



The WCMRC report (Volume 8C, TR 8C-12, S13) describes an enhanced response regime that would be capable of delivering 20,000 tonnes of capacity within 36 hours with dedicated resources staged within the study area. This represents a response capacity that is double and a delivery time that is half the existing planning standards. These enhancements would reduce times for initiating a response to two hours within Vancouver Harbour and six hours for the remainder of the study area and parts of the West Coast of Vancouver Island. These reduced times would be achieved by creating new base locations along the tanker route. Meeting the response capacities within the designated times requires redundancy of equipment, and as a result of the redundancy, the overall capacity of dedicated response equipment available in the Salish Sea region would be in excess of 30,000 tonnes equivalent when calculated under the current Federal guidelines for response organizations.

While the probability of the worst case scenario (total loss of containment for an Aframax tanker) is so low that it is not, in DNV's assessment, a credible planning scenario, this event could be addressed by cascading equipment from other areas. In addition to the resources that would be based in the Salish Sea region, WCMRC has, through its existing mutual aid assistance agreements, access to supplementary resources to provide sufficient capacity to respond to a spill larger than the credible worst case defined in this Application.

The effectiveness of the enhanced response was tested under simulated conditions by EBA with input from WCMRC for a credible worst case oil spill event. The results of these simulations are summarized in Section 5.7.

The WCMRC study serves as a practical example of how response capacity could be enhanced to accommodate the Project. Implementation of the plan would be subject to a number of factors and requires knowledge that will be gained through the outcome of the Federal and Provincial reviews of marine spill response, the TERMPOL process, and further consultation with Aboriginal groups and other marine communities.

While recognizing that there are alternative means to achieve similar results, Trans Mountain is supportive of the enhanced capacity and the general means of implementation described by WCMRC.

Table 5.5.3 summarizes and compares WCMRC's existing and proposed future capacity for emergency response and preparedness.

In order to meet these stricter response times and to ensure appropriate equipment (both type and quantity) is available, WCMRC study recommends the addition of five new spill response bases along the tanker route. New and existing bases are identified on Figure 5.5.2. The letter references on this figure correspond with the identifiers discussed in Table 5.2.2 (Volume 8A, Section 5.2.4). The locations are the hypothetical locations DNV identified as a result of their quantitative risk assessment where an accidental oil spill from a laden tanker leaving Westridge Marine Terminal might occur. The distance between the proposed equipment staging areas and the hypothetical oil spill locations is identified in Table 5.5.4.

The capacity of equipment at the existing and new equipment staging areas is described in more detail in Table 5.5.5.

TABLE 5.5.4
DISTANCE FROM PROPOSED EQUIPMENT STAGING AREAS TO HYPOTHETICAL OIL SPILL LOCATION

Proposed Equipment Staging Area	(NM)							
	Hypothetical Spill Location							
	A	B	C	D	E	F	G	H
Burnaby	2	10	25	35	50	75	80	130
Nanaimo	40	30	25	35	45	70	75	125
Delta Port	35	25	8	5	25	50	55	105
Sidney	55	45	30	20	8	25	30	80
Sooke	95	85	70	65	45	20	10	45
Ucluelet	180	170	155	150	130	110	100	40

Table 5.5.5 provides an example of how the total response capacity in the region could be distributed on a risk informed basis, subject to further development of geographic response plans.

TABLE 5.5.5
PROPOSED RESPONSE BASE CAPACITY FOR FUTURE OIL SPILL EQUIPMENT STAGING AREAS

Example of Distribution of Proposed Equipment to Staging Areas	Response Capacity*	
	m ³	Tonnes
Burrard Inlet (Burnaby) ¹	9,550	9,000
Delta Port area ¹	1,350	1,250
South Vancouver Island (Nanaimo – Chemainus area)	2,800	2,650
North Saanich Peninsula (Sidney area) ¹	11,900	11,200
South Vancouver Island (Victoria – Sooke area)	4,700	4,400
Southwest coast of Vancouver Island (Port Renfrew – Ucluelet area)	1,600	1,500
Total capacity at bases	31,900	30,000
Community response packages will be allocated (150 tonnes) × ten locations	1,600	1,500

Notes: 1 These locations would require full-time staff, based on 24 hours/day, 7 days/week.

* Calculated basis current federal guidelines to Canadian response organizations.

These improvements would result in WCMRC having the capacity to respond quickly to spills in excess of the credible worst case oil spill predicted for a Project-related tanker. This would help minimize the adverse environmental and socio-economic effects potentially resulting from an accidental oil spill in the Salish Sea area.

5.5.3 *Financial Liability and Compensation Regime in the Event of an Oil Spill*

The framework for financial liability and compensation respecting an oil spill in the marine environment from a vessel was outlined in Section 1.4.1.6. Through a combination of the Responsible Party's insurance, sources of international funding, and the Canadian SOPF, a party may be compensated for costs and damages related to an oil spill from a vessel in

Canadian waters in the following manner:

- The first level of funding for emergency response, clean up and compensation to affected parties is from the Responsible Party's protection and indemnity insurance. A protection and indemnity association of ship owners and operators known as the International Group of P&I Clubs offers insurance coverage to ship owners and charterers against third-party liabilities encountered in their commercial operations (Transport Canada 2013b). The Responsible Party's liability is limited based on vessel tonnage to a maximum of about CAD 136.76 million.
- If the Responsible Party's insurance is not adequate to cover costs and compensation, funds are available through the International Oil Pollution Compensation Fund (CAD 172.50 million) and the Supplementary Fund Protocol (CAD 833.34 million).
- Lastly, if the international funding is exhausted, Canada maintains its own source of funding called the SOPF, which has up to CAD 161.29 million of funding available.

In total, there is approximately CAD 1.3 billion in funding available to address the costs of emergency response, clean up and compensation in the event of an oil spill from a tanker.

The SOPF can also be a fund of first resort for claimants, including the Crown. Any party may file a claim with the SOPF administrator respecting loss or damage related to oil pollution from a vessel in Canadian waters. The SOPF administrator has the duty to investigate and assess claims filed with the SOPF. While a potential claim is paid out of the SOPF, the administrator is obliged to take all reasonable measures to recover the amount of compensation paid to the claimant from the Responsible Party.

5.6 Environmental and Socio-Economic Effects of an Oil Spill from a Tanker

This section discusses potential environmental and socio-economic effects of credible worst case and smaller oil spills as specified in the Filing Requirements Related to the Potential Environmental and Socio-Economic Effects of Increased Marine Shipping Activities, received by Trans Mountain on September 10, 2013. Although the historical casualty data and the Project-specific risk assessment summarized in Section 5.2 demonstrate that the probability of a Project-related tanker spills is low, Aboriginal groups and the public-at-large consulted about this Project were concerned about catastrophic spills - those that are least likely but of highest consequence. In addition to fulfilling regulatory requirements, the assessment of potential environmental and socio-economic provides information to regulatory authorities and emergency responders that can be used to identify mitigation opportunities and improvements to current spill response planning and preparedness.

The spill effects methodology and discussion provided here and in Volume 7A for the pipeline and facilities differs from that adopted for routine pipeline, facility and tanker activities because spills represent low-probability, unpredictable events (Section 5.2). Rather than estimating potential residual effects and significance for each element and indicator discussed for routine activities (Section 4.0), spill evaluations identify the potential consequences of credible worst-

case spills using a structured risk assessment approach patterned on a process developed to support the Aleutian Islands Risk Assessment (AIRA 2013):

- This section (Section 5.6) provides a qualitative assessment of potential environmental and socio-economic consequences based on evidence from past oil spills and scientific studies as well as stochastic oil spill fate modelling conducted for the Project (Section 5.4.4). This considers a range of spill volumes (credible worst case and smaller) and locations along the shipping route a Project-related tanker would travel. While it focuses on documented effects, it does not explicitly factor in the way that emergency response approaches described in Section 5.4.4 could reduce these potential effects. Although the Aleutians Island Risk Assessment recommends that an initial qualitative evaluation such as this focus solely on the extent and concentrations of oil as a surrogate for effects on natural resources, the discussion provided in Section 5.6 incorporates information on actual effects observed to be more thorough. A more focused and detailed ERA and HHRA to verify conclusions provided here and inform specific mitigation and emergency response plans will be completed for the Arachne Reef Turn Point SOA scenario and submitted to the NEB in early 2014.
- More detailed assessments of credible worst case and smaller spill scenarios at the Westridge Marine Terminal are provided in Volume 7A, Section 8.0. The potential ecological and human health effects of this representative scenario assume that CLWB (the representative crude oil described in Section 5.4.4) is released during tanker loading. The general fate of oil under both mitigated and unmitigated conditions is described for this scenario. A qualitative ERA then assesses potential effects for a variety of marine ecological receptors making the conservative – and unrealistic – assumption that the mitigation previously described for hypothetical worst-case event would not be implemented. Finally, a qualitative HHRA assesses the potential for people's health to be affected by a spill, including sub-populations known to show heightened sensitivity to chemical exposures, such as young children, the elderly and people with compromised health.

