

**CANADIAN ENVIRONMENTAL ASSESSMENT AGENCY**

**IN THE MATTER OF** an application by the Vancouver Fraser Port Authority pursuant to the *Canadian Environmental Assessment Act, 2012*, SC, c 19, s 52 to build the Roberts Banks Terminal 2 Project.

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**VOLUME 2 OF 2**

**WRITTEN SUBMISSIONS RECORD ON BEHALF OF  
DAVID SUZUKI FOUNDATION, GEORGIA STRAIT ALLIANCE,  
RAINCOAST CONSERVATION FOUNDATION & WILDERNESS COMMITTEE**

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Via email to CEEA.PanelRBT2-  
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April 15, 2019

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# Potential acoustic and cumulative impacts of the Roberts Bank Terminal 2 (RBT2) project, especially related to southern resident killer whales (SRKW)

Prepared for the Review Panel of the  
Canadian Environmental Assessment Agency

Prepared by:

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Prepared for:

**David Suzuki Foundation**  
**and**  
**Wilderness Committee**

*April 11, 2019*

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# Describe your qualifications

## 1. About the author

*1. Please describe your education and training and provide an explanation of your expertise in relation to the issue of marine mammals and marine mammal habitat, and in particular southern resident killer whales. Please also provide a copy of your current curriculum vitae.*

Dr. Scott Veirs is an expert in marine bioacoustics, oceanography, and ecology of the Salish Sea. He specializes in the quantitative evaluation of acoustic impacts on marine mammals from individual and cumulative human activities.

Dr. Veirs was trained in environmental science as the first Earth Systems major at Stanford University and received a Masters and PhD in Oceanography from the University of Washington. For the last 15 years, his research has focused on quantifying underwater noise pollution, particularly from commercial ships, in Washington and British Columbia. From 2005-2012 he organized bioacoustic field research projects for 50 undergraduates during which he observed the behavior of southern resident killer whales over many seasons within their core summertime habitat (the central Salish Sea).

Currently, Dr. Veirs coordinates the Orcasound hydrophone network and serves as Chair of the Marine Mammals Work Group of the Puget Sound Ecosystem Monitoring Project. He is a member of the Acoustical Society of America and most recently presented research with his colleague, Dr. Val Veirs, at the fall, 2018, meeting of the Society in Victoria on computing natural versus anthropogenic noise statistics in killer whale critical habitat. In January, 2019, he was elected Chair of the Marine Mammal Work Group which is part of the Puget Sound Ecosystem Monitoring Program.

Further details regarding his educational background and professional experience are provided in Attachment A.

