Hearing Order OH-001-2014
Trans Mountain Pipeline ULC
Application for the Trans Mountain Expansion Project

Written Evidence of the Raincoast Conservation Foundation,
prepared under the direction of Dr. Paul Paquet, Senior Scientist,
Raincoast Conservation Foundation

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RAINCOAST
CONSERVATION FOUNDATION

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I. Introduction

1.0 Raincoast Conservation Foundation (Raincoast)

1. Raincoast is a not for profit organization dedicated to using conservation science to protect the land, waters and wildlife of coastal British Columbia. It is a team of conservationists and scientists. Since 1996, Raincoast scientists have conducted research in coastal and inland British Columbia, focusing on wild salmon, marine mammals, seabirds, and large terrestrial carnivores. Raincoast's staff scientists supervise and collaborate with graduate students, doctoral fellows, and work with professors to produce peer reviewed publications. Raincoast operates a laboratory at the University of Victoria, a research station on Denny Island, and a Canadian Coast Guard-certified research vessel. Raincoast's research has resulted in numerous peer-reviewed publications of direct relevance to the issues and geographic area affected by the Trans Mountain Expansion Project (the Project).

2. Raincoast scientists have previously provided expert evidence in the National Energy Board's review of the Northern Gateway Pipeline Project (Northern Gateway), in other hearing processes such as the Cohen Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River, and in court cases.

1.1 Raincoast's concerns about the Project

3. As a conservation organization, Raincoast is concerned about the Project's potential adverse effects on a broad range of aquatic, terrestrial, and avian species, as well as the integrity of the lands, waters, and ecological systems that support them. The uncertainty of how species and systems will respond to the changing climate reinforces our concerns. In particular, we are apprehensive about the great whales that live in and near and migrate through the Salish Sea, as several are already at risk and in some cases information about their biological status is lacking.

4. While Raincoast has many concerns about the Project, the focus of its evidence will be on the marine impacts, and specifically impacts on Southern

Resident Killer Whales, Fraser River salmon, and Pacific herring and other forage fish.

1.2 Raincoast's evidence and information about the Project

5. Raincoast submits this statement of written evidence, prepared under the direction of Dr. Paul Paquet[1], which consists of the following reports and statements of evidence with respect to the proposed Project's impacts on Pacific herring and other forage fish, Southern Resident Killer Whales, salmonids, and forage fish:

a) The evidence of Dr. Caroline Fox concerning impacts to Pacific herring and other forage fish (Attachment A);

b) The evidence of Kate Logan, David Scott, Andrew Rosenberger and Misty MacDuffee concerning impacts to Fraser River salmon (Attachment B); and

c) A backgrounder on the Southern Resident Killer Whales (Southern Residents) and threats facing them (section IV below), which attaches:

    i. The Fisheries and Oceans Canada 2011 Recovery Strategy for the Southern Resident Killer Whales (Attachment C);

    ii. The evidence of Dr. Christopher Clark, concerning acoustic impacts of vessel traffic on Southern Residents (Attachment D); and

    iii. The evidence of Dr. Robert Lacy, Kenneth Balcomb, Dr. Lauren Brent, Dr. Darren Croft, Dr. Christopher Clark and Dr. Paul Paquet, which is a population viability assessment of the Southern Residents (Attachment E).

[1] Dr. Paquet was accepted by the Northern Gateway Panel as an expert to give evidence in wildlife biology and ecology. His curriculum vitae is appended to Attachment E (the Population Viability Assessment).

II. Impacts on Pacific Herring and Other Forage Fish

6. The report of Dr. Caroline Fox[2] assesses the potential impacts of the Project on Pacific herring and other forage fish (the "Forage Fish Report"). The report is attached as **Attachment A** to this statement of written evidence.

2.0 Scope of the Report

7. The Forage Fish Report is a review and critique of the Project Application as it applies to Pacific herring and other forage fish. It provides an introduction to these species and to the way they are considered in the Project Application. It evaluates the Project Application's choice of Pacific herring as an indicator species for marine fish and habitat, and addresses deficiencies in the methodology used to assess impacts on Pacific herring and other forage fish in the Application. The report also identifies pathways by which the Project could affect these species.

2.1 Summary of Impacts on Herring and Other Forage Fish

8. The Forage Fish Report identifies problems with the Application's use of Pacific herring as an indicator species for marine fish and habitat, including information limitations. It identifies deficiencies in the methodology used in the Application, including the measurement endpoints (or, factors used to measure effects), which exclude consideration of underwater noise impacts or the impacts of chronic oil spills; the assumption that species' sensitivity to oil exposure depends only on the amount of habitat oiled (as opposed to different species and communities having varying sensitivities), which the report finds is an overly simplistic approach and not supported by scientific evidence; and the Application's failure to assess subsurface oil, which is a failure to address a potential mechanism for oil exposure.

9. The Forage Fish Report examines three pathways by which the Project could have effects on Pacific herring and other forage fish, which the Application considers only minimally or not at all: underwater noise, chronic oil spills, and

[2] Dr. Fox was accepted by the Northern Gateway Panel as an expert in biology of herring and marine birds. Her curriculum vitae is appended to the Forage Fish Report.

large oil spills. Regarding underwater noise, the Application fails to consider behavioural changes beyond large-scale displacement. The Application ignores existing evidence on chronic oil spills, and thereby minimizes existing hazards faced by wildlife and fails to identify chronic oil spills as a potential Project-related effect.

10. The Forage Fish Report concludes that Project-related impacts to Pacific herring and other forage fish could cause impacts across the food web, thereby increasing the contamination of upper-level predators through the process of biomagnification.

III Impacts on Salmon

11. The report of Kate Logan, David Scott, Andrew Rosenberger and Misty MacDuffee[3] assesses the possible impacts of the Project on the numerous important fish populations in the Fraser River, and in particular salmon (the "Salmon Report"). The Salmon Report is attached as **Attachment B** to this statement of written evidence.

3.0 Scope of the Report

12. The Salmon Report examines the potential consequences to Fraser River salmon and other important fish populations (including species at risk) from exposure to oil spilled from a pipeline rupture into the lower Fraser River or from an oil tanker in the Salish Sea. In doing so it explains relevant properties of different oil products and their fate and distribution following a spill in a river. It describes the lower Fraser River in terms of its role as fish habitat and describes the diversity of species that use it, the ways in which they might be exposed to spilled oil, and the consequences of oil toxicity to their survival and to the abundance of fish populations. It also addresses cumulative effects, including other historic and current uses of the Fraser River. It also outlines specific omissions and failures in the Project Application.

[3] Ms. MacDuffee was accepted by the Northern Gateway Panel as an expert in salmonid biology and ecology. Her Curriculum vitae, along with those of the co-authors, is appended to the Salmon Report.

3.1 Summary of Impacts on Salmon of an Oil Spill into the Lower Fraser River from a Trans Mountain Pipeline Rupture

13. The Salmon Report finds that the Fraser and its tributaries are used by dozens of fish species throughout the year either for incubating eggs and embryos, as juveniles for rearing and overwintering, and as adults for migration and spawning. For salmon, the Lower Fraser River acts as a bottleneck through which the entire diversity of Fraser River salmon populations must pass twice during their lifetime. Many depend heavily on Lower Fraser habitats for spawning, incubation and rearing. The report concludes that, due to the large diversity of species of salmonids and other fish that use the lower Fraser River and estuary habitat and their different life histories, there is no safe time of year when the impacts of a spill in the River would be low. A spill during peak migration of economically important or at risk species could be devastating to those populations.

14. The Salmon Report also finds that a spill in the Salish Sea has the potential to accumulate in rearing habitat for Fraser River Salmon and other important salmon populations that rear and migrate in the Salish Sea. Such a spill also has the potential to reach the outer shoreline of the estuary and to be carried into the river as far as New Westminster, depending on the season.

15. The Salmon Report finds that oil could harm salmon due to immediate fish kills during acutely toxic conditions in the first 24-48 hours of a spill or due to oil that is weathered and distributed in the environment which poses a risk of ongoing exposure to toxicity. Weathered oil may form stable emulsions and may submerge, becoming entrained in river bed sediment, where it poses a risk to developing salmonids and may remain for months to years.

IV Impacts on Southern Resident Killer Whales

16. Of particular concern to Raincoast are the Project’s potential impacts on vulnerable marine species such as the endangered Southern Resident Killer Whale. Raincoast has commissioned two expert reports which analyse these impacts. The first, authored by Dr. Christopher Clark, looks at the acoustic disturbance from vessel traffic. The acoustic impacts report is **Attachment D** to this statement of

written evidence. The second, authored by Dr. Robert Lacy, Kenneth Balcomb, Dr. Lauren Brent, Dr. Darren Croft, Dr. Christopher Clark and Dr. Paul Paquet is a population viability analysis which models the increased risk to the long term viability of the Southern Residents population from three threats associated with the marine shipping component of the Project: an oil spill, increased acoustic and physical disturbance from ships, and ship strikes (the "Population Viability Assessment" or "PVA"). The PVA is **Attachment E** to this statement of evidence.

17. These reports are best understood in the context of the Southern Residents' current conservation status and an understanding of the full suite of threats threatening their survival and recovery, many of which will be exacerbated by the Project. This background contextual evidence is presented below in this statement of evidence in the following sections:

- The Southern Residents' endangered status (4.0);
- A description of killer whales generally and the Southern Resident population specifically, including their social organization, lifespan, and reproductive characteristics (4.1);
- The geographical distribution of the Southern Residents, their critical habitat, and the significance of prey to distribution and critical habitat (4.2);
- The population's size and changes over time (4.3);
- The vulnerability of small populations (4.4);
- The main threats to the population (4.5), including the separate report by Dr. Clark on acoustic impacts of vessels (Attachment D); and
- The cumulative effect of threats and viability of the population (4.6), including the separate report by Dr. Lacy and others (Attachment E).