5.6.1 Socio-Economic Effects

Marine oil spills can affect the human environment in various ways. Spills can have community and regional economic effects, can contribute to changes in human health, and can affect the sense of individual and community well-being. Potential socio-economic effects of credible worst case and smaller spills will vary depending on the exact location and nature of the incident, and will be influenced by factors including:

- distance from human settlements;
- size and population density of nearby human settlements (e.g., rural versus urban areas);
- particular patterns of resource use in the vicinity (e.g., commercial, recreational, traditional); and

- key economic activities and sectors in areas that may be reached by the spill, in particular the presence of resource-based economic activities (e.g., tourism, commercial fisheries, traditional uses by Aboriginal people).

This section provides a summary of how credible worst-case and smaller spills from a Project-related tanker could affect the health, economy and general well-being of people in the Salish Sea.

The discussion provided in Section 5.5 describes the spill response measures that would be undertaken by the ship owner, WCMRC, CCG and Transport Canada to respond quickly to an accidental oil spill thus minimizing the adverse environmental and socio-economic effects potentially resulting from an accidental oil spill in the Salish Sea region. Where applicable, the information provided here reflects issues identified by Aboriginal peoples, residents, land users, service providers and regulatory authorities. The complexity of predicting socio-economic effects, particularly for hypothetical scenarios, is a function of numerous factors including:

- the constant change that is occurring in socio-economic conditions of any community or region, influenced by an array of economic, political and cultural factors;
- a lack of precise information about goods, services, and employment demands for hypothetical spill scenarios;
- the role of human interpretation and its influence on individuals' physical and perceptual experiences of social effects; and
- inherent uncertainty regarding individuals' abilities, willingness and confidence to respond to change (Loxton *et al.* 2013).

Given the complexity of predicting socio-economic outcomes, this discussion of the potential socio-economic effects of marine oil spills references past spills and other relevant incidents as examples of actual documented effects rather than evaluating one or more specific scenarios. The Exxon Valdez Oil Spill (EVOS) is the largest and best studied example of the effects of a large oil spill on many aspects of the coldwater marine environment, and of communities and residents who live near, or depend on marine resources. The Exxon Valdez Oil Spill Trustee Council (EVOSTC) publishes periodic updates on the status of resources affected by the EVOS; the most recent assessment was published in 2010 (EVOSTC 2010). Many of the socio-economic studies following the EVOS are relevant to the shipping route a Project-related tanker would travel, although differences in regional human population, resource use patterns, and other economic, political and cultural factors are acknowledged.

A growing body of literature shows that both positive and adverse effects can occur, influenced by the spill volume, location, nature of the resources affected, the extent of traditional and non-traditional activities in the affected area, and the duration of clean-up and recovery. The assessment of potential socio-economic effects provided below can be used to:

- understand the types of effects that might result from credible worst case and smaller spills;
- highlight particularly vulnerable groups and resource uses; and
- help inform spill prevention, preparedness and response activities.

5.6.1.1 *Economy*

Marine spills can have both positive and negative effects on local and regional economies over the short- and long-term. Spill response and clean-up creates business and employment opportunities for affected communities, regions, and clean-up service providers, particularly in those communities where spill response equipment is, or would be, staged (Section 5.5). This demand for services and personnel can also directly or indirectly affect businesses and resource-dependant livelihoods. The net overall effect depends on the size and extent of a spill, the associated demand for clean-up services and personnel, the capacity of local and regional businesses to meet this demand, the willingness of local businesses and residents to pursue response opportunities, the extent of business and livelihoods adversely affected (directly or indirectly) by the spill, and the duration and extent of spill response and clean-up activities. As an example, positive spill-related economic effects were documented for major spill clean-up areas following the EVOS (McDowell Group 1990). Negative effects on tourism and commercial fishing were also documented, as described below.

5.6.1.1.1 Commercial Fishing

Commercial fishing and aquaculture is an important economic activity in the Salish Sea region and available information on important fishery areas and effort are provided in Fishery Resources Survey (TERMPOL 3.3, Volume 8C, TR 8C-3). A marine spill, particularly a large one that affects one or more important commercial fishing areas, would likely result in loss of commercial fishing income due to regulated or voluntary closures and possibly reduced demand due to concerns about fish quality. For example, following the EVOS, emergency fishing closures were instituted for salmon, herring, crab, shrimp, rockfish and sablefish immediately following the spill. All fisheries were re-opened the next year, but income from commercial fishing decreased substantially (EVOSTC 2010). Changes to commercial fishing income persist, but as with other resources affected by the EVOS (Section 5.6.2.1), other factors have influenced this change and discerning what is spill-related has been difficult (EVOSTC 2010).

5.6.1.1.2 Tourism and Recreation

The shipping route for Project-related tankers passes through or directly adjacent to areas important for boating, recreational fishing, ecotourism, kayaking, coastal camping and scuba diving. During stakeholder meetings, some attendees expressed concern over the potential of a pipeline spill affecting tourism in areas such as the Gulf Islands. A Project-related tanker spill could affect the tourism and recreation industry both by directly disrupting the activities of tourists and recreationalists and by causing economic effects to recreation or tourism-based businesses.

In the event of a spill, recreational fishing, boating and beach use may be restricted or prohibited near the spill site and in clean-up areas. These restrictions would typically apply during the active clean-up period, but voluntary and regulated changes in recreational use patterns could extend until affected areas and resources are stable or recovered. In addition, resident and non-resident visits to spill-affected areas may decrease due to lack of available business services such as accommodations and charter boats (McDowell Group 1990; EVOSTC 2010).

Effects on recreation or tourism-based businesses appear to be greatest during the clean-up period, both due to decreased demand by visitors, and labour shortages associated with service industry workers seeking higher paying spill clean-up jobs (McDowell Group 1990). Although money and jobs generated in this industry have grown since the EVOS, and future tourism

projections are promising, EVOSTC (2010) does not currently consider recreation and tourism to be fully recovered because some ecological resources are not rated as recovered (see discussion of ecological resources in Section 5.6.2.1).

5.6.1.1.3 Property Damage

Marine spills could potentially damage marinas, boats, and business/commercial establishments and infrastructure, resulting in costs for individuals and lost income for affected neighbourhood businesses. Municipalities may also incur infrastructure repair and replacement costs. In such cases, and other instances of economic loss, the vessel responsible for the spill would be responsible for compensating those who suffered damage.

5.6.1.2 Human Health

In order to experience physical effects from hydrocarbon exposure, a person must inhale, ingest or touch the spilled product, and be exposed for a long enough period for it to be harmful. This can happen through a number of pathways, including:

- inhaling vapours released from spilled oil;
- direct contact with contaminated soil, or ingesting food that grows in contaminated soil;
- drinking from a source contaminated by a spill; and
- eating plants, fish or animals contaminated by a spill.

When discussing human health effects, the potential effects associated with short-term and long-term exposure to hydrocarbons are referred to as acute and chronic effects, respectively. In the event of a marine spill, the tanker owner, CCG, WCMRC, and Transport Canada will initiate spill response and notify municipal, provincial and federal authorities responsible for the protection of public health. Evacuation of affected areas will occur if health and safety of the public is threatened and this will limit opportunities for short-term exposure to hydrocarbon vapours and potential for acute effects. Involvement of local, provincial and federal public health officials will also ensure that controls to limit long-term exposure and chronic effects potential will be implemented if warranted. Examples of such controls include closure of recreational or commercial fisheries, beach closures, the issuance of drinking water or food consumption advisories, and forced evacuation. This will limit long-term exposure from all pathways, including: inhalation; ingesting contaminated food, fish, plants, or animals; drinking from a contaminated source; or incidental skin contact with oil.

Over the short-term, the primary risk factor for human health is lighter end, volatile and semi-volatile hydrocarbons (C_1 to C_{12}) that are present in the air as vapours at or near the source, and then disperse in a downwind direction. COPC include BTEX as well as simple polycyclic aromatic hydrocarbons (PAHs). Trace amounts of sulphur-containing chemicals and longer-chain, semi-volatile hydrocarbons (C_{13} to C_{21}) also could be present. Based on the known health effects of these COPC, potential effects would likely be dominated by irritation of the eyes and/or breathing passages, possibly accompanied by nausea, headache, light headedness and/or dizziness. These effects could range from barely noticeable to quite noticeable, depending on the exposure circumstances and the sensitivity of the individuals exposed (see below). Odours might be apparent, dominated by a hydrocarbon-like smell, with some prospect for other distinct odours due to the presence of sulphur-containing chemicals in the vapour mix.

The odours themselves could contribute to discomfort, irritability and anxiety. The exact nature and severity of any health effects will depend on several factors, including:

- The circumstances surrounding the spill, including the time of year and meteorological conditions at the time. These circumstances will affect the extent to which chemical vapours are released from the surface of the spilled oil and the manner in which these vapours will disperse.
- A person's whereabouts in relation to the spill, including their distance from the source and their orientation to the spill with respect to wind direction. Exposures would be highest immediately downwind of the source, declining with increasing distance and the potential for health effects to occur as well as the severity of any effects will follow the same pattern. The potential for health effects at cross-wind or upwind locations will be lower or zero.
- The timeliness of emergency response measures. Measures taken to either remove the hazard from the general public (e.g., spill isolation, containment and mitigation) or remove the general public from the hazard (e.g., securing the spill area, evacuation of people from the area) will reduce exposure and probability of any associated health effects. The sooner these measures can be implemented, the lower the likelihood of any effects.
- A person's sensitivity to chemical exposures. It is widely accepted that a person's age, health status and other characteristics can affect the manner and extent to which they respond to COPC exposure, with the young, the elderly and people with compromised health often showing heightened sensitivity.