# Acoustic impacts of the Project, particularly on Southern Resident Killer Whales

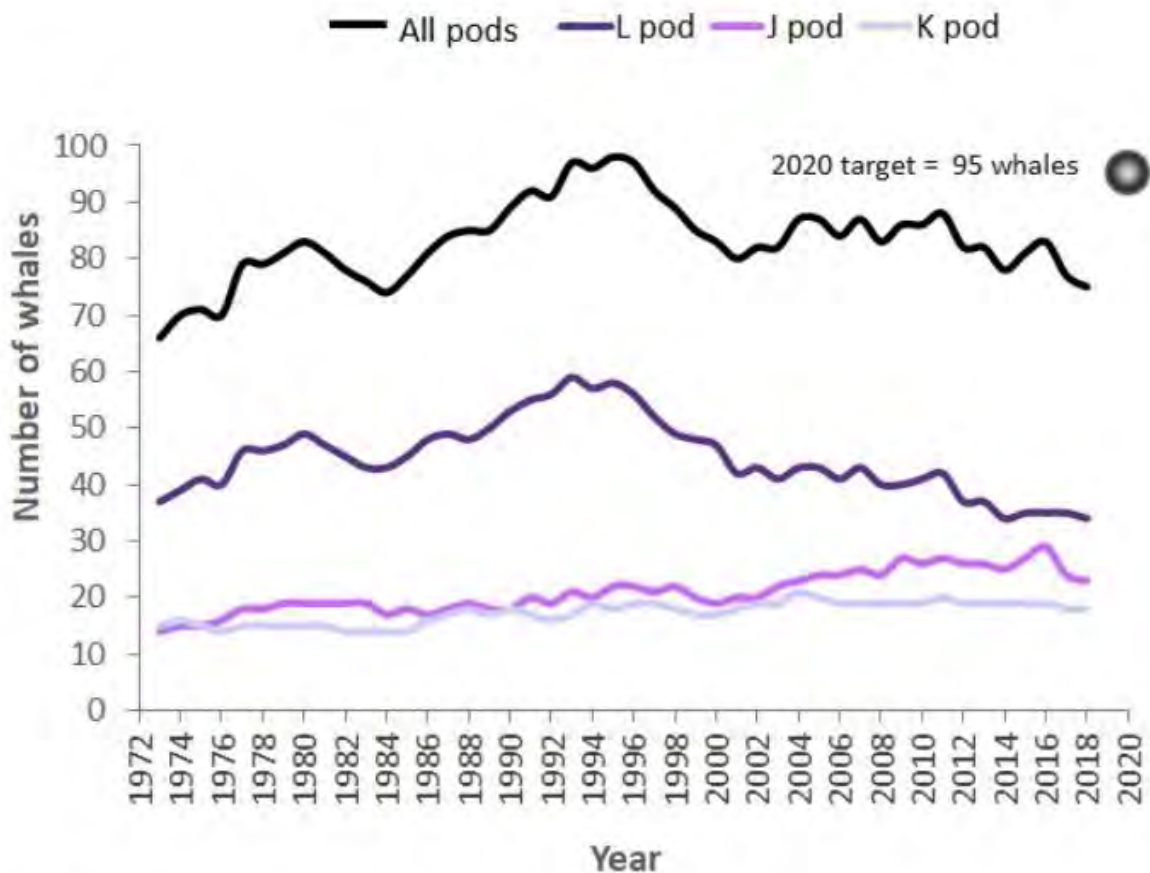
## 2. Please describe the current status of the Southern Resident Killer Whale population.

**As of 2019, the SRKW population is increasingly bound towards extinction with many individuals currently starving. Some experts are calling this “[the last generation](#).”**

The current status of the Southern Resident killer whale (SRKW) population is tenuous, at best. These salmon-eating orcas remain endangered on both sides of the U.S./Canada border and are struggling to obtain sufficient quantities of their preferred prey, Chinook salmon. Not only are many runs of Chinook extirpated or endangered within the SRKW's range -- from northern California to Haida Gwaii -- but also their access to scarce Chinook is reduced by noise and physical disturbance from vessels (commercial ships, recreational boats, and whale watching boats). Added to these risk factors is the bioaccumulation of persistent chemical pollutants in their blubber. When orcas starve (due reduced salmon supply or access), the lipid-soluble contaminants are mobilized during metabolism of fat reserves, resulting in suppression of their immune systems and increased vulnerability to disease and catastrophic events, like oil or fuel spills.

The SRKWs are listed as endangered both in Canada (under the Species at Risk Act) and in the U.S. (under the Endangered Species Act). These listings were triggered by declines in the population that occurred in the late 1990s and early 2000s, especially in the size of L pod. (See figure below from the [Puget Sound Partnership's orca vital sign](#) which shows SRKW census data provided by the Center for Whale Research.)

