to Juan de Fuca Strait. It is a low probability event due to high oversight by MCTS and well established TSS.	Collision (Lat/Long: 48.49401/ -124.99440)

Notes: All in-transit hypothetical spill locations have been modelled for both credible worst case (16,500 m^3) and smaller spill size (8,250 m^3)

1 These identifiers correspond to the locations outlined in Figure 5.5.2

2 The hypothetical spill at the Westridge Marine Terminal is described in Volume 7A

3 The hypothetical spill at Arachne Reef in the Turn Point Special Operating Area is the hypothetical scenario described in Section 5.7.

Source: TERMPOL 3.15 (Volume 8C, TR 8C-12)