5.6.1.3 *Community Well-Being*

There is great diversity in the communities and regions along the shipping route a Project-related tanker would travel. Marine oil spills may adversely affect community well-being by affecting cultural and heritage resources, traditional lands, culture, and practices, and psychological well-being. Stakeholder engagement activities conducted for the Project indicate that in almost every geographic region people are currently concerned about the effects an oil spill would have on human and environmental health. In the event of a spill, it is likely that this concern would evolve into stress and anxiety among some residents.

5.6.1.3.1 Cultural and Heritage Resources

Heritage resources could be affected by a spill in a number of ways. Oil and clean-up activities can directly damage artifacts and sites or disturb their context, which may result in permanent loss of information critical to scientific interpretation. Looting or vandalism of heritage sites was also reported immediately following the EVOS, but subsequent measures to manage the activities of spill response personnel appear to have been effective in preventing additional loss (EVOSTC 2010).

5.6.1.3.2 Aboriginal Culture and Subsistence Use

Aboriginal peoples have historically used or presently use the shipping route to maintain a traditional lifestyle and continue to use marine resources throughout the Salish Sea region 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 waters within the region to access subsistence resources, neighbouring communities and coastal settlements.

The EVOS affected subsistence harvest of Aboriginal communities and individuals. Adverse effects resulted from reduced availability of fish and wildlife, concern about possible health effects of eating fish and wildlife, and disruption of traditional lifestyle due to participation in, or disturbance by, clean-up activities. Fears about food safety have diminished over time and harvest levels have increased since the spill, but the increase has been variable, and composition of harvested species has changed. Other factors have influenced this change and discerning what is spill-related is difficult (Palinkas *et al.* 1993, EVOSTC 2010; see also Section 5.6.2.1).

5.6.1.3.3 Local Infrastructure and Services

In the event of a spill, particularly a credible worst-case incident, demands are likely to be placed on local, municipal, regional and independent emergency responders (fire, police, ambulance, disaster agencies), hospitals, clinics, social service and relief organizations, and local, municipal, regional and federal government officials and staff. Actual effects would depend on the size and nature of a spill, the number of people potentially affected and the availability of proper equipment and trained personnel. Mutual aid agreements described in Section 5.5 have been reached to help responders lend assistance across jurisdictional boundaries if required.

5.6.1.3.4 Psychological Effects

Research has shown that in the event of an oil spill, affected communities and individuals may experience a number of psycho-social effects. Culture is an important factor that affects the potential psycho-social effects of a spill. Documented effects include: declines in traditional social relations with family members, friends, neighbours and coworkers; a decline in subsistence production and distribution activities; perceived increases in the amount of and problems associated with drinking, drug abuse, and domestic violence; and a decline in perceived health status and an increase in the number of medical conditions verified by a physician including depression, anxiety and post-traumatic stress disorder. These effects may be short-term or persist for years in individuals or groups most directly affected by a spill (Palinkas *et al.* 1992, 1993; Picou and Gill 1996; Lyons *et al.* 1999, Arata *et al.* 2000, Gill *et al.* 2012). Psychological effects did not extend throughout the entire community; for example, the estimated rate of generalized anxiety disorder was around 20 per cent and post-traumatic stress disorder was about 9.4 per cent (Palinkas *et al.* 1993). Strongest predictors of stress were family health concerns, commercial ties to renewable resources, and concern about economic future, economic loss, and exposure to oil (Gill *et al.* 2012).

Regardless of the actual exposure, the possibility of exposure and the perception that contamination has occurred may be sufficient to cause anxiety or psychological effects in some people (Aguilera *et al.* 2010). Evidence from past incidents indicates that psychological effects would be most likely in the event of a large spill affects an important subsistence or commercial resource. Individuals and groups who would be at greatest risk of adverse effects include:

- those involved in the clean-up efforts;
- those who already have chronic physical or mental illness;

- those whose jobs and livelihoods are directly affected by the spill, including family members; and
- Aboriginal peoples who participate in subsistence hunting and gathering and whose families rely on subsistence foods to support healthy diets.

5.6.2 Environmental Effects

As with socio-economic effects, numerous factors contribute to the complexity of predicting environmental outcomes of hypothetical worst case and smaller spills. However, the ecological risk assessment process provides an established, accepted and transparent method to evaluate potential acute and chronic effects of hypothetical spill scenarios for a suite of ecological receptors. For this reason, an ecological risk assessment process was applied to assess environmental effects, rather than the qualitative approach adopted to evaluate potential socio-economic effects of marine oil spills.

5.6.2.1 Ecological Risk Assessment Methods

This section summarizes results of the preliminary quantitative ecological risk assessment (ERA) completed to evaluate the effects of hypothetical credible worst case and smaller spills of CLWB along the shipping route a Project-related tanker would travel.

The ERA discusses the range of potential effects to ecological resources by considering the probability of exposure to predicted surface oil slicks, the probability that oil will impinge upon shorelines, and the characteristics and sensitivity of potentially affected aquatic and shoreline habitats within the study area. Potential environmental effects were visualized and quantified using GIS overlays of data layers containing information on biological resources, sensitive habitats and other areas of ecological importance, and the results of seasonal oil spill modelling summarized in Section 5.4.

The ERA followed a standard protocol composed of the following stages:

- problem formulation;
- exposure assessment;
- hazard assessment;
- risk characterization; and
- discussion of certainty and confidence in the predictions.

5.6.2.1.1 Problem Formulation

Problem formulation defines the nature and scope of the work and establishes the boundaries so that the ERA is directed at the key areas and issues of concern. Data were gathered to provide information on the general characteristics of the study area, the oil being considered, the hypothetical scenarios being considered, potential ecological receptors and any other relevant issues.

A summary of information on the study area, ecological receptors and relevant findings from the EVOS, and the hypothetical scenarios considered by the ERA is provided here.

Spatial Boundaries

The spatial boundaries for this ERA were based on the oil spill modeling domain (Volume 8C, TR 8C-12, S9 and S10). The following spatial boundaries were considered in the ERA:

- oil spill footprint - the area predicted to be directly affected by oil as a result of a release at various locations along the shipping route; and
- RSA - The area of ecological relevance where environmental effects could potentially result from accidents and malfunctions within the limits of the domain for the stochastic oil spill modelling. The RSA is generally centered on the marine shipping route, 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 the Juan de Fuca Strait out to the 12 nautical mile limit of Canada's territorial sea. The western boundary of the RSA extends further out to sea than the western boundary of the Salish Sea and the northern boundary of the RSA is limited to the southern portion of the Strait of Georgia. Puget Sound is excluded from the RSA.

Ecological Receptors

This section describes the ecological receptors selected for the marine spill ERA and also summarizes findings relevant to these receptors from monitoring conducted following the EVOS (1989).

i) The Exxon Valdez Oil Spill (EVOS)

The EVOS is the largest and best studied example of the effects of a large oil spill on many aspects of the coldwater marine environment. This spill is directly relevant to the Project for the purposes of an ERA as many of the ecological receptors studied following the EVOS also occur along the shipping route a Project-related tanker would travel, or in the Salish Sea more generally. That being said, despite the relevance from an ERA perspective, it is not predicted an EVOS type of oil spill would happen related to the Project. Improvements in tanker construction (*i.e.*, double vs. single hull; segregated cargo compartments) and navigational safety measures have resulted in fewer tanker accidents and few accidents resulting in the accidental release of oil (see Section 5.2) since EVOS.

Despite the intensive studies that followed the EVOS, findings on actual effects and recovery remain controversial. The EVOSTC publishes periodic updates on the status of resources affected by the EVOS; the most recent assessment was published in 2010 (EVOSTC 2010). The EVOSTC recognizes that as time passes, the ability to distinguish oil-related effects from other factors affecting fish and wildlife resources diminishes. Some resources currently identified as not having recovered from the spill may have been in decline regionally, and elsewhere, prior to the spill, so that recovery of the resource to its pre-spill status may be an unrealistic expectation.

Two major reviews of the ecological significance and residual effects of the EVOS (Peterson *et al.* 2003, Harwell and Gentile 2006) reached different conclusions. Peterson *et al.* (2003) concluded that unexpected persistence of sub-surface oil and chronic exposures at sublethal levels continue to affect wildlife, and that cascading indirect effects of oil exposure delayed recovery from the oil spill. Harwell and Gentile (2006) concluded that no ecologically significant effects were detectable across a suite of more than 20 ecological receptors including primary

producers, filter feeders, fish, and bird primary consumers, fish and bird top predators, a bird scavenger, mammalian primary consumers and top predators, biotic communities, ecosystem level properties of trophodynamics and biogeochemical processes, and landscape level properties of habitat mosaic and wilderness quality.