18. The Southern Resident Killer Whales are the world's most studied group of orcas. Once abundant throughout the waters of the Pacific Northwest, the Southern Residents are now one of the most imperilled killer whale populations in the world. The Southern Residents are listed as endangered species under Canadian and U.S. law due to their genetic and cultural distinctiveness, small population

size, low reproductive rate, and the presence of various anthropogenic (human caused) threats that have the potential to prevent recovery or to cause further declines. Vulnerability to oil spills and disease are significant concerns. (COSEWIC 2008, National Marine Fisheries Service 2008). Both the Canadian and U.S. Southern Resident recovery strategies identify 3 major human caused threats thought to have contributed to past declines and deemed to be currently responsible for impeding recovery: physical and acoustical disturbances caused by marine traffic and other industrial activities, nutritional stress from inadequate prey availability, and exposure to environmental contaminants. Notably, these environmental disturbances, independently and combined, harm the whales and degrade their critical habitat, thereby jeopardizing their survival (National Marine Fisheries Service 2011, COSEWIC 2008, Fisheries and Oceans Canada 2011). Critical habitat is defined as the habitat necessary for the survival and recovery of the Southern Residents (Environment Canada 2004). Canadian and U.S. scientists have designated areas of the Salish Sea as critical habitat of the Southern Residents – including the Southern portion of Georgia Strait, Boundary Pass, Haro, and Juan de Fuca Straits. The proposed shipping route for the oil tankers associated with the Project transects this entire area.

19. The Project is a proposed expansion of an existing pipeline from Edmonton, Alberta to Burnaby, British Columbia. The expanded pipeline will carry diluted bitumen from the oil sands to be loaded onto tankers at the Westridge marine terminal in Burnaby and shipped overseas. Tankers will travel through the Salish Sea and into the open ocean, passing through the critical habitat of the Southern Residents. The marine shipping component of the Project will see a sizable increase in the number and frequency of tankers carrying diluted bitumen through Southern Resident critical habitat. The Project would increase the number oil tankers arriving at the Westridge marine terminal from approximately 5 per month to approximately 34 per month, equivalent to an increase from 120 to 816 tanker transits annually, thereby raising the likelihood of spills and ship strikes, and increasing ocean noise. The Project application states that the additional traffic

will result in an increase of vessel traffic in the shipping lanes of 13.5% over current traffic. As detailed below, the proposed Project will contribute to and exacerbate the three key human caused threats to Southern Residents and their critical habitat: environmental contamination, physical and acoustic disturbance, and reduced prey availability.

4.0 Southern Residents Are an Endangered Species

20. In Canada, the Southern Residents are listed as endangered under the federal Species at Risk Act. An endangered species is defined in the Act as "facing imminent extirpation or extinction". The Southern Residents were designated as an endangered species by the national Committee on the Status of Endangered Wildlife in Canada in 2001 due to their small and declining population, low reproductive rate, and the existence of a variety of anthropogenic (human caused) threats that have the potential to prevent recovery or to cause further declines. Principal among these anthropogenic threats are: environmental contamination, reductions in the availability or quality of prey and both physical and acoustic disturbance.

21. The 2011 Final Revised Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada (the "Recovery Strategy") states that the recovery goal for the Southern Resident population is "to ensure their long-term viability by achieving and maintaining demographic conditions that preserve their reproductive potential, genetic variation, and cultural continuity". The Recovery Strategy is appended as **Attachment C** to this statement of written evidence.

22. In addition, Canada's draft Action Plan (Fisheries and Oceans Canada 2014) for the Southern Residents and the Northern Resident Killer Whales specifies the following objectives as a broad strategy for recovery:

- Ensure that Resident Killer Whales have an adequate and accessible food supply to allow recovery.

- Ensure that chemical and biological pollutants do not prevent the recovery of Resident Killer Whale populations.
- Ensure that disturbance from human activities does not prevent the recovery of Resident Killer Whales.
- Protect critical habitat for Resident Killer Whales and identify additional areas for critical habitat designation and protection.

23. In the U.S., the Southern Resident population is listed as endangered under the Endangered Species Act because it comprises a small number of whales and therefore is vulnerable to the variability in population growth rates arising from random differences among individuals in survival and reproduction within a season (i.e. demographic stochasticity[4]), and to catastrophic events such as oil spills (National Marine Fisheries Service 2008). The recovery goal is to restore the Southern Residents to the point where they no longer require the protections of the Endangered Species Act (National Marine Fisheries Service 2008).

24. The U.S. recovery plan for the Southern Residents provides very specific criteria for recovery, requiring an average population growth rate of 2.3 percent per year for 14 years before the whales can be “downlisted” from their current endangered status, and for 28 years before they can be “de-listed” from protection under the Endangered Species Act (National Marine Fisheries Service 2008).

4.1 Species Description

25. Killer whales (*Orcinus orca*) currently comprise a single species varying regionally in diet, size, colouration, and vocal patterns (Ford et al. 2000, Barrett-Lennard and Ellis 2001, Morin et al. 2010.). Killer whales that share a common range, are morphologically and behaviourally similar, and associate at least occasionally and often form discrete communities. Whales that collectively constitute these identifiable populations are called ecotypes (Barrett-Lennard and Heise 2006). Three distinct forms, or ecotypes, of Pacific killer whale inhabit the

[4] Demographic stochasticity is the random change in population size over time due to variation in individual survival and reproductive success

waters of the coast of British Columbia: transient, offshore, and resident (Bigg et al. 1990, Ford 1989, 1991; Yurk et al. 2002, Hoelzel et al. 1998, Barrett-Lennard 2000, Hoelzel et al. 2002) These 3 ecotypes are sympatric (i.e. overlapping in range without interbreeding) but ecologically, socially, and genetically isolated (Ford et al. 1998, 2000, Barrett-Lennard and Ellis 2001, Morin 2010). Of the three ecotypes, resident killer whales are the most studied. The resident ecotype includes two populations: the Southern Residents and the Northern Resident Killer Whales. These two populations have not been observed interacting and genetic studies confirm they rarely, if ever, interbreed (Barrett-Lennard and Ellis 2001, Morin et al. 2010). The Project will most significantly impact the Southern Residents, but the Northern Residents could be affected as well – in particular by the potential repercussions of a catastrophic oil spill, such as reduced or devastated Chinook salmon stocks.

26. Resident killer whales feed exclusively on fish and cephalopods (such as squid) and travel in acoustically active groups of 10 to 25 or more individuals (Ford et al. 2000). Their collective organization is highly structured and centered on fundamental social units called matrilines, which comprise all existing members of a female lineage. These remarkably stable groups contain up to three generations of maternal descendants of a single living or recently deceased female, with both male and female offspring remaining in their natal matrilines for life (Bigg et al. 1990).

27. Groupings of matrilines that reflect the relatedness of recently diverged matrilines are referred to as pods (Ford and Ellis 2002). Pods that share one or more calls belong to a common clan (Barrett-Lennard and Heise 2006). The Southern Residents comprise a single clan, consisting of three pods, J, K and L pods, which contain 20 matrilines (Ford et al. 2000). Each resident pod has a distinct dialect made up of about a dozen discrete calls (Ford 1989, 1991). These dialects can be distinguished, providing each pod with a unique acoustic signature. Dialects are highly stable over time, likely learned from mothers and associated

kin (Ford et al. 2000). The function of dialects is not entirely understood, although they appear to play an important role in mate selection (Barrett-Lennard 2000).

28. Resident killer whales have the longest post reproductive life span of all nonhuman animals. Females stop reproducing in their 30s to 40s but can survive into their 90s. Resident killer whales are unusual in that mothers maintain strong social relations with their adult sons throughout their lives. Mothers likely increase the survival of their adult sons in a number of ways, including assisting in foraging and providing support during antagonistic encounters (Foster et al. 2012). Post reproductive aged females lead groups during collective movement in salmon foraging grounds. Leadership is especially prominent in difficult years when salmon abundance is low, which is critical because salmon abundance drives mortality and reproductive success in resident killer whales (Brent et al. 2015).

29. Killer whales experience age-specific survival; mortality rates are generally highest among young calves, and lowest among reproductive age females. Survival is sex-specific - male killer whales have higher mortality rates (and decreased life expectancy), compared with females. Killer whales are extremely long-lived and very slow to reproduce. Females give birth to typically only 4 to 6 calves during their 25-year reproductive period (Olesiuk et al. 2005). Olesiuk et al. (1990) found average life expectancy of Resident Killer whales (calculated for whales surviving their first 6 months due to high neonate mortality) was 50.2 years for females and 29.2 years for males. Females lived up to a maximum of 80-90 years and males up to 50-60 years. Notably, one of the oldest adult females included in the 1990 survey is still alive. Having been born around 1911 (about 103 years old), the world's oldest known killer whale belongs to J pod of the Southern Resident population.

4.2 Distribution of Southern Residents

30. The distribution and movements of their prey largely dictate the distribution and movements of cetaceans (whales and dolphins). Other life processes, such as resting, socializing, mating, and calving are undertaken wherever the animals happen to be in order to feed (Bjørge 2002, Hoyt 2005).