1972-2018

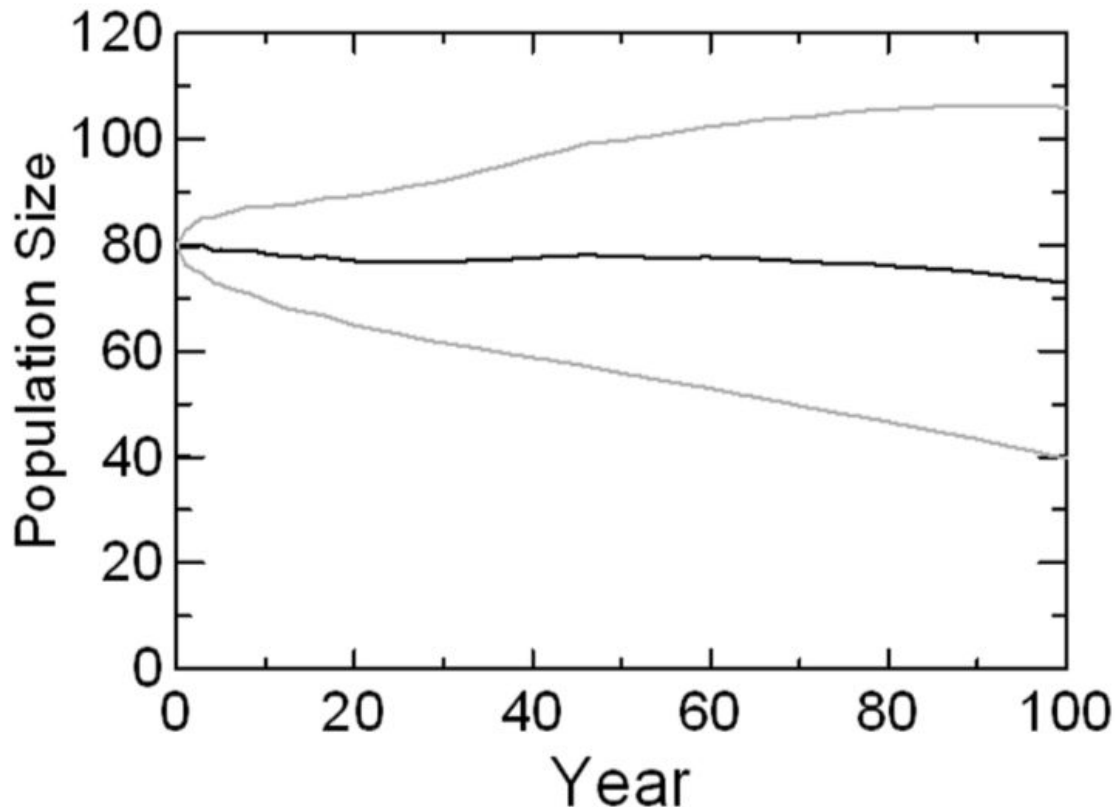


Source: July 1 census, Center for Whale Research

The total SRKW population reached a 33-year low of 75 whales in 2018. The U.S. recovery goal of an annual average growth rate of +2.3% (over 30 years) has only been met in 6 of the 13 years since the population was declared endangered in the U.S. Instead of the desired long-term growth, there has been a long-term decline since 1995 when the total population peaked at 98 animals. More recently, there has been a net loss in *each of three pods* since 2011, resulting in the annual average growth rate of the *total* population between 2011 and 2018 being -2.0%. Because of these recent declines, we are far from meeting the population goal of 95 animals by 2020 which was set by the Puget Sound Partnership in 2011 (and would have represented a 1.0% annual average growth rate from 2010 to 2020).

The most-recent peer-reviewed population viability analysis provided a 100-year forecast of the SRKW population starting in 2015 and using reproductive rates observed during 1976-2014 (Lacy et al., 2017). The study concluded that under current levels of salmon supply, vessel disturbance, and toxic chemical burdens, the SRKW population will not recover, but instead will

most likely remain near its current size. The good news was that with a 15% increase in salmon supply and a 50% reduction in vessel noise (to increase hunting efficiency and therefore access to salmon), the population could achieve the recovery goal: a growth rate of +2.3%. The bad news was that any increased impacts (like fewer fish or more noise pollution) beyond the current levels would result in the slow decline of the population towards extinction. These optimistic and pessimistic possible outcomes fall above and below the status quo population projection (black line) and within bounds of the population simulations (grey lines), as depicted below (Figure 1 of Lacy et al., 2017).