A key point identified by Peterson *et al.* (2003) is the emerging appreciation of more complex, chronic, or ecosystem-based effects of oil spills than was previously understood under an “old paradigm” that considered primarily acute or short-term effects of spilled oil. The marine spills ERA summarized here integrates this understanding of acute and chronic effects of oil spills on ecological receptors.

ii) ERA Ecological Receptors

Potential environmental effects of the tanker marine spill scenarios are evaluated for four main ecological receptor group/habitat combinations:

- shoreline and near shore habitats;
- marine fish community and supporting habitat;
- marine birds and supporting habitat; and
- marine mammals and supporting habitat.

The EVOSTC (2010) lists 32 ‘injured resources’ and ecosystem services and evaluates the recovery status for each. Table 5.6.2.1 groups many of these resources together to represent the ecological resources being evaluated through the ERA .

TABLE 5.6.2.1

RELATIONSHIP BETWEEN ERA ECOLOGICAL RECEPTORS AND ‘INJURED RESOURCES’ ASSESSED BY EVOSTC (2010)

Ecological Resource in ERA	Injured Resources Assessed by EVOSTC (2010)	Recovery Status from EVOSTC (2010)
Shoreline Habitats	Clams Mussels Intertidal Communities	Recovering Recovering Recovering
Marine Fish Community	Pacific Herring Pink Salmon Sockeye Salmon Rockfish Subtidal Communities Sediments	Not recovering Recovered Recovered Very likely recovered Very likely recovered Recovering
Marine Birds and Marine Bird Habitat	Black Oystercatcher Cormorant Common Loon Harlequin Duck Barrow’s Goldeneye Common Murre Kittlitz’s Murrelet Marbled Murrelet Pigeon Guillemot	Recovering Recovered Recovered Recovering Recovering Recovered Unknown Unknown Not recovering

TABLE 5.6.2.1

RELATIONSHIP BETWEEN ERA ECOLOGICAL RECEPTORS AND 'INJURED RESOURCES' ASSESSED BY EVOSTC (2010) (continued)

Ecological Resource in ERA	Injured Resources Assessed by EVOSTC (2010)	Recovery Status from EVOSTC (2010)
Marine Mammals	Harbour Seal Killer Whales – AB Pod Killer Whales – AT1 Population River Otter Sea Otter	Recovered Recovering Not recovering Recovered Recovering

Each of the four ERA ecological receptor groups includes a variety of individual receptors and/or habitats with differing sensitivity to oil exposure. For this reason, each receptor group was divided into sub-categories that reflected their sensitivity to oil exposure. These sub-categories, termed biological sensitivity ranking factors (BSF), ranged from a value of 1 (low sensitivity) to a value of 4 (very high sensitivity). The potential for negative environmental effects of oil exposure at any given location was indicated by the overlap of the probability of oil presence (from the oil spill modeling results), and the sensitivity of the receptor or habitat present at that location. Where a specific receptor had status as an endangered species, the status was considered as an additional factor. Likewise, the presence of provincial and national parks or other designated conservation areas represented an additional factor for consideration (*i.e.*, societal values) in addition to intrinsic biological sensitivities.

The discussion provided here summarizes information on the four ERA ecological receptors, their biological sensitivity, and relevant findings from EVOS monitoring. Further detail on these receptors and their biological sensitivity ranking factors is provided in Ecological Risk Assessment of Marine Transportation Spills Technical Report (Volume 8B, TR 8B-7).

a. Shoreline Habitats

The shoreline habitats receptor includes 13 different shoreline and near shore habitat types in the intertidal or littoral zone, including the area of the foreshore and seabed that is exposed at low tide, and submerged at high tide. Substrate types for these habitats range from sand through to rock, with additional classes for marsh, as well as rip rap or wood bulkheads or pilings such as may be used for shoreline protection. In addition, areas of eelgrass are also considered to fall within the shoreline habitat, giving a total of fourteen different shoreline habitat types.

Low-energy or protected shorelines almost always have a fine subsurface substrate (sand or mud), even though the surface veneer may be coarse pebble, cobble or boulder. The presence of a water-saturated fine subsurface layer is an important factor that affects sensitivity to oil exposure because it provides a barrier that limits oil penetration of sub-surface sediment, and hence limits long-term retention of oil. In contrast, coarse (pebble, cobble or boulder) shorelines that are highly exposed may be coarse to considerable depth, increasing permeability and the potential for retention or sequestration of stranded oil.

Tidal marshes are often associated with river mouths and estuaries, behind barrier islands, or on tidal flats where low-energy wave action and fine-grained sediment accumulation provides an elevated surface where marsh vegetation can become established. Eelgrass beds are also typically found in soft sediments of protected bays, inlets and lagoons.

The ERA biological sensitivity ranking for each shoreline type was generally correlated with the tendency for shoreline types to absorb or retain spilled oil, they also represent habitat complexity and the ability of the different habitat types to sustain biodiversity and productivity. Exposed bedrock or sand substrates were considered to be subject to high levels of natural disturbance, and to have relatively low levels of biodiversity and productivity, and were assigned a low sensitivity ranking (BSF 1), whereas sheltered rocky substrates capable of supporting a rich and diverse intertidal community, marshes, and eelgrass beds were assigned high (BSF 3) or very high (BSF 4) biological sensitivity rankings.

The recovery status categories used by the EVOSTC to describe the status of injured resources are obviously critical to their assessment. The status of “recovering” (Table 5.6.2.1) means that the resources are demonstrating substantive progress toward recovery objectives, but are still being adversely affected by residual impacts of the spill or are currently being exposed to lingering oil. The recovery status of the Shoreline Habitats receptor group is impeded by effects on the seaweed and intertidal community exacerbated by isolated pockets of oil that became sequestered in beach substrates as well as oil spill response activities. With the advantage of hindsight, certain oil spill response activities (e.g., hot water washing, pressure washing, and physical removal of oiled substrates) have been concluded to be more damaging than beneficial. For clams, both oil exposure and oil spill response activities affected the community, but baseline information on most clam species is lacking. The EVOSTC concede that clam populations found on oiled but untreated beaches have likely recovered from the effects of the spill. However, it appears that disturbance of the rock armoring on beaches impedes subsequent recovery, and this is an important finding that has been incorporated into oil spill response techniques. For mussels, bioaccumulation of PAHs continues to be a primary concern. In most instances, concentrations of oil in mussels from the most heavily oiled beds were indistinguishable from background by 1999. However, small areas of lingering or sequestered oil continue to hold back an assessment of “recovered”.

Harwell and Gentile (2006) address the question of residual sources of oil exposure. In their view, the important question is not whether sources of hydrocarbon from the EVOS still exist, as they clearly do; but rather whether they pose a substantial risk to populations and communities comprising the Prince William Sound ecosystem. The beach surface area contaminated by subsurface oil in 2001 was estimated to be 6.7 ha, and the quantity of oil involved was estimated to represent about 6.5 m³ of total residual oil from the EVOS. This compares to estimates that approximately 782 km of shoreline in Prince William Sound, and about 1,315 km of shoreline in the Gulf of Alaska were oiled to some degree. This comparatively small area of residual oiling in shoreline habitats is the rationale for EVOSTC “recovering” conclusion, but masks the fact that the vast majority of shoreline habitat had recovered within 10 years of the oil spill, notwithstanding inappropriate methods used during the oil spill response activities.

A key finding of the EVOS was that the negative effects of high-pressure hot water washing were substantial. Oiled but untreated shoreline sites recovered more quickly than oiled sites where aggressive cleaning techniques were applied. Whether cleaned or not, intertidal communities had recovered within 5 years after the EVOS (Harwell and Gentile 2006); recovery of oiled shoreline habitat within 2 to 5 years following a large oil spill is a reasonable expectation with the implementation of appropriate oil spill response activities.

b. Marine Fish Community

The ERA marine fish community receptor includes marine fish and marine invertebrates (e.g., mollusks and crustaceans), but not marine mammals or birds. Acute effects of spilled oil on fish and marine invertebrates are rarely observed, except in situations where oil is confined and

dispersed into shallow water. Hydrocarbon effects on fish are generally caused by exposure to relatively soluble components of the oil. BTEX compounds or light polycyclic aromatic hydrocarbons (PAHs) such as naphthalenes are usually considered to be the most likely contributors to acute toxicity, although some light aliphatic hydrocarbons may also contribute to toxicity. These compounds also tend to be volatile and are rapidly lost to the atmosphere, so the initial 24 to 48 hours following an oil spill is the period when acute toxicity is most likely to occur.

Two major mechanisms of toxicity to marine fish are recognized (although other more specific mechanisms may also exist). These are:

- Non-polar narcosis, whereby reversible exposure to and accumulation of hydrocarbons from the water column causes interference with intracellular functioning at a target lipid site, potentially causing death if a critical hydrocarbon concentration is exceeded in the target lipid. Salmonid fish are sensitive to the narcosis pathway, and small fish are more sensitive than large fish.
- Blue sac disease (BSD), whereby exposure to 3- and 4-ring PAH compounds results in a syndrome of cardiac, craniofacial, and/or spinal deformity and death in developing embryos. Sensitivity to BSD is greatest in newly fertilized eggs, and decreases with the hardening of the egg membrane, and with increasing developmental stage. Embryos of herring and salmon species are among those more sensitive to BSD.