31. Although they have an overall range of approximately 2,000 km (Ford 2006), Southern Residents reside in the Salish Sea for 8-9 months each year, largely because of the historical abundance of their preferred prey Chinook salmon. The 3 Southern Resident pods, J, K and L, each form long-term stable groups that frequent the Salish Sea for varying amounts of time from May through October. The pods each have different spatial distributions within summer (Hauser et al. 2007) and occupy the outer coast to differing degrees during winter (Krahn et al. 2004). Of the three Southern Resident pods, J pod is most “resident” to the Salish Sea, intermittently observed throughout the Georgia Basin throughout the year (Ford et al. 2000).

32. During the spring, summer, and fall the Southern Residents’ home range includes the inland waterways of Puget Sound, the Strait of Juan de Fuca, and the Strait of Georgia, where they congregate to intercept and eat migratory Chinook and chum salmon (Ford 2006). During the summer and fall, Southern Residents are primarily found in the trans-boundary waters of Haro Strait, Boundary Pass, the eastern portion of the Strait of Juan de Fuca, and southern portions of the Strait of Georgia. The main area of concentration is Haro Strait and vicinity off southeastern Vancouver Island, but they are commonly seen in Juan de Fuca Strait, and the southern Strait of Georgia (Ford et al. 2000). These areas are identified in the Southern Resident Recovery Strategy as critical habitat. Seasonal occurrence of whales in these habitats is strongly associated with salmon abundance and foraging is the primary activity undertaken there (DFO 2011). These areas are primarily situated on important migratory corridors for Chinook salmon, which make up most of the Southern Residents’ diet.

33. Hauser et al. (2007) found that some parts of critical habitat were used in common by all pods, others were used almost exclusively by individual pods or consistent combinations of pods, suggesting specialization to particular areas.

Importantly, all pods occur in the vicinity of shipping lanes and thus will be affected directly by the Project (Figure 1).

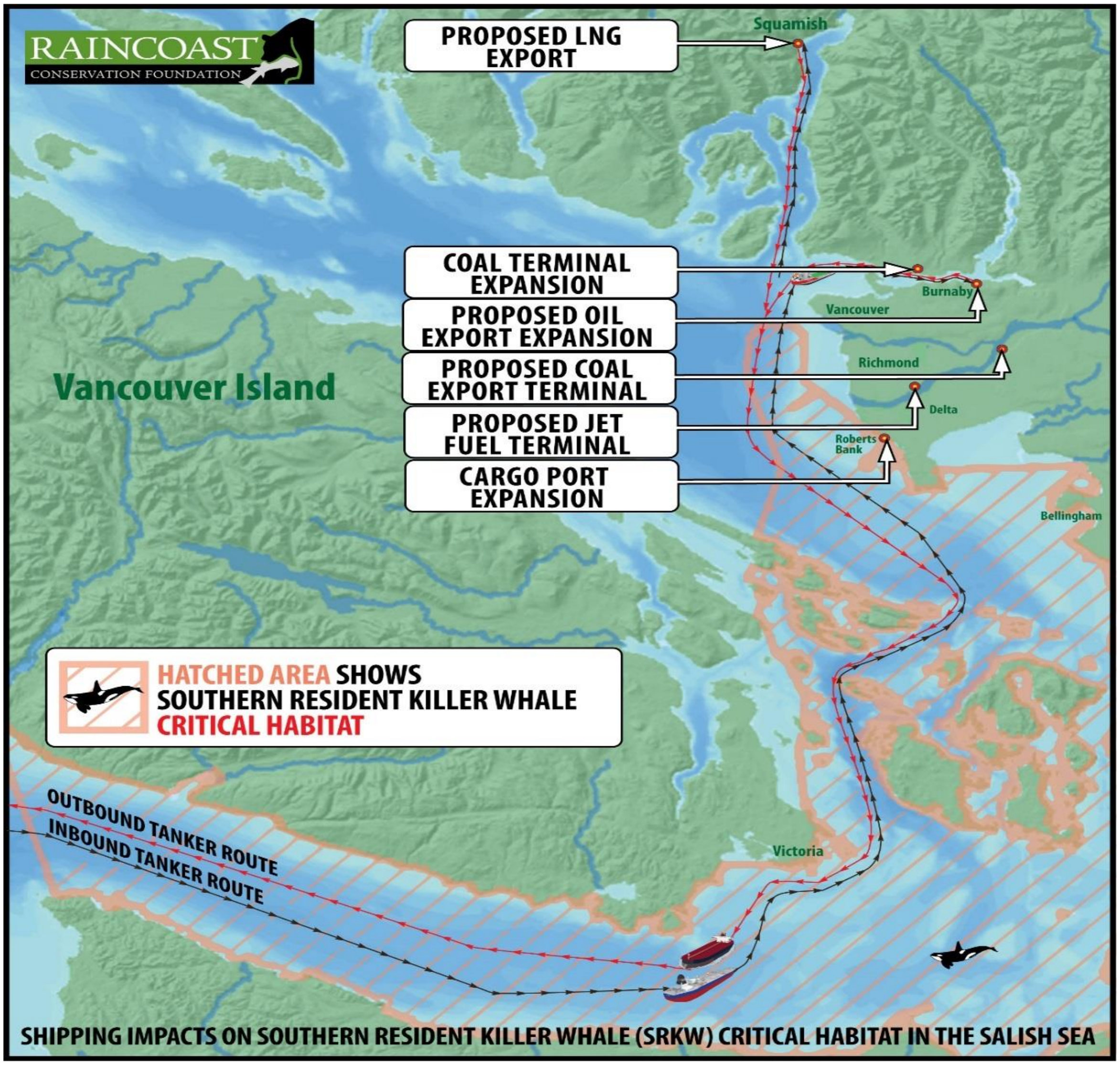

Figure 1. The map shows tanker routes in the Salish Sea and their overlap with critical habitat of the Southern Resident killer whales.

34. The hatched area indicated in Figure 1 is designated as critical habitat for Southern Residents in Canadian and American endangered species legislation based on consistent and prolonged seasonal occupancy. This critical habitat is identified in Canadian and U.S. recovery plans as necessary for the survival and recovery of endangered Southern Residents (Environment Canada 2004, Ford

2006, Fisheries and Oceans Canada 2011, National Marine Fisheries Service 2006 a, b). The proposed route of Project-related tankers transects the entire Salish Sea portion of the Southern Residents' critical habitat (Vol 8A Figure 4.2-22 (PDF 16) Filing ID A3S4X9). The map also identifies other proposed projects which will contribute to a cumulative increase in shipping through critical habitat.

4.3 Population Trends and Status

35. As the most studied and attentively monitored population of killer whales worldwide (K. Balcomb pers. comm.), the size of the Southern Resident community has been known since the first complete photo identification census in 1976, and was estimated for the preceding years (Olesiuk et al. 1990). Population levels of Southern Residents before 1960 are not known with any accuracy, but presumed to be greater than the highest levels observed in the past 55 years (K. Balcomb pers. comm.). Scientists estimate the minimum historical population size of Southern Residents was about 140 animals (NOAA 2014). In the mid-1960s, the population was thought to number about 100 animals.

36. Based on available data from the annual killer whale censuses, the size of the Southern Resident population has fluctuated from a low of less than 67 animals in 1971 to a high of 98 individuals in 1995. During that time, several major declines were documented. The first, caused by live-capture for marine parks, occurred between 1967 and 1973 (Bigg and Wolman 1975). A second decline of 12% occurred between 1980 and 1984. Both declines were followed by periods of growth, with the population ultimately increasing to 98 individuals in 1995. Subsequently, the population declined to 81 animals in 2001 and then increased slowly to 88 animals in 2011, waning again to 79 animals in 2014. Three additional births (2 in J, 1 in L) have occurred thus far in 2015. The declining trends seem to have been influenced primarily by changes in L pod, which is the largest of the 3 pods. In contrast, population growth has primarily reflected increases in J and K pods (K. Balcomb pers. comm.).

37. Notably, population size has remained at less than 100 individuals for the last 4 decades with an average of 85 individuals in the last decade (Vélez-Espino et al.

2013). Population growth rate is most sensitive to changes in adult and juvenile survival. Thus, factors that cause even small changes in survival will have a large impact on population growth. Slight variations in the foraging ability of whales or availability of prey in different core areas among Southern Resident pods may contribute to the observed differences in pod population trends and mortality rates, thus affecting population viability. The L pod, in particular, has lower survival rates than the J and K pods and has the most direct influence on overall Southern Resident population trends, primarily because of its large size (nearly 2 times larger) relative to the other two pods (Ford et al. 2000, Baird 2001, Krahn et al. 2004). Pod-specific trends are important because males rarely mate with females from their own pod and Southern Residents only mate within their own population (i.e. with other Southern Residents). Consequently, the reproductive success of a resident pod is determined not only by the fecundity of the females within that pod but also by the availability of fertile males from other resident pods.

4.4 Vulnerability of Small Populations

38. The Southern Resident population is at additional risk from human caused stressors by virtue of its low population size. Small populations are particularly susceptible to adverse effects of chance variability. This occurs when there is a random drop in birth rate, an increase in death rate, or repeated offspring of the same sex in a generation, all of which can lead to extinction. In addition, when small populations experience random events such as food shortages, disease, or oil spills, the loss of individuals (especially breeding females) can have dire consequences. This underscores the importance of numbers to maintain the resilience and adaptive abilities of populations that face disturbances.

39. Small populations are also vulnerable to reduced genetic variation. By their very nature, small populations are a subset of individuals from what was once a much larger population. As small populations breed, the role of chance error in genetic make-up becomes higher. For populations to adapt and evolve with changing conditions genetic variability must be present. Reducing genetic variation can decrease survival.