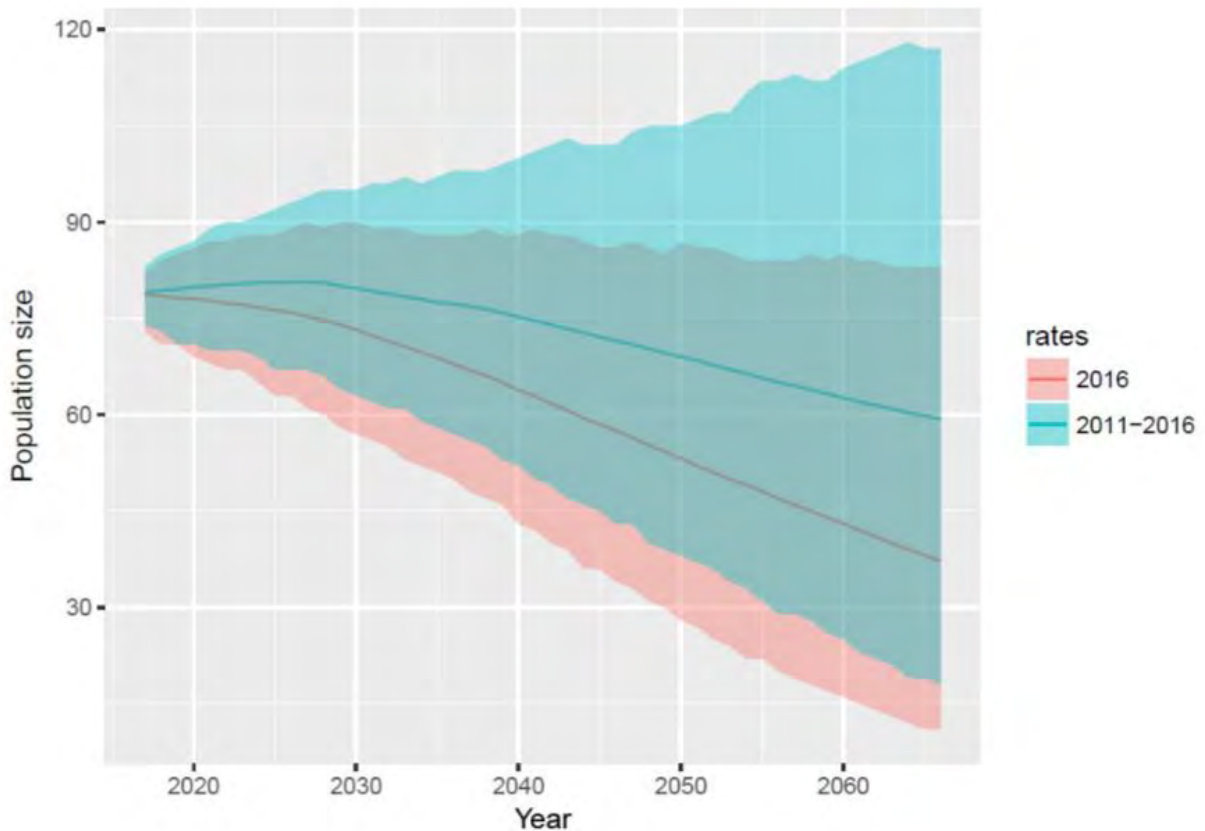


Unfortunately, very worrisome recent changes have occurred in the condition of the SRKW population. First, the birth rate has decreased (no births in 2017 or 2018, and thus far only one birth in 2019). Second, demographically important females have been lost. Since 2014, the population has lost nearly 20% of females that are of reproductive age (10-42 years old). In early 2017, the oldest female in this matriarchal species died at an estimated age of 105 years -- representing a loss of leadership and experience for finding food. A third concern is an elevated level of unsuccessful pregnancies, likely a manifestation of a lack of adequate food for reproductive females. Finally, there is growing evidence of deteriorating body condition from drone-based observations (Fearnbach et al., 2018). Multiple individual animals are starving.

These changes mean that the vital rates used by Lacy et al. (2017) may be overly-optimistic. The most-recent status review in the U.S. (NMFS, 2016) included a 50-year forecast of SRKW



population based on reproductive rates from 2011-2016 (blue region in their Figure 3.1 shown below) -- a time period when the reproductive rates were lower than the longer-term mean rates. Over the long haul, the median population simulation declines dramatically under the 2011-2016 conditions (blue line). If the reproductive rates from the single poor year of 2016 are used, the decline is immediate and precipitous (red line).



The December 2016 status review stated that this most-pessimistic projection “provides information on what could happen if poor reproduction continues” (NMFS, 2016). Regrettably, SRKW reproduction in 2017 and 2018 was even worse than in 2016.