Due to the behaviour of oil spilled on water, the potential for toxicity to the marine fish community is greatest near the surface where more soluble hydrocarbons can dissolve from the floating fresh oil, or form droplets that can be temporarily dispersed down in to the water column by wave action. However, extensive formation and dispersion of oil droplets into the water column is unlikely to occur in sheltered waters. The potential for acutely toxic concentrations of hydrocarbons to extend down into deep water is very low, due to the limited solubility of hydrocarbons, and the dilution that would accompany mixing into deep water.

For the non-polar narcosis mode of toxic action (see Ecological Risk Assessment of Marine Transportation Spills Technical Report [Volume 8B, TR 8B-7]), toxicity of a sensitive species, is defined as representing the 5th percentile on a species sensitivity distribution (Di Toro *et al.* 2000). Assuming that this synthetic sensitive species is the same regardless of the specific habitat under consideration, for the ERA, the sensitivity of the marine fish community is related to the degree of exposure of the particular habitat to dissolved hydrocarbons. Therefore, deep water habitat is assigned a low sensitivity rank (BSF 1) and shallow water habitat a high sensitivity rank (BSF 3). The very high biological sensitivity rank (BSF 4) is assigned to developing eggs and embryos in shallow water habitat (represented here by herring spawning areas).

The ERA Marine Fish Community ecological receptor group is represented in the EVOSTC (2010) assessment by a variety of fish species, as well as sediments and subtidal communities. Most of these are concluded to be “recovered” or “very likely recovered” (Table 5.6.2.1); the latter designation reflecting limited scientific research in recent years, but a low probability that there are any residual effects of the spill (EVOSTC 2010). Sediments (including both intertidal and subtidal areas) are listed as “recovering”, primarily because lingering or sequestered oil is present on some armored oiled beaches. No oil was found in sub-tidal sediments at previously oiled sites when re-sampled in 2001. Harwell and Gentile (2006) note that while just over one

third of nearshore sediment samples collected after two years at heavily oiled sites had detectable residual traces of EVOS oil, results suggest that the vast majority of the approximately 4,500 km² seafloor of Prince William Sound had no detectable traces of oil from the EVOS within two years of the spill.

The most controversial EVOSTC recovery assessment for the Marine Fish Community receptor is for Pacific herring. Prior to the spill, the herring population (or harvest) was increasing as documented by record harvests in the late 1980s. The EVOS occurred at a time when herring were spawning, and there is no doubt that herring spawn was exposed to spilled oil and dissolved PAH at sufficient concentration to cause local effects (such as developmental deformities). Notwithstanding this exposure, the herring population continued to increase until four years after the spill when there was a crash in the adult herring population. Although many studies published in the 1990s and 2000s suggested that the herring population crash resulted from the EVOS, the cause of the decline and poor recovery of the Prince William Sound herring population has been described as perplexing by scientists working on behalf of the EVOSTC (Rice and Carls 2007). Pearson *et al.* (2011) argue that the underlying cause of the population collapse was poor nutrition, and perhaps disease associated with the very large herring population size, and generally low abundance of zooplankton. Harwell and Gentile (2006) conclude that the population loss resulting from direct mortality attributable to the EVOS is not clear. On balance, the population collapse four years after the spill was likely caused by factors other than the EVOS, suggesting that there are no remaining ecologically significant effects on Pacific herring that can be attributed to the spill.

Effects of the EVOS were generally localized and short-term on marine fish populations as a whole (EVOSTC 2010). Intertidal fishes showed declines in density and biomass at oiled sites relative to reference sites in 1990, but this could reflect changes in habitat quality as well as oil exposure. Rockfish utilize the nearshore environment as young-of-the-year and juveniles, and may have been affected in this manner, but studies have not identified any conclusive link between exposure to Exxon Valdez oil and endpoints such as larval growth of fish in 1989, or lesions associated with oil exposure. Pink salmon spawning in intertidal areas near Prince William Sound were potentially exposed to hydrocarbons in water, and in some cases to hydrocarbons in spawning substrates. Although potential for developmental effects on pink salmon embryos, including mortality was demonstrated at some locations, no convincing change in pink salmon population size was documented. Sockeye salmon appear to have been affected by the fishery closure, as more spawners than normal appear to have entered freshwater habitat in 1989, resulting in overgrazing of planktonic food webs in nursery lakes. This led to lower than optimal growth rates in juvenile sockeye that were never exposed to oil, which in turn appears to have led to a subsequent decrease in returns of adult spawners some years later.

Effects of the EVOS on marine fish and fish habitat were generally limited to areas where oil was driven into near-shore areas, and these effects were for the most part short-term (days to weeks, rather than years). Evidence has been presented for longer-term effects on some habitats, such as intertidal pink salmon spawning areas where sequestered oil may have leached into spawning gravels up to several years after the spill. However, these areas were very limited and did not result in effects at the population level for pink salmon. Evidence for the marine fish community receptor suggests that the EVOS did not have substantial effects on marine fish populations initially, or recovery occurred within one or two years at most.

c. Marine Birds

Seabirds can be highly sensitive to oil spills, due principally to the effects of oiling on feathers (*i.e.*, loss of insulative properties and buoyancy), as well as to ingestion of oil or contaminated food. In addition, birds that are gregarious are potentially at greater risk of population-level effects if oil is present in an area where they congregate or feed. The waters of the Strait of Georgia, Haro Strait, Juan de Fuca Strait and the Gulf Islands provide migratory, nesting, feeding and wintering habitat for a wide variety of shorebirds, gulls, waterfowl and alcids (auks).

Four biological sensitivity ranking classes are defined for the ERA marine bird receptor, on a scale of 1 (low sensitivity) to 4 (high sensitivity). The ranking scheme reflects guild membership, as is appropriate considering the similar lifestyle, behaviour, and exposure mechanisms that accompany each guild. A low sensitivity rank (BSF 1) is assigned to shoreline dwelling species and waders that are generally widely distributed. Medium sensitivity (BSF 2) is assigned to species with a life history that is not exclusively marine, such as gulls and terns. Ducks and other waterfowl that tend to be moderately sensitivity to oil exposure and may congregate are assigned a high sensitivity (BSF 3). Finally, a very high sensitivity (BSF 4) is assigned to species that tend to rely heavily on the marine environment or have high sensitivity to oil exposure, such as auks and divers. These birds tend to nest in colonies and also often congregate in feeding areas.

Additional consideration is also given to known breeding colony locations and Important Bird Areas (IBAs) located within the RSA. A description of each of these IBAs, including recorded species and corresponding seasonality (as available), is presented in Table 5.6.2.2. The location of known bird colonies is shown in Ecological Risk Assessment of Marine Transportation Spills Technical Report (Volume 8B, TR 8B-7).

TABLE 5.6.2.2

SUMMARY OF IMPORTANT BIRD AREAS (IBAS) WITHIN THE RSA FOR MARINE TRANSPORTATION

Identification Number	Site Name	Description	Bird Species	Seasonality
Canada				
BC001	McFadden Creek Heronry	The McFadden Creek Heronry is a relatively small (0.5 km ²), fully forested IBA, located on the north side of Saltspring Island, British Columbia.	Great Blue Heron (BC Coast)	Breeding
BC015	Active Pass	The Active Pass IBA comprises the water body (approximately 17 km ²) between Galiano and Mayne Islands in the southwest region of the Strait of Georgia.	Bald Eagle	Breeding Spring Migration Summer Non-Breeding Wintering
			Bonaparte's Gull	Fall Migration Spring Migration
			Brandt's Cormorant	Wintering
			Pacific Loon	Spring Migration Wintering
BC017	Boundary Bay – Roberts Bank – Sturgeon Bank (Fraser River Estuary)	This IBA represents the Fraser River Delta including Boundary Bay, Roberts Bank and Sturgeon Bank as well as agricultural lands in and around Richmond, Surrey and White Rock. It is a large (approximately 750 km ²) complex IBA encompassing several types of habitats, including marine, estuarine, freshwater and agricultural habitats.	American Wigeon	Fall Migration Wintering
			Barn Owl (BC)	Breeding Wintering
			Black-bellied Plover	Fall Migration Summer Non-Breeding Wintering
			Brant	Spring Migration Wintering
			Dunlin	Fall Migration Spring Migration Wintering
			Glaucous-winged Gull	Wintering
			Great Blue Heron (BC Coast)	Spring Migration Summer Non-Breeding Wintering
			Mallard	Fall Migration Wintering
			Mew Gull	Fall Migration Spring Migration Wintering
			Northern Pintail	Fall Migration Wintering
			Peregrine Falcon (BC)	Fall Migration Spring Migration Wintering
			Red-necked Grebe	Fall Migration Spring Migration Wintering