40. Random variation in reproduction and survival, genetic drift[5], and environmental change such as increasing ocean temperature or an oil spill can interact to doom a small population to extinction. This is called an extinction vortex, and it is due to a positive feedback loop: the negative consequences of lower effective population size make the population smaller, causing stronger negative effects from habitat degradation or human activity, leading to an even smaller population size (Gilpin and Soule 1986). Chains of events such as these mean that the extinction probability for a small population can be extremely high (Figure 2).

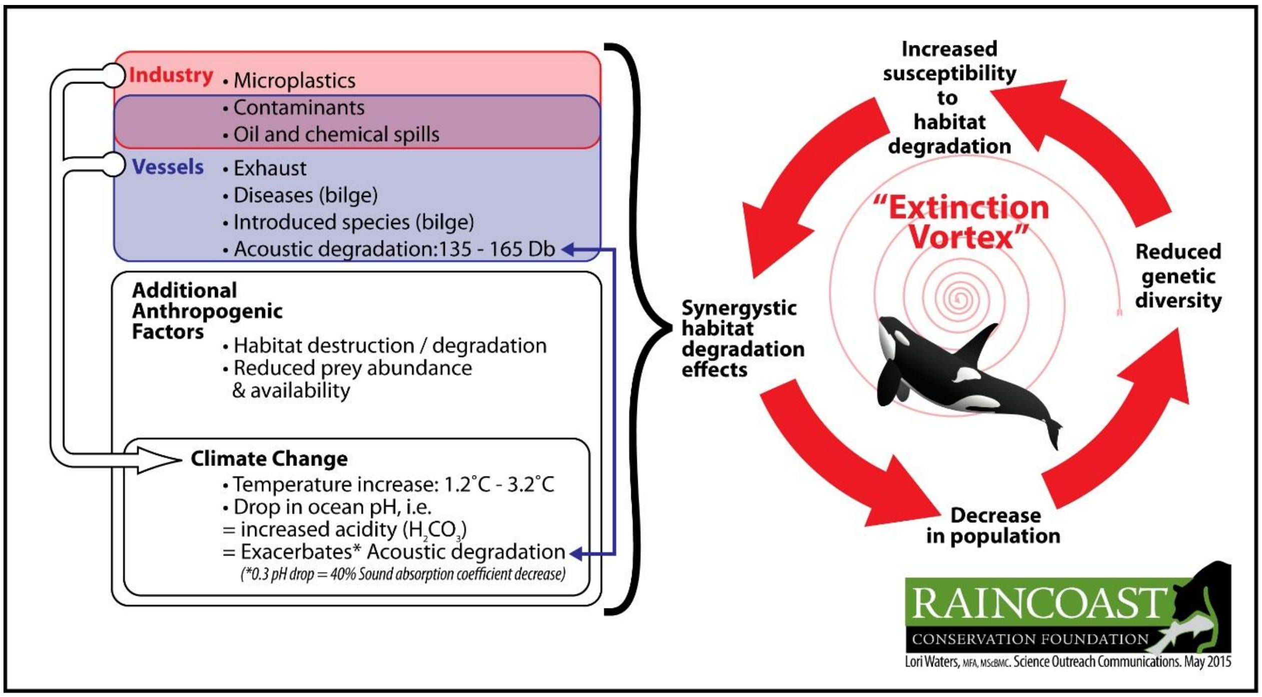

Figure 2. The small and highly vulnerable population of Southern Resident killer whales living in the Salish Sea are subject to multiple threats, which compromise their viability and heighten their risk of extinction. Additional threats of the kind associated with Kinder Morgan's proposal will increase that risk.

[5] Variation in the relative frequency of different genotypes in a small population, owing to the chance disappearance of particular genes as individuals die or do not reproduce.

4.5 Anthropogenic Threats and Stressors

41. Anthropogenic stressors that disturb, harm, and kill have endangered the Southern Residents and placed their viability in serious jeopardy. As with many endangered wildlife populations, the viability and conservation status of the Southern Residents is adversely affected by repeated and multiple human caused disturbances that interact and have cumulative harmful effects.

42. The main factors believed to be impeding recovery and viability of the Southern Residents include physical and acoustical disturbance caused by marine traffic and other industrial activities, nutritional stress from inadequate prey availability, and exposure to environmental contaminants. These threats will be exacerbated by the Project and will be addressed in detail in the subsections below.

43. Other specific disturbances include residual effects of live captures for aquaria on age and sex structure, disease, and changing climate (Fisheries and Oceans Canada 2008, COSEWIC 2008, National Marine Fisheries Service 2008, NOAA 2014, Barrett-Lennard pers. comm., O'Hara pers. comm.). With the exception of past captures for aquaria, these disturbances are not expected to decrease in the foreseeable future, and most will be intensified by the Project.

44. As noted in section 4.3, the size of all three Southern Resident pods were reduced in number from 1965-75 as a result of **whale captures** for marine park exhibition. Of 63 residents estimated to be removed from British Columbia and Washington, 48 were thought to originate from the Southern Resident community (Olesiuk et al. 1990). Removals were heavily biased towards juveniles and young males, thus affecting not only population size but also the structure of the population. These captures substantially reduced the Southern Resident population and altered the sex and age ratio of the Southern Residents, creating a reproductive gap that led to population declines in the 1980s. It took approximately 20 years to return to pre capture levels.

45. **Disease** may interact with other stressors, including Project-related stressors and others described in this section to which the Southern Residents are exposed.

The young, especially newborns, and the old may be most affected by the cumulative effects of multiple stressors (Calzeda et al. 1994). However, any killer whale that has a compromised immune system or is immunosuppressed due to the cumulative effect of several stressors (Sih, et al. 2004, National Marine Fisheries Service 2008) may become infected by inhaling opportunistic pathogens that normally live in their blowholes and upper respiratory tract, by pathogens within the sea surface microlayer they inhale while surfacing to breath, or while sharing a meal of Chinook at the surface (Schroeder et al. 2009). Though relatively little is known about infectious diseases in the Southern Resident population, killer whales are consistently exposed to a variety of biological agents, including viruses, bacteria, fungi, and macroparasites through feeding, breathing and direct contact with air, water, and/or other individuals of their own or other species in the ocean. Humans can unintentionally introduce biological agents directly or indirectly to the marine environment (Daszak et al. 2001; Ross 2002); for example, ballast water discharges can release invasive species acquired by ocean-going vessels into a new environment (Levings et al. 2004).

46. Although the implications of **climate change** for Southern Residents have not been studied in depth, threats that may affect them are increasing temperatures, ocean acidification, sea level rise, range shifts, and altered stream flow and availability and abundance of prey. Prey availability may be affected by increased ocean temperatures changing the behaviour of Chinook and other salmon (Mantua et al. 2010), or by increased river temperatures, which could cause significant Chinook losses (such as 17% by 2100 in a standard warming scenario) due to Chinook’s temperature tolerances (Muñoz et al. 2014). Alterations in stream flow patterns from significant changes in precipitation patterns and increased temperatures in estuarine and marine habitats will also create impediments to salmon survival (Mantua et al. 2009). Ocean acidification may cause changes to nutrient cycling in phytoplankton, which can affect marine food chains, along with increased solubility of calcium carbonate, which is used as a skeletal structure in many marine invertebrates (Doney et al. 2008); this could reduce the marine food

supply to salmon, affecting prey availability. The predicted rise in sea level in the Pacific Northwest could affect Southern Residents in two ways: by destroying estuarine habitat, which most Chinook salmon are dependent upon, and by increasing toxic pollutants due to inundation, erosion, landslides, and increased flood washing coastal debris and toxic waste into the ocean ecosystem (Glick et al. 2007).

47. Several **potential sources of natural mortality** may also affect killer whales, including entrapment in coastal lagoons or constricted bays, accidental beaching, disease, parasitism, biotoxins, and starvation (Baird 2001). Importantly, anthropogenic factors may make killer whales more vulnerable to natural sources of mortality. For example, exposure and accumulation of contaminants may compromise the immune systems of killer whales, making them highly susceptible to diseases and injuries that can result in death. The proximate cause of death, disease or injury, is a natural source of mortality, but the death is ultimately human caused.

4.5.1 Prey Quantity, Quality, and Availability is key to Southern Resident survival and is threatened by the Project

48. Although killer whales feed on a wide range of prey species, the Southern Residents are dietary specialists, feeding primarily on fish (Ford et al. 1998). Resident whales spend about 60% to 65% of daylight hours foraging for fish, with salmon constituting 96% of their diet (Ford and Ellis 2006; Ford et al. 1998). Increasing evidence suggests that killer whales have become prey limited due to reductions of their dominant prey, Chinook salmon (*Oncorhynchus tshawytscha*), and other salmon species constituting smaller portions of their diet. This reduction of prey is attributable to multiple anthropogenic disturbances to the environment, as well as overfishing. The Project could further harm prey availability.

4.5.1.1 Southern Residents' dominant prey species is Chinook salmon

49. During the summer months, Southern Residents eat a diet estimated to be 80–90% Chinook salmon (Ford and Ellis 2006, Hanson et al. 2010). Fraser River Chinook salmon make up the bulk of the whales' summer (May-August) diet

while they are in the Salish Sea. They also consume Chinook from the Columbia, Sacramento, Klamath, and other coastal river systems (NOAA 2014). In the fall and spring the whales eat a wider variety of salmon species, including coho, chum, and steelhead (NOAA 2014). Chum salmon (*O. keta*) is more prevalent than Chinook in the diet in September-October. Coho salmon (*O. kisutch*) are taken in low numbers in June-October. Sockeye (*O. nerka*) and pink (*O. gorbuscha*) salmon are not significant prey species despite their high seasonal abundance.