As I will explore further in this report, based on the biological observations made during the RBT2 environmental assessment process, the SRKW population is now firmly “in the red zone” (notice that all of the simulations in the red-shaded zone above indicate long-term decline). If we want to prevent the extinction of the SRKWs we must make bold reductions in our human impacts on this iconic and endangered species. An incremental increase or even no-net-increase in human impacts will not be sufficient to save them.

### 3. Please describe the current state of the acoustic environment in the Salish Sea.

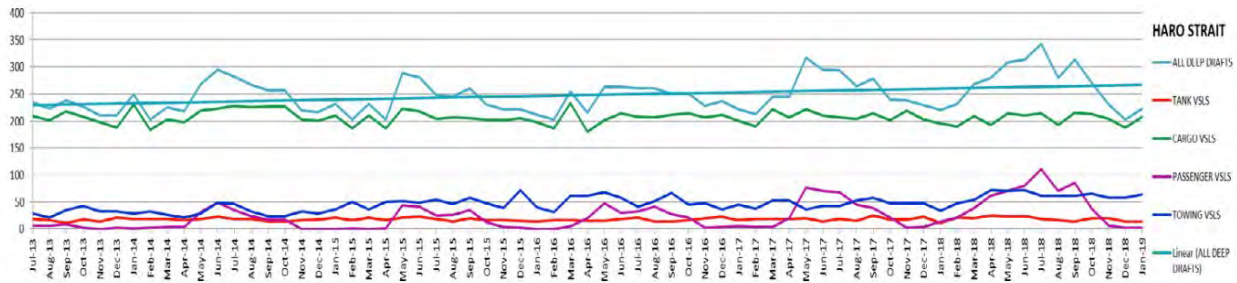
**The acoustic environment of the Salish Sea is highly polluted, the dominant noise source is ships, and container ships are the most-intense polluters.**

Since the end of the age of sail, the Salish Sea has become an urban estuary with shipping lanes and common boat routes that overlap in space and time with SRKW critical habitat. The growth of human population in Washington and British Columbia to now nearly 8 million people has driven a wide range of activities that have impacted the local ocean. Mining, logging, and agriculture affected the freshwater habitats of salmon while the marine environment was impacted directly by the harvest of marine life -- from the extirpation of humpback whales and culling of pinnipeds to the overfishing of salmon, bottom fish, and forage fish. Today, some old impacts have been reduced to varying extents: forestry is becoming more sustainable, humpbacks are beginning to return, fishing pressure has been reduced, and some river habitats are under repair.

However, human population growth around the Salish Sea continues and coincident demand for natural resources, products, and space is driving new developments -- each with new impacts, many of which affect the marine acoustic environment. Some types of development, like pile driving to build a new pier, can affect the acoustic environment with noise that is intense, but of limited duration. Impact pile driving is a local example of *acute noise pollution*. In contrast, vessel noise is less intense at the source, but much more continuous and common. Ship noise is a local example of *chronic noise pollution*.

In the modern era, commercial shipping is the dominant source of chronic noise pollution in the acoustic environment -- both in the open oceans (Hildebrand, 2009) and within the Salish Sea. While the killer whales first experienced only a few ferries, fishing boats, and tugs towing log booms, today the main source of noise in the acoustic environment of the Salish sea is the commercial shipping sector -- a wide variety motorized vessels related to the transportation of natural resources, products, and people.