TABLE 5.6.2.2

**SUMMARY OF IMPORTANT BIRD AREAS (IBAS) WITHIN THE RSA FOR MARINE
TRANSPORTATION (continued)**

Identification Number	Site Name	Description	Bird Species	Seasonality
Canada				
BC017	Boundary Bay – Roberts Bank – Sturgeon Bank (Fraser River Estuary)	This IBA represents the Fraser River Delta including Boundary Bay, Roberts Bank and Sturgeon Bank as well as agricultural lands in and around Richmond, Surrey and White Rock. It is a large (approximately 750 km ²) complex IBA encompassing several types of habitats, including marine, estuarine, freshwater and agricultural habitats.	Snow Goose	Fall Migration Wintering
			Surf Scoter	Fall Migration Spring Migration Wintering
			Thayer's Gull	Fall Migration Wintering
			Trumpeter Swan	Wintering
			Western Grebe	Fall Migration Spring Migration Wintering
			Western Sandpiper	Spring Migration
BC018	Pacific Spirit Regional Park	The Pacific Spirit Regional Park IBA is a relatively small IBA (less than 2 km ²) located on Point Grey, British Columbia. This IBA is bordered to the east by residential areas and to the west by the University of British Columbia Farm.	Great Blue Heron (BC Coast)	Breeding
BC020	English Bay & Burrard Inlet	This large IBA (140 km ²) comprises English Bay, False Creek and Burrard Inlet including Vancouver Harbor, Indian Arm and Port Moody Arm. It incorporates numerous types of habitats with industrial encroachment in and around Vancouver to less impacted areas in Indian Arm.	Barrow's Goldeneye	Fall Wintering
			Great Blue Heron (BC Coast)	Summer Non-Breeding
			Surf Scoter	Fall Migration Wintering
			Waterfowl	Wintering
			Western Grebe	Fall Wintering
BC023	Squamish River Area	The Squamish River Area IBA is located at the northeastern tip of Howe Sound in proximity to Squamish, British Columbia. It comprises the Squamish, Mamquam and Cheakamus rivers and their respective shorelines (approximately 50 km ²).	American Dipper	Year-Round Resident
			Bald Eagle	Wintering
			Trumpeter Swan	Wintering
BC025	White Islets and Wilson Creek	This IBA comprises the water body south of Wilson Creek and surrounding the White Islets (approximately 30 km ²) located west of Howe Sound in proximity of Sechelt, British Columbia.	Glaucous-winged Gull	Breeding
			Harlequin Duck	Other
			Marbled Murrelet	Wintering
			Pelagic Cormorant	Breeding
			Surf Scoter	Other
			Surfbird	Spring Migration

TABLE 5.6.2.2

SUMMARY OF IMPORTANT BIRD AREAS (IBAS) WITHIN THE RSA FOR MARINE TRANSPORTATION (continued)

Identification Number	Site Name	Description	Bird Species	Seasonality
Canada				
BC045	Chain Islets & Great Chain Islet	This IBA is a relatively small IBA (less than 2 km ²) surrounding Great Chain Islet and several smaller islets located in waters southeast of Victoria, British Columbia.	Black Oystercatcher	Breeding
			Brandt's Cormorant	Fall Migration
			Double-crested Cormorant	Breeding
			Glaucous-winged Gull	Breeding
			Harlequin Duck	Other
			Pelagic Cormorant	Breeding
			Pigeon Guillemot	Breeding
BC047	Sidney Channel	The Sidney Channel IBA, located in proximity to Sidney, British Columbia, comprises the water body (approximately 90 km ²) between Vancouver Island, James Island and Sidney Island. It is located generally east of Haro Strait.	Black Oystercatcher	Breeding
			Brandt's Cormorant	Fall Migration
			Brant	Spring Migration Wintering
			Glaucous-winged Gull	Breeding
			Great Blue Heron (BC Coast)	Breeding Year-Round Resident
			Harlequin Duck	Fall Migration
			Marbled Murrelet	Summer Non-Breeding
			Mew Gull	Spring Migration
			Pigeon Guillemot	Wintering
BC048	Cowichan estuary	The Cowichan estuary IBA includes Cowichan Bay and generally represents the water body (approximately 40 km ²) located northwest of Saanich Inlet. Both Cowichan Bay and Saanich Inlet connect to Haro Strait through Satellite Channel.	Rhinoceros Auklet	Breeding
			Colonial Waterbirds/Seabirds	Wintering
			Double-crested Cormorant	Wintering
			Mew Gull	Wintering
			Mute Swan	Wintering
			Pacific Loon	Spring Migration
			Red-necked Grebe	Fall Migration
			Thayer's Gull	Wintering
			Trumpeter Swan	Wintering
BC052	Porlier Pass	The Porlier Pass IBA (approximately 16 km ²) comprises the water body between Valdes and Galiano Islands as well as some of the shorelines of both islands.	Waterfowl	Wintering
			Western Grebe	Wintering
			Black Oystercatcher	Breeding
			Cormorant species	Wintering
			Glaucous-winged Gull	Breeding
BC055	Snake Island	This IBA is relatively small (4 km ²) and surrounds Snake Island which is located within the approach to Nanaimo, British Columbia and approximately 3 km from the northwest point of Gabriola Island.	Mew Gull	Fall Migration
			Scoters	Wintering
			Black Oystercatcher	Breeding
			Glaucous-winged Gull	Breeding
			Pelagic Cormorant	Breeding
			Pigeon Guillemot	Breeding

TABLE 5.6.2.2

SUMMARY OF IMPORTANT BIRD AREAS (IBAS) WITHIN THE RSA FOR MARINE TRANSPORTATION (continued)

Identification Number	Site Name	Description	Bird Species	Seasonality
Canada				
BC073	Carmanah Walbran Forest	This large forested IBA (approximately 250 km²) is generally located inland on the west coast of Vancouver Island and includes Carmanah Walbran Provincial Park.	Marbled Murrelet	Breeding
BC097	Amphitrite and Swiftsure Banks	This relatively large IBA comprises two separate water bodies located west of Vancouver Island: one in and around Amphitrite Bank, and the other around Swiftsure Bank. Only the Swiftsure Bank portion of this IBA (approximately 20 km²) is within the boundaries of the RSA.	Black-legged Kittiwake	Not Specified
			California Gull	Other
			Cassin's Auklet	Other
			Common Murre	Not Specified
			Glaucous-winged Gull	Not Specified
			Herring Gull	Not Specified
			Northern Fulmar	Other
			Rhinoceros Auklet	Not Specified
			Sabine's Gull	Other
			Sooty Shearwater	Other
Thayer's Gull	Not Specified			
Tufted Puffin	Not Specified			
United States				
USWA277	Drayton Harbor / Semiahmoo	This IBA is a relatively small and relatively enclosed water body (approximately 6.5 km²) comprising Drayton Harbor in Blaine, Washington. It is located east of Semiahmoo Bay and generally enclosed by the Semiahmoo Spit.	Bald Eagle Black Scoter Common Loon Greater Scaup Harlequin Duck Horned Grebe Long-tailed Duck Peregrine Falcon Red-necked Grebe Surf Scoter White-winged Scoter	Not Specified
USWA282	Lower Dungeness Riparian Corridor	The Lower Dungeness Riparian Corridor IBA includes the Dungeness River, adjacent riparian forest and estuary. This relatively small IBA (less than 5 km²) is located in Dungeness, Washington.	American Dipper Bullock's Oriole Cedar Waxwing Olive-sided Flycatcher Red-eyed Vireo Warbling Vireo Willow Flycatcher	Not Specified
USWA288	Protection Island	This very small IBA (1 km²) comprises Protection Island located approximately 3 km off Diamond Point, Washington.	Double-crested Cormorant Glaucous-winged Gull Pelagic Cormorant Pigeon Guillemot Rhinoceros Auklet Tufted Puffin	Not Specified

TABLE 5.6.2.2

SUMMARY OF IMPORTANT BIRD AREAS (IBAS) WITHIN THE RSA FOR MARINE TRANSPORTATION (continued)

Identification Number	Site Name	Description	Bird Species	Seasonality
United States				
USWA3289	Deception Pass	The Deception Pass IBA is a very small IBA (1 km ²) comprising the water body located between Whidbey Island and Fidalgo Island, Washington.	Black Oystercatcher Pigeon Guillemot Red-throated Loon	Not Specified
USWA3347	Samish / Padilla Bays	This large IBA (approximately 240 km ²) comprises Samish and Padilla Bays, located in proximity to Anacortes, Washington.	Black Oystercatcher Brant Dunlin Great Blue Heron Marbled Murrelet Red-necked Grebe Trumpeter Swan Western Grebe	Not Specified
USWA3348	Olympic Continental Shelf	The Olympic Continental Shelf IBA is very large IBA (2,200 km ²) generally comprising marine environments. It includes two general areas, one located in the Juan de Fuca Strait, the other in the Pacific Ocean. In the Juan de Fuca Strait, it follows the northwestern shoreline of Washington State, from the city of Port Angeles west to Cape Flattery extending a few kilometers from the mainland. From Cape Flattery, it then extends south to Taholah (located approximately 50 km northwest of Aberdeen, Washington), extending to the edge of the continental shelf, approximately 55 km from the mainland.	Black-footed Albatross Brandt's Cormorant Brown Pelican Cassin's Auklet Common Murre Leach's Storm-Petrel Marbled Murrelet Pelagic Cormorant Pink-footed Shearwater Rhinoceros Auklet Sooty Shearwater South Polar Skua Tufted Puffin	Not Specified
USWA3351	Port Angeles Harbor / Ediz Hook	This IBA is relatively small (approximately 5.5 km ²) comprising Port Angeles Harbor bordered to the north by Ediz Hook.	Heermann's Gull Thayer's Gull	Not Specified
USWA3786	Sequim Bay	The Sequim Bay IBA (approximately 60 km ²), located less than 5 km east of Sequim, Washington encompasses the open waters and intertidal zones of Sequim Bay and is partially enclosed by Travis Spit and Gibson Spit.	Black-bellied Plover Dunlin Heermann's Gull	Not Specified

Sources: Canada: IBA Canada Site Summaries (2012).