50. Non-salmonid fish do not appear to currently constitute an important component of the Southern Residents' diet. Bottom fish (including ling cod, kelp greenling and sablefish) and squid might represent an important component of their diet in some areas or during certain times of the year, but determination of their year-round diet has yet to be confirmed. Residents are known to eat one species of squid (*Gonatopsis borealis*) and 22 other species of fish including rockfish (*Sebastes spp.*), Pacific halibut (*Hippoglossus stenolepis*), and Pacific herring (*Clupea pallasi*). There is no evidence of any resident killer whales eating marine mammals.

4.5.1.2 The capacity of the Southern Resident population to expand is limited by reliance on Chinook

51. Long-term demographic studies show that Southern Resident survival (Ford et al 2009), fecundity (Ward et al. 2009), and social cohesion[6] (Parson et al. 2009, Foster et al. 2012) are positively correlated with annual indices of Chinook salmon abundance.

52. Because their diet is highly specialized, this dependence may be a limiting factor for the Southern Residents. Southern Residents likely forage selectively for Chinook salmon over other available salmonids because of their large size and high fat content, and the year-round availability of this species in coastal waters (Ford et al. 1998, Ford and Ellis 2005). Adult Chinook salmon are the largest of the salmonids and have the highest caloric and fat content, which likely explains

[6] **Social cohesion** is defined as the willingness of individual whales to cooperate with each other in order to survive and prosper.

the whales' strong preference for them (Ford and Ellis 2006). Extensive surface observations and collection of prey fragments from sites of kills by resident whales have shown that these whales forage selectively for Chinook salmon regardless of their abundance (Ford and Ellis 2006). Southern Residents are clearly obligate predators of Chinook salmon, and secondarily Chum salmon. They show restricted dietary flexibility and limited ability to switch away from their preferred food, making individuals and populations highly susceptible to shortages of prey.

53. As noted above, habitat designated as critical for Southern Residents is intimately linked to the presence and availability of these preferred prey species. The presence of salmon, particularly Chinook, is linked directly to how, where, and when Southern Residents use critical habitat (Heimlich-Boran 1988, Nichol 1990, Nichol and Shackleton 1996, Osborne 1999). The habitat most important to Southern Residents in the summer and fall are channels, shorelines, or other topographic or oceanographic features that concentrate their migratory prey, salmon (DFO 2011). As noted above in section 4.2, during the summer and fall, Southern Residents are primarily found in the trans-boundary waters of Haro Strait, Boundary Pass, the eastern portion of the Strait of Juan de Fuca, and southern portions of the Strait of Georgia. Reduction in the quantity, quality, and availability of prey within critical habitat threatens its very function, and potentially limits the carrying capacity of the Southern Residents' historical range.

4.5.1.3 Chinook stocks are at a fraction of historic levels and are further threatened by the Project

54. Salmon stocks in BC are declining and, therefore, the availability of prey for Southern Residents is declining. Most Chinook salmon stocks in the eastern North Pacific are at a fraction of their historic levels due to a combination of historical overfishing, degradation and loss of habitat, dams and other blockages to migration, and large-scale climate variation (Gustafson et al. 2007).

55. Climate change is predicted to exacerbate declining salmon stocks. Several studies suggest loss or substantial reduction of salmon stocks from climate change impacts on rivers in North America. In the US, comparisons with climates in past

geological ages (i.e. paleoclimates) suggest possible declines of 30- 60% in salmonids in the Colombia basin due to climate change (Chatters et al. 1995). Other models predict probable salmonid disappearance from the Rocky Mountains (Keleher and Rahel 1996). With the addition of climate change Chinook numbers will continue to decline. Muñoz et al. 2014 predict a 17% chance of catastrophic loss in the Chinook salmon population by 2100 based on the average warming projection of 4 C, with this chance increasing to 98% in the maximum warming scenario of 5.5 C (Dillon et al. 2010).

56. The Project itself also poses additional threats to Chinook salmon. These are addressed in detail in the report of Logan Report on Salmon, which is Attachment B to this statement of written evidence; and in the report of Christopher Clark on acoustic impacts, which is attachment D to this statement of written evidence. As discussed in the Logan Report on Salmon, the Project could have serious adverse effects on salmon stocks in the Fraser River thereby depressing Chinook abundance and thus prey availability. As discussed in the Clark Report on acoustics, the presence of vessels alters fish behaviour potentially making them less accessible to killer whales. Juvenile Pink and Chinook salmon and Atlantic herring show a high probability to changing their schooling behaviour from a loosely formed school to a tight school and to increase their swim speed in response to boat noise. Thus, vessel noise associated with the Project may affect Chinook behaviour and create additional risks for prey availability for Southern Residents.

4.5.2 Environmental Contaminants including oil spills

57. The Project will introduce contaminants into the Salish Sea and thus increase the risk of exposure to marine mammals including killer whales through the chronic discharges of oil and other pollutants such as ballast water, accidental oil spills, and exhaust emissions. This increase in will exacerbate the current threat posed by environmental contamination. Further, the Southern Resident Recovery Strategy is clear that an exposure to an oil spill has the potential to be catastrophic for the Southern Residents.

4.5.2.1 Southern Residents already carry significant contaminant loads

58. Long-lived and high trophic level marine mammals such as killer whales are vulnerable to accumulating very high concentrations of persistent chemicals, including pesticides, industrial by-products, flame retardants, and oil. The Southern Residents, residing in the highly polluted waters of the Salish Sea, are some of the most contaminated marine mammals in the world (Ross 2006). The intentional and unintentional discharges of chemicals are important sources of pollution in high vessel traffic zones (Fisheries and Oceans Canada 2011).

59. Reflecting their aquatic or semi-aquatic lifestyle and feeding ecology, marine mammals are highly susceptible to the effects of environmental contaminants. Marine mammals are considered particularly vulnerable to the accumulation of high concentrations of Persistent Organic Pollutants (POPs) because of their summit position in aquatic food chains, their long lifespan, and their relative inability to eliminate these contaminants (Ross 2000, Ross 2006). POPs are persistent, bioaccumulative, and toxic (P-B-T). Because these chemicals are oily (lipophilic), they are easily incorporated into organic matter and the fatty cell membranes of bacteria, phytoplankton, and invertebrates at the bottom of aquatic food webs. As small fishes and other organisms at low trophic levels graze on these organisms, the lipids and the POPs are consumed. Larger fishes, seabirds, and marine mammals in higher positions in aquatic food chains then consume these small fishes. That stepwise process delivers nutrients and contaminants into high trophic level wildlife such as killer whales. Lipids, however, are burned off at each trophic level and used for metabolism, growth, and development, whereas the POPs remain largely intact. This leads to a process known as biomagnification, with higher and higher concentrations of POPs occurring at each trophic level (Fisk et al. 2001, Hoekstra et al. 2003). For example, all of the Southern Residents, including young whales, have high levels of pollutants that were banned long ago, like PCBs and DDT (legacy pollutants). The levels of PCBs found in their blubber exceed those we know to affect the health of other marine mammals.

60. With elevated exposure to toxic chemical pollution and accumulated contaminant burdens, high trophic level marine mammals such as killer whales have shown susceptibility to adverse health effects such as immunotoxicity, endocrine disruption, reproductive impairment, and developmental abnormalities (Ross et al. 2000). Southern Resident killer whales are vulnerable to all of these syndromes (Ross 2006) (Figure 3).

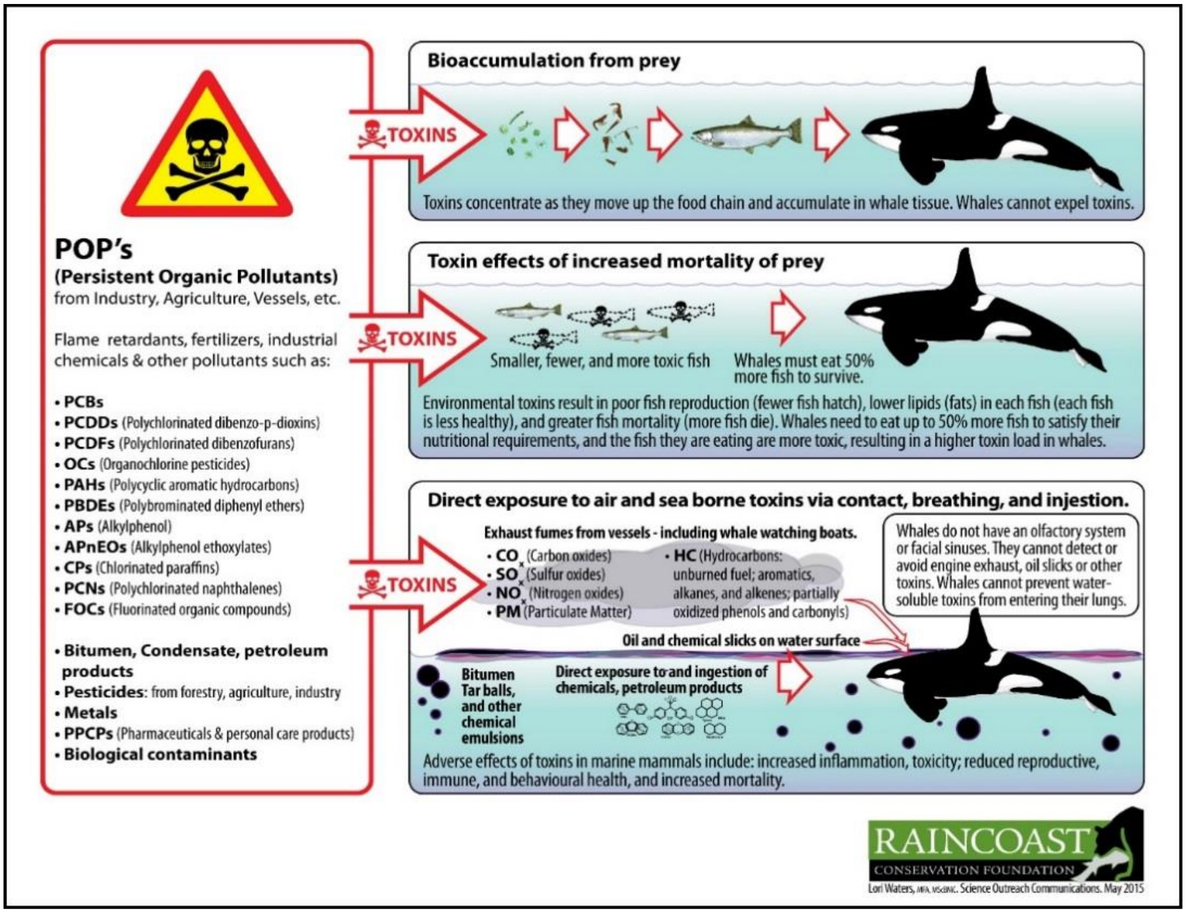

Figure 3. The Southern Residents killer whales, residing in the highly polluted waters of the Salish Sea, are some of the most contaminated marine mammals in the world (Ross 2006). The figure shows the many the sources of pollutants and ways that killer whales are exposed to toxic contaminants, as well as and the harmful effects on the whales and their prey.