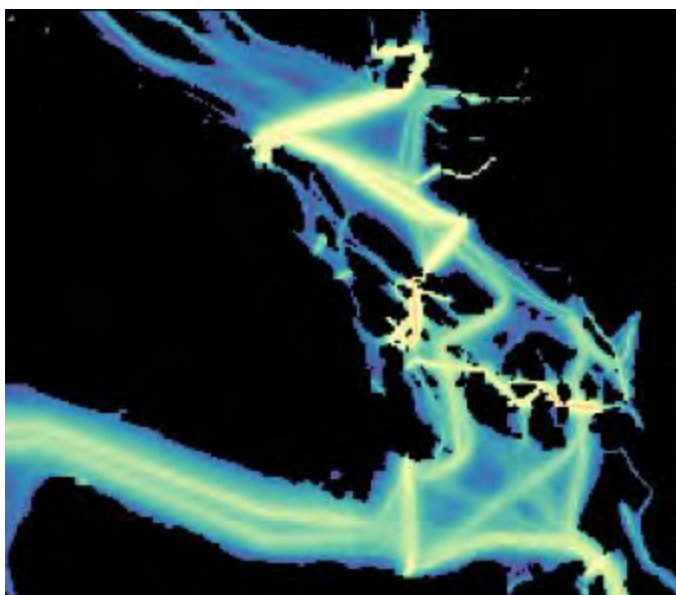
Ships dominate the soundscape in the core summertime habitat of the SRKWs, an area known as Haro Strait. On average about 20 ships/day (Veirs & Veirs, 2006) or 1 ship/hour (Erbe et al., 2012) transit Haro Strait, each typically elevating the background noise levels for at least a half hour. This current amount of traffic has been growing for a century, though there is shorter-term variance driven by economic and operational dynamics of the many classes of ships that use the Strait. A recent example of the traffic levels in Haro Strait (2013 through 2018) is [PSHSC passageline plot](#) shown below:



During the RBT2 EIS process (2013-2019), passenger (cruise) ships and tug/tow traffic have been growing while cargo and tanker traffic have held steady.

An analysis of Haro Strait traffic (~1,600 unique ships making ~2,800 isolated transits in 2011-2013) characterizes the modern fleet that dominates the acoustic environment of the southern Salish Sea (Veirs et al., 2016). Table 2 of that paper indicates that the most common types of ships are bulk carriers (34%) and container ships (18%). Tugs and cargo ships each make up about 10% of the traffic, while vehicle carriers, tankers, military, and fishing vessels are each about 2-7% of the total. The final ~5% of traffic consists of passenger vessels (cruise ships and ferries), miscellaneous, pleasure craft (recreational boats >20 m long), and research vessels.

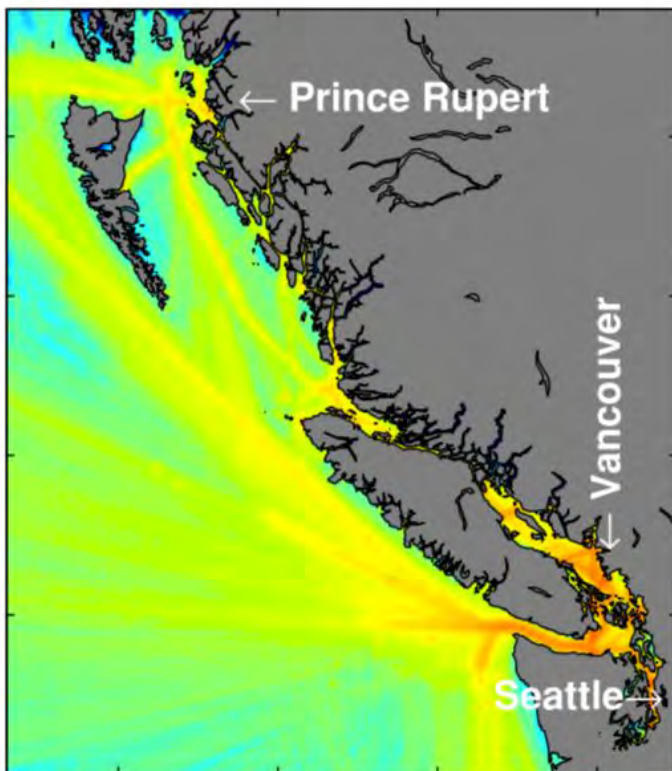
A helpful visualization of the regional cumulative impact from this commercial traffic and other vessel movements is the monthly average sound pressure level for July as calculated by a cumulative vessel noise model (MacGillivray et al., 2016) that accounts for a wide range of vessels (including most ship classes, whale watching boats, and recreational boats), as well as the amount of time they spend in the region and their source level. The warmer colors represent higher levels of underwater noise and land is black.