United States: Audubon Important Bird Areas Profiles (2013).

The ERA marine bird ecological receptor group is represented in the EVOSTC literature by a variety of species including: cormorants and loons are (listed as “recovered”); black oystercatcher, harlequin duck and Barrow’s goldeneye (“recovering”); Kittlitz’s murrelet and marbled murrelet (“unknown”); and pigeon guillemot (“not recovering”) (EVOSTC 2010; Table 5.6.2.1).

For the marine bird species listed as “recovering” the limiting factor in each case appears to be concern about exposure to lingering oil at sites that represent a small proportion of the available habitat. Only nine carcasses of adult black oystercatchers were recovered following the EVOS, and although the actual number of mortalities may have been several times higher, this represents a small fraction of the population of 1,500 to 2,000 black oystercatchers breeding in south-central Alaska. It is estimated that about 1,000 harlequin duck (about 7 per cent of the wintering population) were killed by oil exposure at the time of the spill. Similarly, an unknown number of Barrow’s goldeneye died as a result of oil exposure, but population-level effects of oil exposure have not been documented since 1990. The listing of these species as “recovering” reflects a measured metabolic response linked to oil exposure (cytochrome P450 induction), but it is not clear whether this has affected on survival, growth or reproduction of individuals, or translates into a population-level effect. Harwell and Gentile (2006) noted that by 1993 population numbers for harlequin duck equalled pre-spill population numbers, and that the area of habitat affected by sequestered oil was so small in relation to the available habitat that no plausible risk remains to the harlequin duck population. The same rationale would also apply to black oystercatcher and Barrow’s goldeneye.

Recovery of marine bird populations following the EVOS was generally rapid and uncomplicated. A major factor causing the EVOSTC to identify certain bird populations as “recovering” rather than “recovered” has been evidence of low-level exposure to hydrocarbons from cytochrome P450 testing. While this measure can identify exposure, it does not identify effects of hydrocarbon exposure on individuals or at a population level. It is reasonable to expect marine bird recovery at a population level within two to five years following a large oil spill.

d. Marine Mammals

The marine waters of the study area provide habitat for a variety of marine and semi-aquatic mammals including:

- terrestrial mammals such as bears and moose, which may frequent and be exposed to oil in shoreline areas, depending upon the availability of food resources they may be seeking;
- pinnipeds, including Steller sea lion and harbour seal;
- cetaceans, including but not limited to southern resident killer whale, humpback whale, various dolphins and porpoises, and other species; and
- river otter, mink and potentially sea otter, which are highly dependent upon the insulative value of their fur, and which are potentially exposed to high rates of oil ingestion through grooming, if their fur becomes oiled.

Aquatic mammals such as otters and mink that rely upon fur for insulation in cold ocean water are extremely sensitive to oiling, as well as having potentially high exposure to oil ingestion, if coastal habitat is oiled. Mammals that rely upon blubber for insulation are less sensitive to

external oiling, although the potential for mortality cannot be ruled out due to other exposure pathways or mechanisms.

Oil ingestion remains a potentially important exposure pathway, and fouling of baleen plates can have adverse effects on baleen whales, although this would not be a problem for toothed whales.

Wildlife species that are normally terrestrial (such as bear and moose) could potentially be exposed to oil that strands along shorelines, or accumulates in coastal marshes or estuaries. External oiling and oil ingestion are a possibility for these animals, although these exposures are not likely to result in mortality.

For the ERA marine mammal receptor, a low sensitivity (BSF 1) is assigned to wildlife species that are normally terrestrial. The medium sensitivity (BSF 2) is assigned to pinniped species, such as seal and sea lions. Whales are assigned a high sensitivity rank (BSF 3) and species such as sea otter, river otter and mink that rely upon fur for insulation in cold ocean water are extremely sensitive to oiling, as well as having potentially high exposure to oil ingestion are assigned a very high sensitivity (BSF 4).

The ERA marine mammal ecological receptor group is represented in the EVOSTC literature by a variety of species, including harbour seal and river otter (“recovered”), sea otter and killer whale – AB Pod (“recovering”) and killer whale – AT1 Population (“not recovered”; Table 5.6.2.1).

Sea otters were severely affected by the EVOS, with a large number of carcasses being collected throughout the spill area. No apparent population growth occurred for Prince William Sound sea otters between 1989 and 1991. Since that time, areas that were heavily oiled have shown slower rates of population increase than less-oiled areas (EVOSTC 2010). Since 2004; however, even cytochrome P450 biomarker results for sea otters from oiled and unoled areas have been similar, and population trends in oiled areas have been positive. Harwell and Gentile (2006) concluded that at the scale of Prince William Sound, sea otter populations had returned to, or may exceed pre-spill numbers, and that no continuing ecologically significant effects persisted.

The effects of the EVOS on killer whales are complex and controversial. Two whale groups have received intensive follow-up since the EVOS: the AB pod (resident) and the AT1 population (transient). Resident killer whales feed primarily on fish (especially salmon), whereas transient killer whales feed primarily on seals. Despite being called transient, the AT1 pod appeared to range only through the Prince William Sound and Kenai Fjords region. Both groups lost members and exhibited higher than expected mortality rates following the EVOS, and it is possible that direct inhalation of vapours may have been a cause of mortality for some whales, as they were observed swimming in the freshly-spilled oil near the Exxon Valdez at the time of the spill.

The EVOSTC (2010) has established recovery objectives for killer whales that are specific to these two groups (*i.e.*, a return to the pre-spill number of 36 members in the AB pod, and a stable population trend in the AT1 population). These objectives may not account for natural variability, and both groups of whales were and continue to be subject to pressures external to the EVOS. Harwell and Gentile (2006) note that the AB pod clearly lost members following the EVOS, but this was the exception to the trend in the overall Prince William Sound population of killer whales, which rose from 117 in 1988 to 155 in 2003. Effects of the EVOS on the AB pod may also be compounded by stress introduced to this pod by conflict with the longline fishery

prior to the EVOS (Harwell and Gentile 2006). The AB pod was also reported to split into two distinct units subsequent to 1990 (EVOSTC 2010). The AT1 population of killer whales is also subject to external pressures. This group of whales, which feeds preferentially on seals, has been exposed to dietary intakes of PCBs, DDT and DDT metabolites and carries levels of these substances in blubber that cause reproductive problems in other marine mammals (EVOSTC 2010).

Harwell and Gentile (2006) concluded that there is no plausible risk to killer whales from residual toxicity associated with the EVOS, and that such effects were limited to certain groups of whales, even at the time of the spill. The larger populations of both resident and transient killer whales did not show effects, and are showing increase.

Evaluating the recovery of marine mammal populations following the EVOS has been complex. River otter and harbour seal populations appeared to recover quickly. One factor causing the EVOSTC to identify sea otter populations as “recovering” rather than “recovered” has been evidence of low-level exposure to hydrocarbons based on cytochrome P450 testing. While this measure can identify exposure, it does not confirm effects of hydrocarbon exposure on individuals or at a population level. As discussed previously, recovery conclusions for killer whales are complicated by a focus on specific whale groups that are subject to additional stressors and have not recovered, in contrast with population-level trends which are increasing. On balance; however, it is reasonable to expect marine mammal recovery at a population level within five to ten years following a large oil spill.

Hypothetical Oil Spill Scenarios

No hypothetical scenario can represent all potential environmental and socio-economic outcomes, but scenario-based hydrocarbon spill evaluations can provide decision makers and resource managers with a clearer understanding of potential effects pathways, the range of potential outcomes, vulnerable resources, and spill preparedness and response priorities and capabilities. Stochastic oil spill fate modeling completed for three of the four hypothetical spill locations described in Section 5.4 (Figure 5.5.2) was used to evaluate potential ecological effects with a preliminary quantitative ERA (Buoy J) (Location H) was excluded because results of the Strait of Georgia (Location D), Arachne Reef (Location E) and Race Rocks (Juan de Fuca Strait, Location G) reflect the range and extent of ecological effects that could result from a spill along the shipping route a Project-related tanker would travel. The discussion provided in Section 5.5 describes the spill response measures that would be undertaken by the ship owner, WCMRC, CCG and Transport Canada to respond quickly to an accidental oil spill thus minimizing the adverse environmental and socio-economic effects potentially resulting from an accidental oil spill in the Salish Sea area.