4.5.2.2 Oil spills from small Chronic Sources

61. Chronic toxicological effects from small oil spills are a serious concern for killer whales (Garrett and Ross 2010, P. O'Hara pers. comm.). Chronic small-scale

discharges of oil into oceans greatly exceed the volume released by major spills (Clark 1997) and represent another potential concern. Such discharges originate from numerous sources, such as the dumping of tank washings and ballast water by tankers, the release of bilge and fuel oil from general shipping, and the disposal of municipal and industrial wastes. Chronic oil pollution kills large numbers of seabirds (e.g., Wiese and Robertson 2004), but its impact on killer whales and other marine mammals is poorly documented (P. O'Hara pers. comm.). The long-term effects of repeated ingestion of sub-lethal quantities of petroleum hydrocarbons on marine mammals are also unknown. The significant increase in oil shipments associated with the Project will correspondingly increase the risk of small chronic oil releases.

4.5.2.3 Large Oil Spills

62. Exposure to petroleum hydrocarbons released into the marine environment via oil spills and other discharge sources represents another potentially serious health threat for Southern Residents. Marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, but acute or chronic exposure poses greater toxicological risks (Grant and Ross 2002).

4.5.2.3.1 Risk of a large oil spill with impacts on Southern Residents

63. Oil spills represent highly visible threats to marine organisms, and killer whales appear vulnerable when such spills take place in their habitat (Garrett and Ross 2010). Increased vessel traffic, pipeline ruptures, oil refinery releases, and accidental releases from vessels all contribute to a heightened risk of exposure of killer whales to oil and related products. The Southern Resident population is currently at risk of a large oil spill because of commercial tanker traffic in Puget Sound and the Strait of Georgia (Baird 2001, Grant and Ross 2002). The proposed expansion of oil tanker traffic by 13 % in the south coast of BC due to the Project would increase that risk.

64. Whether an oil spill would directly affect the Southern Residents depends largely on traffic levels, the size of the whale population (i.e., the larger the

population the greater the probability of exposure), and the distribution of whales relative to the spill. All of the Southern Residents are periodically in the same location at the same time (known as a "super pod"), making the whales very vulnerable to a catastrophic event like an oil spill during such times (NOAA 2014). (Figure 4).

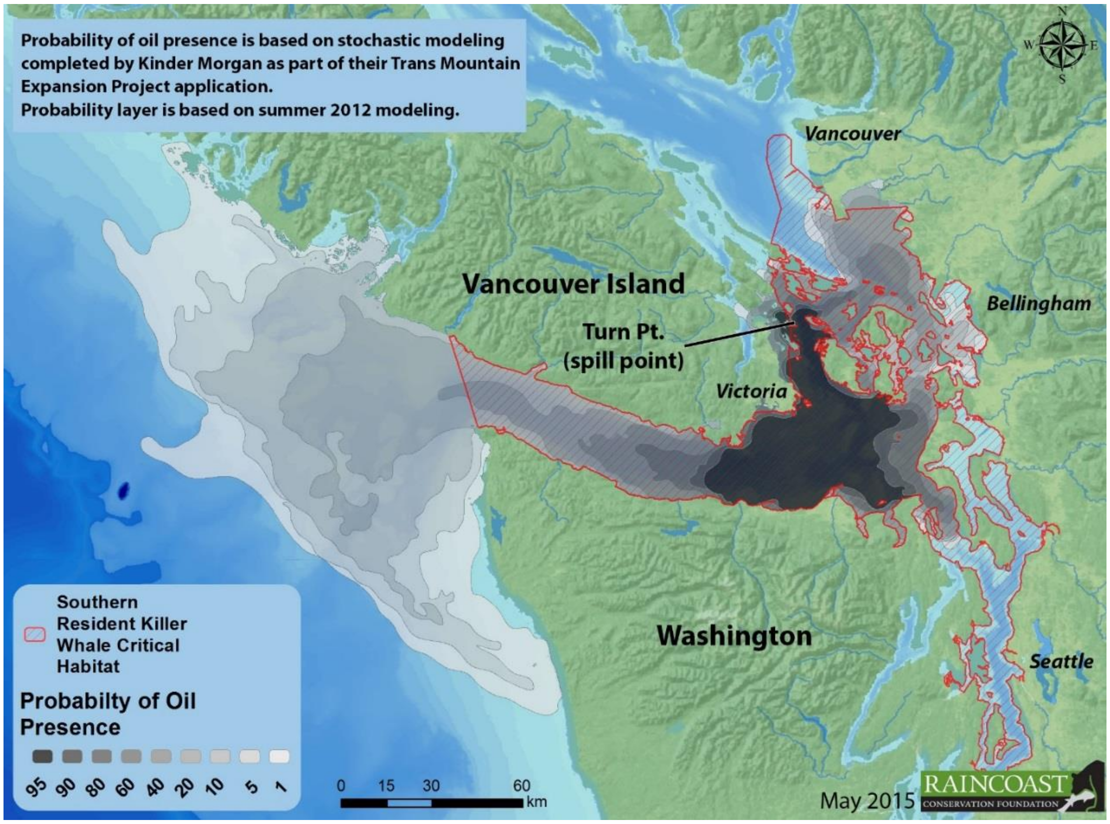

Figure 4. The figure shows the probability of oil presence and dispersion within the Salish Sea following a summer oil spill. The overlap with critical habitat of Southern Resident killer whales is significant.

4.5.2.3.2 Nature of exposure of killer whales to an oil spill

65. As evidenced by the 1989 Exxon Valdez Oil Spill in Prince William Sound, Alaska, killer whales do not appear to avoid oil. The limitations of senses such as vision, touch, taste, and smell in the marine environment mean that sound is the preferential sensory medium for a large proportion of marine animals including killer whales (Fisheries and Oceans Canada 2011). Consequently, killer whales likely have very little awareness of oil-polluted waters. In addition, their strong

attraction to specific areas (e.g. critical habitats) for breeding or feeding may override any tendency to avoid the noxious presence of oil.

66. Inhalation of vapors at the water's surface and ingestion of hydrocarbons during feeding are likely pathways of exposure if whales surface in or near slicks. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion, pneumonia, liver disorders, neurological damage, stomach or intestinal irritation or lesions, and death (Geraci and St. Aubin 1990, Hall et al. 1996, Jenssen 1996, St Aubin 1990). Although not always fatal, exposure can cause immediate injury to eyes, airway passages (blowhole, trachea, lungs), mouth and skin (St Aubin 1990). Ultimately, the magnitude of harmful effects appears related to the amount of oil to which they are exposed and the duration of the exposure (National Marine Fisheries Service 2008).

67. Oil spills are also potentially destructive to prey populations and consequently may adversely affect killer whales by reducing food availability. In addition, prey that have been contaminated by oil and ingested by whales provide another pathway for accumulation of toxic substances.

4.5.2.3.3 Potentially catastrophic nature of effects of an oil spill on Southern Residents

68. As recognized by the Canadian and U.S. recovery strategies, exposure to an oil spill could be catastrophic because Southern Resident killer whales are already severely compromised and have difficulty contending with additional disturbance (Fisheries and Oceans Canada 2011, National Marine Fisheries Service 2008). In addition, as discussed in section 4.4, small, genetically isolated and slow reproducing populations such as the Southern Residents characteristically lack resilience and are often unable to recover from severe disturbances. Furthermore, because they are highly social and have a propensity to travel and forage together in groups (Barrett-Lennard and Heise. 2006), and seasonally use the area immediately surrounding the tanker route, Southern Residents are extremely

vulnerable to oil spills, especially when grouped together in confined areas such as narrow channels (Williams et al. 2009).

69. At present the probability of Southern Residents being exposed to an oil spill is considered to be low. However, the sizable expansion in tanker traffic carrying petroleum products associated with the Project increases the likelihood that whales will be affected by a spill. Moreover, the viability of the endangered Southern Residents depends on a small fraction of their range (i.e. critical habitat) that overlaps the primary shipping lanes, thereby heightening the chances that an oil spill will have devastating and long lasting effects.