This modeled acoustic overview of the southern Salish Sea highlights where on-average vessel noise dominates (due to intensity and/or persistence) during the summer. Summer is the season when SRKWs are most commonly present in the same area, seeking salmon returning to Salish Sea rivers, especially the Fraser (Hanson et al., 2010). You can see common vessel routes in light yellow-green -- both the commercial ships in the shipping channels and boat traffic between popular ports. Brighter yellows and orange delineate more prevalent sources, primarily ferries and tugs.

A similar modeling effort and visualization compared ship noise energy levels in the Canadian part of this region with the rest of coastal British Columbia (see figure below from Erbe et al., 2014). They adjusted the noise levels according to how SRKWs hear (using audiograms from captive killer whales) to show that -- from the perspective of southern resident killer whales -- the southern Salish Sea is the most-polluted acoustic environment in all of coastal British Columbia.

## Killer Whale



These independent visualizations make it clear that the acoustic environment of the Salish Sea is already highly polluted. Most of the southern Salish Sea, including the area associated with noise impacts from the proposed RBT2 project (the “regional model area”), is currently of poor

“acoustic environmental quality” if judged by the European noise standards (annual mean 1/3-octave band levels at 63 and 125 Hz; Erbe et al., 2014).

A hopeful observation is that half of the ship noise pollution in Haro Strait is caused by only 15% of the fleet (Veirs et al., in review, 2018). This means that if the most intense sources in each class of ship were retrofitted with quieting technologies or replaced with ships that have less than median source spectra for their class, then the regional noise levels could be dramatically (and permanently) reduced.

Container ships bound to/from ports in Canada or Washington State are responsible for much of the noise pollution in the southern Salish Sea. Not only do they make up about 20% of the traffic within the summertime critical habitat of SRKWs (northbound in Haro Strait), but also they are the class of ships that moves the fastest (mean speed over ground of 19.2 +/- 1.9 knots) and has the most intense source levels (Veirs et al., 2016).

#### 4. Please describe the relationship between the acoustic environment and marine mammals such as the Southern Resident Killer Whales and their habitat.

**Hearing is at least as important to killer whales as vision is to us. An acoustic environment with low noise levels is important for many SRKW vital functions, including foraging, communication, and navigation.**

Sound is the medium of choice in the oceans; light is comparatively useless. While sea water is nearly transparent to sound, the water molecules quickly scatter and absorb light. This causes the oceans to be dark at depths of just a few hundred meters -- even in crystal clear waters at noon on a sunny day.

In the Salish Sea, underwater visibility is greatly reduced. Not only do suspended sediments from rivers and beaches make the water murky, but so do plankton -- microscopic plants and animals that drift with the tides. Consequently, it is rare for a SCUBA diver to be able to see more than 10 meters in the Salish Sea. And during the spring bloom -- the annual explosion of phytoplankton growth -- sometimes you can't see your hand in front of your face.

Remarkably, even such murky water is nearly transparent to sound. Sound attenuation is so low in salt water that low-frequency calls of baleen whales can travel 1000s of kilometers across the entire Pacific ocean and still be audible. This means that on a quiet day underwater in Haro Strait, SRKWs can communicate at ranges of tens of kilometers and use their echolocation clicks at the surface to locate salmon swimming 100-200 meters beneath them. Unfortunately, it also means that typical ship noise is audible to many types of marine mammals, including

toothed whales like SRKWs -- at ranges up to 30 kilometers (see Fig. 3 above from Erbe et al., 2014).

The very low attenuation of sound in the sea has driven the evolution of killer whales into apex predators that are acoustic virtuosos. They make a wide range of signals (calls, whistles, and clicks) and they emit these sounds almost all the time, typically calling many times per minute during all behavior states except resting. They also have incredible hearing abilities that enable them to sense or explore their environment with exquisite resolution. Whale watchers commonly observe SRKWs coordinate navigation acoustically, with a whole pod simultaneously changing direction despite being spread out beyond sight of one another. Toothed whales can emit extremely intense echolocation clicks and then listen for nuances in the echoes that enable them to not only locate fish that are too far away to be seen, but probably also discern their size and species.