The six hypothetical oil spill scenarios evaluated in the ERA are summarized in Table 5.6.2.3. These include scenarios at three locations along the marine transportation route, representing two crude oil spill volumes: a credible worst case spill of 16,500 m³; and a smaller volume of 8,250 m³ (see Section 5.2). Each hypothetical spill scenario was evaluated under a range of environmental conditions, including winter, spring, summer and fall. Stochastic spill modelling results are summarized in Section 5.4.

ERA results for the Strait of Georgia, Race Rocks and Arachne Reef scenarios are described in Sections 5.6.2.2, 5.6.2.3 and 5.6.2.4, respectively. An overall summary of potential marine spill ecological effects is provided in Section 5.6.2.5.

TABLE 5.6.2.3

SUMMARY OF HYPOTHETICAL MARINE TRANSPORTATION OIL SPILL SCENARIOS

Scenario	Seasonal Condition	Incident Summary	Release Volume (m ³)	Representative Crude Oil
1	Winter	Strait of Georgia (Location D) - Main ferry crossing. Collision with crossing traffic from Fraser River and ferries is a low probability event, but considered because of higher number of crossings per day. - See Section 5.6.2.2	16,500 m ³	Cold Lake Winter Blend
	Spring			
	Summer			
	Fall			
2	Winter	Arachne Reef (Turn Point SOA, Location E) - 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 value. - See Section 5.6.2.4	8,250 m ³	Cold Lake Winter Blend
	Spring			
	Summer			
	Fall			
3	Winter	Race Rocks (Juan de Fuca Strait, Location G)- 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. - See Section 5.6.2.3	16,500 m ³	Cold Lake Winter Blend
	Spring			
	Summer			
	Fall			
4	Winter	Arachne Reef (Turn Point SOA, Location E) - 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 value. - See Section 5.6.2.4	8,250 m ³	Cold Lake Winter Blend
	Spring			
	Summer			
	Fall			
5	Winter	Race Rocks (Juan de Fuca Strait, Location G)- 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. - See Section 5.6.2.3	16,500 m ³	Cold Lake Winter Blend
	Spring			
	Summer			
	Fall			
6	Winter	Arachne Reef (Turn Point SOA, Location E) - 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 value. - See Section 5.6.2.4	8,250 m ³	Cold Lake Winter Blend
	Spring			
	Summer			
	Fall			

5.6.2.1.2 Exposure and Hazard/Effect Assessment

The ERA exposure and hazard/effects assessment stage identified the probability of oiling at any given location within the modelling area. A low probability of oil exposure was assigned to areas having <10 per cent probability. Areas having a probability of ≥10 per cent but <50 per cent were assigned a medium exposure probability. A high exposure probability was assigned to areas having a probability of oiling ≥50 per cent but <90 per cent, and a very high exposure probability to areas having a probability of oiling ≥90 per cent.

Probability of oiling contours were superimposed on ecological resource sensitivity maps to quantify the length of shoreline (km) or the area of a particular habitat type (km²) that is potentially affected at low, medium, high or very high probability levels. Because a low probability of oiling indicates that oil exposure is unlikely, the ERA focused on areas having medium, high or very high probability of oil exposure. Analyses were summarized in tabular format, so that the quantity of habitat exposed to different probabilities of oiling could be quantified, and then compared to the total amount of that habitat within the RSA. This approach was repeated for each biological sensitivity rank and each season (Ecological Risk Assessment of Marine Transportation Spills Technical Report [Volume 8B, TR 8B-7]).

5.6.2.1.3 Risk Characterization

The ERA risk characterization stage considered the biophysical characteristics of the marine environments along with results of the exposure and hazard/effects assessments to define risk for each ecological receptor type. The potential ecological consequence of crude oil exposure at any given location were considered to be the product of the probability of oil presence, and the sensitivity of the receptor or supporting habitat that may be present at that location with results expressed in terms of probability ranges.

Potential ecological effects from accidental oil spills were evaluated using a different approach than potential effects from routine Project activities. Project construction or operation activities can usually be described with a high level of confidence. In contrast, serious accidents such as grounding or collision of a tanker with another vessel are expected to have a very low probability of occurring and spills may or may not result from these incidents (Section 5.2). All of the residual environmental effects of an accident leading to a crude oil spill were assumed to be of negative impact balance. ERA conclusions were expressed in terms of the spatial extent of effects and time to recovery of the environmental effects for each ecological receptor. Qualitative magnitude (or degree of injury) ratings were based on the following definitions:

- Negligible: a change from existing conditions that is difficult to detect; or a very low probability that an ecological receptor will be exposed to spilled oil.
- Low: a change that is detectable, but that remains well within regulatory standards; or a situation where an ecological receptor is exposed to spilled oil, but the exposure does not result in serious stress to the receptor.
- Medium: a change from existing conditions that is detectable, and approaches without exceeding a regulatory standard; or a situation where an ecological receptor is stressed, but does not die as a result of exposure to spilled oil.
- High: a change from existing conditions that exceeds an environmental or regulatory standard; or a situation where a species of management concern dies as a result of exposure to spilled oil.

The temporal context of environmental effects is also important. Rather than focusing on the duration and frequency of accidents, the effects assessment considered the reversibility, and in particular to the expected time to recovery for each ecological receptor in the event of exposure to spilled oil. The recovery assessment phase considered the potential beneficial effects of remediation (such as oil spill cleanup activities) that would be applied following an oil spill to promote biological recovery of affected ecological receptors (Ecological Risk Assessment of Marine Transportation Spills Technical Report [Volume 8B, TR 8B-7]).

5.6.2.1.4 ERA Certainty and Confidence

When conducting ecological risk assessments, it is standard practice to implement conservative assumptions (*i.e.*, to make assumptions that are inherently biased towards safety) when uncertainty is encountered. This strategy generally results in an overestimation of actual risk. For this ERA, prediction confidence is based on the following factors:

- environmental fate modeling;

- selection of marine ecological receptors and derivation/assignment of biological sensitivity factors; and
- exposure and hazard assessment.

In the event of an oil spill, the fate and effects would be strongly determined by specific characteristics of the oil, environmental conditions, and the precise locations and types of organisms exposed. The goal of ERA scenario modelling investigations was not to forecast every situation that could potentially occur, but to describe a range of possible consequences so that an informed analysis can be made as to the likely effects of oil spills under various environmental conditions.

Ecological receptors were selected to represent species believed or known to be sensitive to spills, and which act as indicators of overall environmental health. Each of the four ecological receptor groups includes a variety of individual receptors and/or habitats with differing sensitivity to oil exposure. For this reason, each receptor group was divided into sub-categories that reflected their sensitivity to oil exposure. For nearshore and shoreline littoral (intertidal) habitats, biological sensitivity factors were based on habitat complexity and ability of different habitat types to sustain high levels of biodiversity and productivity. For the marine fish community and marine fish habitat receptor, biological sensitivity factors were based on water depth with the highest biological sensitivity class reserved for developing eggs and embryos in shallow water habitat. For marine birds and marine bird habitats, and marine mammals the classification scheme considered lifestyle, behaviour, and exposure mechanisms, and in particular the role of fur or feathers in providing thermal insulation.

The recovery assessment was carried out primarily based on the recovery of ecological receptors following the 1989 EVOS. That oil spill, while a major disaster caused by the grounding of a large single-hulled oil tanker, shows that marine ecosystems do recover from the effects of oil spills. Most of the instances of delayed recovery are associated with the effects of lingering or sequestered oil affecting a small area of habitat, or relate to effects on specific groups of whales which experienced harm from which they may not fully recover, but which are compensated for by gains made by other groups in the region. The EVOS was also an important learning experience in terms of oil spill response, and some of the oil spill response strategies that were employed at that time were found to be inappropriate. Current oil spill response planning and deployment incorporates those lessons, so that better outcomes can be expected than were observed at some sites following the EVOS. For the four ecological receptor groups considered here: shoreline habitats; marine fish community; marine birds; and marine mammals, recovery predictions and time to recovery are based upon relevant real-world experience, and are accorded a high level of confidence.

A summary of ERA results for the three marine tanker spill scenarios is provided below. Additional information is contained in Ecological Risk Assessment of Marine Transportation Spills Technical Report (Volume 8B, TR 8B-7).

5.6.2.2 *Location D: Strait of Georgia*

The Strait of Georgia (Location D) credible worst case and smaller spill scenarios are described in Sections 5.4.4 and 5.6.2.2 (Figure 5.5.2). This discussion begins with a summary of the modelled fate and behaviour of oil spilled as a result of this hypothetical scenario, specifically relating to the probability of surface oiling and shoreline oiling. Potential effects on each of the four ecological indicators are then described. Additional information is contained in Ecological Risk Assessment of Marine Transportation Spills Technical Report (Volume 8B). While not