4.5.2.3.4 Observed effects of the Exxon Valdez Oil Spill on killer whales

70. Prince William Sound, Alaska is home to both transient and resident killer whales. Before the Exxon Valdez spilled 40,000 tonnes of crude oil into Prince William Sound in 1989, the AT1 transient population was stable at 22 whales (Matkin et al.1999). Less than a week after the Exxon Valdez spill[7], whales from the AT1 (transient) pod were observed surfacing in heavily oiled waters directly in the slick (Matkin et al. 1999). Nine whales disappeared the winter following the spill, and all were deemed dead. Subsequent to the spill and exposure, 15 transient whales went missing from the AT1 group, a number of which were females. Although only 5 carcasses were ever found, the missing whales are almost certainly dead. Scientists have hypothesized that these whales died from inhaling toxic oil vapours or from eating oiled harbour seals (Garret and Ross 2010).

71. Since the spill, no recruitment of calves into this population has been recorded. All evidence suggests this unique population of killer whales is going extinct (Saulitis et al. 2002, Matkin 2008). The timing and magnitude of missing individuals directly following the spill, plus the known exposure of the AT1 pod to the oil, suggests that oil is responsible for the decline (Exxon Valdez Oil Spill

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[7] The size of the spill is estimated to have been 40,900 to 120,000 m^3 (10,800,000 to 31,700,000 US gal), or 257,000 to 750,000 barrels.

Trustee Council 2009), although other factors might have contributed (Fraker 2013).

72. As with the AT1 pod, the AB pod of resident whales was observed surfacing in oil slicks immediately following the spill. Six of the 36 members of AB (resident) pod were missing within one week of the spill and 8 more disappeared (died) within 2 years (Dahlheim and Matkin 1994, Matkin et al. 1994, 1999a, 2003, 2008, Matkin and Saulitis 1997). Nearly all of these deaths occurred from the time of the spill through the following winter. The mortality rate was 19% in 1989 and 21% in 1990, roughly 10 times the natural rate. Many of the whales that died were young and reproductive females. Although calves have been born into this population, unexpected mortalities and the loss of these important females has meant an uphill battle for recovery. Again, mortalities were likely attributable to petroleum or petroleum vapours inhaled by whales.

73. These reported mortality rates are unprecedented for the northeastern Pacific (Dahlheim and Matkin 1994, Matkin et al. 1999). Despite strong spatial and temporal correlation between the spill and the mortalities, causes of death for the missing animals could not be confirmed because their carcasses were never located, or if they were, were not fully necropsied. However, the synchronous losses of unprecedented numbers of killer whales from two ecologically and genetically separate groups and the absence of other obvious lethal disturbances implies it is highly probable that oil exposure contributed to their deaths or did so indirectly for orphaned calves (Matkin et al. 1999, National Marine Fisheries Service 2008, National Marine Fisheries Service 2008).

74. Five other resident pods observed swimming through very lightly oiled waters following the spill did not experience losses (Matkin et al. 1994). However, these five pods likely spent less time in the spill area and were observed only in lighter sheens, which suggests that lesser degrees of exposure may not have been immediately harmful to the whales (National Marine Fisheries Service 2008).

75. Similar to the currently small population of Southern Residents in the Salish Sea, the afflicted Alaskan populations were small and compromised before the

Exxon Valdez spill by multiple threats that included chronic exposure to pollutants, as well as prey-related stress (in that case associated with fishery conflicts) (Vol 8A, Section 5.6.2, Filing ID A3S5Q3). Combined, these threats likely increased the whale's susceptibility to oil contamination resulting from the spill. Markedly, in contrast with the smaller populations, the larger populations of transients and resident killer whales in Prince William Sound increased subsequent to the Exxon Valdez spill (Vol. 8A, Section 5.6.2, Filing ID A3S5Q3), which seems to underscore the perils of small and already threatened populations such as the Southern Residents.

4.5.3 Acoustic and Physical Disturbance

76. Repeated disturbance of wild animals is implicated as a factor reducing the quality of life, foraging efficiency, fitness, or reproductive success of individual animals. Anthropogenic disturbance has been linked to changes in foraging behavior (e.g. Galicia and Baldassare 1997), reproductive success (e.g. Safina and Burger 1983), and mating system and social structure (e.g. Lacy & Martins 2003). These, in turn, either individually or synergistically, can influence population dynamics and persistence (Lusseau et al. 2006, Lusseau and Bader 2007). Accordingly, short-term behavioural responses could have long-term biologically significant consequences for fitness and viability of individuals and their populations. The Southern Resident Recovery Strategy is clear that acoustic and physical disturbance is a major threat to the Southern Residents. The increased tanker traffic associated with the project will increase physical disturbance in critical habitat, as well as increasing the noise pollution.

77. The inland waters of Washington state and British Columbia are highly urbanized areas with significant vessel traffic from container ships, tankers, ferries, tugboats, recreational boats, and fishing vessels. These are the same areas where whales spend much of their time in the summer and fall. Southern Resident killer whales are also the focus of considerable recreational and commercial whale watching.

78. Both private and commercial boat traffic have increased dramatically in recent years, and killer whales must navigate in increasingly busy waters (Osborne 1999, Foote et al. 2004). Container ships, tankers, fishing boats, whale-watching boats, and recreational boat traffic increase levels of underwater noise, the likelihood of chronic and catastrophic oil spills, harmful exhaust emissions, as well as the risk of ship strikes. Lusseau et al. (2007) contend that vessel traffic may already have contributed to the decline of the Southern Residents through the following means:

> "Collisions between vessels and killer whales occur occasionally in residents, including southern residents, and other killer whales and result in injury or death (Ford et al. 2000, G. M. Ellis pers. comm.). Unburned fuel and exhaust from vessels may contribute to toxin load. The presence of noise from vessels may contribute to stress (Romano et al. 2004). Noise from vessel traffic may mask echolocation signals (Bain and Dahlheim 1994, Erbe 2002), reducing foraging efficiency."

79. Individual whales manage disturbances as another influence in their environment. They do this by assessing the costs of coping with these influences in relation to other energetic trade-offs associated with the occupancy of the habitat in which the disturbance takes place (K. Balcomb pers. comm.). When individuals cannot elude proximity to the disturbance, their fitness is often reduced as observed through reduced reproductive success. For example, in killer whales adaptive responses to disturbance may result in increased energy expenditure, or disrupt feeding activity, which may reduce acquisition of energy (Bain 2002, Williams et al. 2006). Such impacts are of particular concern, since Southern Residents are likely food limited.

80. Vessels in close proximity disrupt the behaviour and activities of Southern Residents, causing psychological stress and impairing foraging (Ayers et al. 2012, Williams et al. 2002, 2006, National Marine Fisheries Service 2010). Killer whales change their behaviour in response to vessel traffic, calling louder to other whales, spending more time traveling than foraging for food, and engaging in more high-energy activities such as breaching and tail slapping (National Marine Fisheries Service 2010). In addition, resident killer whales are more vulnerable to vessel

disturbance while feeding than during resting, travelling, or socializing activities (Williams pers. comm.). Consequently, these disturbances are critical conservation issues for populations that may be food-limited (e.g., Williams et al. 2011) (Figure 5).

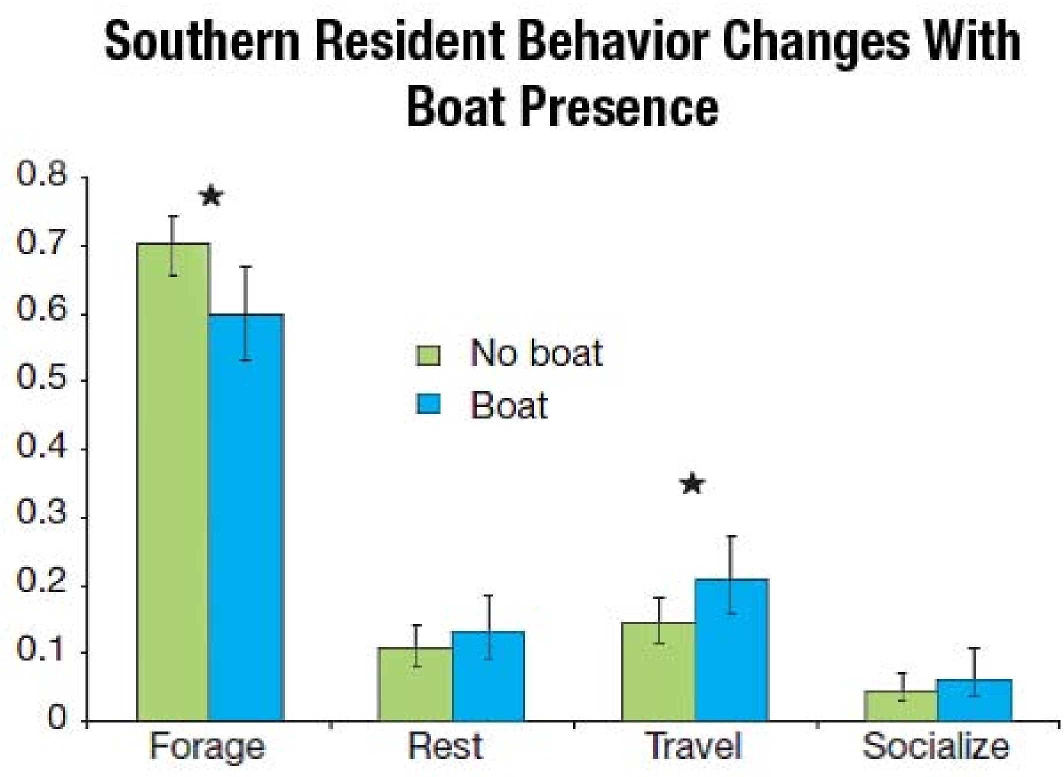

Figure 5. This figure shows the amount of time Southern Residents from J, K, and L pod spent foraging, resting, traveling, and socializing with and without the presence of boats in two areas near San Juan Island. When vessels were present, the whales foraged significantly less and travelled more. Figure from NOAA (2014), Data from Lusseau et al. 2009.

81. The cumulative impacts from vessels interfere with the whales' ability to communicate and find food, affecting their health and survival (Lusseau et al 2007, NOAA 2014). Disturbances associated with marine shipping represent a risk to the ecological integrity of the Salish Sea (Fisheries and Oceans Canada 2011), and threaten the viability of the Southern Resident killer whale population (COSEWIC 2008, National Marine Fisheries Service 2008, NOAA 2014). These threats to the Southern Residents exist now with existing levels of commercial

shipping. The Project threatens to increase shipping in an already busy shipping lane.

4.5.3.1 Acoustic Disturbance due to Vessel Noise

82. As stated in the Southern Resident Recovery Strategy, ocean noise is a significant and increasing threat to the Southern Residents and their critical habitat. The report of Dr. Christopher Clark, attached as **Attachment D** to this statement of written evidence, focuses on acoustic impacts of the oil tanker traffic associated with the Project on Southern Residents. The report explains the importance of sound to killer whales' critical life functions (navigation, mating, socializing, and hunting), and elevated noise from human activity, including the Project, can hinder these functions. Dr. Clark describes the extent of existing noise in critical habitat and how it affects the Southern Residents' feeding and other functions, and explains how the Project will exacerbate this situation, including through effects on feeding, effects on ability to communicate, and the cumulative energetic costs of other behavioural responses; he further states that these may cause population-level consequences. He explains that it is essential to assess noise effects using the quiet pre-industrial environment as a baseline in order to understand the biological and ecological impacts on critical habitat, rather than accepting present-day conditions as normal. Dr. Clark also states that acoustic impacts interact with other threats. He also provides a critique of the Project Application's assessment of acoustic impacts.

4.5.3.2 Ship Strikes

83. The increase in shipping associated with the project creates an increased risk of ships striking marine mammals and in particular great whales such as Blue, Fin, Sei, Humpback, and Grey whales as well as smaller cetaceans such as killer whales, dolphins and porpoises. Many of these marine mammals are listed as species at risk in Canada. Injury and death because of ship strikes are significant threats to recovering populations of marine mammals, posing the greatest risk to small or isolated whale populations such as the Southern Residents, where a single strike-related mortality could have population-level effects. The small size and

highly social nature of the Southern Resident population renders it unable to absorb anything beyond very low levels of human related mortality (Williams and Lusseau 2006).

84. Killer whales are susceptible to serious injury and mortality from vessels (Williams O'Hara 2010). Areas of high marine traffic (e.g. the Salish Sea) can pose a lethal threat to these animals (Douglas et al. 2008). Whales are killed and seriously injured after being struck by vessels. However, many incidents of ship strike go unnoticed or unreported, making it difficult to understand the extent of the problem. Although the extent of ship strikes is unknown, we do know they happen. In its Response to a National Energy Board Information Request, Trans Mountain identified 6 recorded killer whale strikes in recent years with the largest vessel being a ferry in the Strait of Georgia.

85. The probability of ships encountering and striking killer whales directly depends on traffic levels, vessel types, the size of the whale population or population aggregate (i.e., the larger the population the greater the probability of encounter), the distribution of whales, and temporal and spatial use of habitat by the whales. A recent risk assessment that included only the northern portion of Southern Resident critical habitat in the Salish Sea showed where ship strikes are most likely to occur (Williams and O’Hara 2010). With few exceptions, high-risk areas were found in geographic bottlenecks, such as narrow straits and passageways, where both whale and ship densities are concentrated. The region of highest ship strike risk was constrained to Johnstone Strait, where risk was estimated to be about an order of magnitude higher than anywhere else along the coast. Notably, the largest numbers of reported and confirmed ship strikes for the Salish Sea have occurred in Johhnstone Strait, and secondarily Haro Strait.

86. A fully quantitative assessment of ship strike risk for Southern Residents has not been carried out. A risk assessment of marine mammal-ship strikes associated with the Trans Mountain Expansion Project and provided as part of the Project Application focused only on Canadian waters (Stantec 2015). Although the most complete analysis to date, the assessment lacks a quantitative analysis centered on

systematic line transect surveys to estimate seasonal and spatial density of marine mammals. To estimate the distribution of Southern Residents, the assessment relied on occurrence data, which was derived from opportunistic sightings collected primarily from whale watchers and not corrected for effort. Importantly, density (number of animals in a defined area) cannot be derived from opportunistic sightings. Consequently, the assessment is severely limited and unreliable for estimating ship strike risk or identifying areas of greatest risk. Moreover, the estimates of risk did not quantify the uncertainty of the estimates, which is one of the cautionary hallmarks of reliability in science. Notably, Stantec's assessment is not dependable and possibly wrong. Reliance on the assessment for decision making could very well increase risks for killer whales by leading to poor choices regarding the effects of increased vessel traffic associated with the Project.

87. The causal association between faster modern ships and the increase of whale ship-strike incidences has been firmly established. Laist et al. (2001) found that fatal ship strikes were rare before the 1800s, were infrequent until 1950, and have since increased steadily with the number of ships and the greater speeds of ship travel. Accordingly, the risk of ship strikes in the Salish Sea could be lowered through vessel speed restrictions and regulated avoidance of areas where killer whales congregate (e.g. critical habitats). For example, in designated locations along the U.S. east coast at specific times of the year all vessels 19.8 metres or longer must travel at 10 knots or less to reduce the threat of ship collisions with critically endangered North Atlantic right whales (Conn and Silber 2013).

88. Another effective way to reduce ship strikes is to reduce the co-occurrence of ships and whales by shifting shipping lanes away from known areas of high whale aggregations. In California, shipping lane approaches to the Los Angeles, Long Beach, and San Francisco Bay ports were modified to reduce the co-occurrence of ships and whales in the San Francisco Bay area and Santa Barbara Channel. The revised California traffic separation scheme went into effect on June 1, 2013 (NOAA).

4.6 Cumulative Effects and Viability of the Southern Resident Population

89. While each of the threats described above is alone a potential problem for Southern Residents, in reality the whales experience a combination of threats, which in some cases act together to create greater problem then they would individually. The Project has the potential to exacerbate many threats facing the whales. Proper risk assessment must consider the compounded or cumulative risk that these threats together create.

90. In ecosystems, the safe level for one stressor is often strongly dependent on the level of other stressors. As the level of disturbances increases, adverse effects occur from influences that may be individually minor but are collectively multiplicative and significant. Cumulatively, these effects account for the documented endangerment of the Southern Residents, compromising the effectiveness of habitats to sustain Southern Residents, as well as the viability of individuals and populations. The damage caused by these threats is likely additive and overwhelming, and cannot be mitigated in the sense of eliminated. It can be moderated, but multiple stressors that are moderated are still cumulative and are additively higher than baseline, which is already more than can be tolerated. At present, cumulative threats are not being effectively mitigated and the expectation is that many of these hazards will likely increase in the future (NOAA 2014, pers. comm. L. Barrett-Lennard). Assuming that conditions will worsen with the addition of the Project is reasonable (NOAA 2014).

91. How current threats may act synergistically to impact killer whales is unknown, but in other species multiple stressors have been shown to have strong negative and often lethal effects, particularly when animals carry elevated levels of environmental contaminants (Sih et al. 2004). At present, compounding adverse effects of natural and anthropogenic stressors (acoustic disturbance, toxic contaminants) place killer whale populations in serious jeopardy. Additional threats increase mortality and morbidity in killer whales, elevating the

susceptibility and sensitivity of already stressed individuals and populations to future disturbances.

Table 1. Factors affecting the viability and recovery of Southern Resident killer whales. The interacting and potentially synergistic effects of these stressors are thought to be important (Garrett and Ross 2010).

THREATS	Habitat Alienation/ Degradation	Contaminants	Prey Availability	Acoustic Degradation	Oil & Toxic Spills	Disease	Small Population Size	Climate
Habitat Alienation/ Degradation		X		X	X			X
Contaminants	X		X		X	X	X	X
Prey Abundance/ Availability	X	X		X	X		X	X
Acoustic Degradation	X		X				X	X
Oil & Toxic Spills	X	X	X			X	X	
Disease		X	X		X		X	X
Small Population Size	X	X	X	X	X	X		X
Climate	X	X	X	X	X	X	X	

92. The report of Dr. Robert Lacy provides a population viability analysis ("PVA") of the Southern Resident Killer Whales; this report is attached as **Attachment E** to this statement of written evidence. This report explains the methodology and results of a PVA that considers the risks associated with multiple aspects of the proposed Project. A PVA is a species-specific risk assessment frequently used in conservation biology, which uses quantitative methods to evaluate and predict the likely future status of a population based on certain scenarios. A PVA is one way to try to predict the cumulative or combined impacts of effects over the long term on a population.

93. In the case of Dr. Lacy's report, the PVA models the future population on current base line conditions with no Project, and contrasts that with a model that

assumes the Project is approved. The model was used to estimate the increased risk to the Southern Residents from three threats associated with the marine shipping component of the project: an oil spill, increased acoustic and physical disturbance from ships, and ship strikes. The authors find that if base line conditions persist the Southern Resident population will most likely remain about at its current size or continue a very slow decline. However, modelling shows that increased threats from Project related effects increase the risk of extinction and accelerate decline. It is abundantly clear that the population cannot withstand additional negative pressures, recover from its current endangered status, and persist.

V Literature Cited and Bibliography

94. The literature cited in this killer whale backgrounder is attachment F to this statement of written evidence.