Since the glaciers retreated from the Salish Sea ~10,000 years ago and Pacific salmon returned to the rivers of the Cascade and coastal mountain ranges, southern resident killer whales have interacted with humans and used sound to hunt, communicate, and navigate. When humans used the canoe for transportation and through the age of sail that brought Vancouver and colonists to the Salish Sea, only natural sources of noise affected the relationship of killer whales and their acoustic environment. Earthquakes, breaking waves, lightning, and rain storms were likely the most intense and predominant sources in the geophony (non-biological natural sounds in a soundscape) for the SRKWs then, as they are now. Calving and cracking ice would have been common during deglaciation. The biophony (sounds made by life) back then were also probably similar to what we commonly hear underwater in the modern Salish Sea: the low-frequency calls of other cetaceans, predominantly humpback and minke whales; high-frequency clicks and whistles from other Pacific white-sided dolphins and Dall's or harbor porpoises; the underwater barks and roars of sea lions and seals; the grunts and hums of soniferous fish; and the snaps and pops made by invertebrates, likely including snapping shrimp and sea urchins.

All of these natural and human noises are environmental cues for marine organisms, especially those that have exquisite sonic systems, like SRKWs. Examples of cues that may be important to SRKWs are: the distant calls from Bigg's (mammal-eating) killer whales; sounds made by potential prey, like grunts from bottom fish; sounds of their prey pursuing or consuming its prey (e.g. salmon foraging for herring); the sound of a distant high-speed vessel that is on a collision course; or the first faint pings from military mid-frequency sonar that could cause acoustic injury if not avoided.

Very little is known about the role of such environmental cues in the acoustic ecology of the Salish Sea. Such cues are often faint and thus may be inaudible even in low levels of anthropogenic noise. The importance of detecting faint environmental cues may be the most profound reason that extended periods of quiet may be important in marine soundscapes. Importantly, such acoustic cues have not been considered in the environmental assessment of

the Project's impacts on SRKWs; the only signals that have been considered are those emitted by the SRKWs themselves.

Combinations of experiments and models suggest that SRKWs are able to accomplish amazing acoustic feats in a natural soundscape (at low background noise levels, without any anthropogenic noise pollution). In addition to being able to communicate with each other at ranges of up to 16 km (Miller et al., 2006), killer whales can echolocate an adult Chinook salmon at a range of 100 meters easily (Au et al., 2004), and possibly at 400+ meters (Holt, 2008). They may also be able to use their echolocation to determine the spatial orientation of a salmon at such ranges, and even discriminate the species of salmon (Au et al., 2010) before or during pursuit of a target.

## 5. Please describe how physical and acoustic disturbance from vessels affects marine mammals such as Southern Resident Killer Whales and their habitat.

**It's already too loud for SRKWs. The interference of noise with communication and echolocation signals can cause SRKWs to forage less efficiently. Reducing current noise levels to ensure scarce salmon are accessible may be as important to SRKW recovery in the short-term as boosting salmon abundance is in the long-term.**

Disturbance from vessels can hinder important marine mammal activities, like hunting, communicating, and navigating. Vessels can affect marine mammals, including SRKWs, in two main ways. Both mechanisms can also affect marine mammal habitat.

The first way is physical disturbance. Vessels can get so close that the whales react when they become aware of the vessel (either visually -- below or above water, acoustically, or otherwise). A minor example is an animal changing its behavior when it is surprised (e.g. a harbor seal plunging into the water after noticing a kayaker quietly paddling nearby). An extreme example of physical disturbance is contact, which does happen occasionally -- even with killer whales (Williams and O'Hara, 2010) -- when an animal collides with a stationary vessel or is struck by a moving vessel or its propeller). Vessels can also affect habitat through physical disturbance (e.g. a ship wake disturbing surf smelt on a beach).

The second way is acoustic disturbance. Vessel noise can affect marine mammals and/or their habitat. For acoustic disturbance of a marine mammal to occur, the animal must be sensitive to at least some of the frequencies of noise emitted by the vessel, and the received level of the noise must be above or near the hearing threshold of the animal. Furthermore, the position of the animal must overlap in space and time with the noise from the vessel. Even if a marine mammal species of concern isn't present when the noise pollution occurs, its habitat can be damaged by the sound because many other types of marine life are sensitive to vessel noise, including larvae, invertebrates, and fish (e.g. Slabbekoorn et al., 2018).

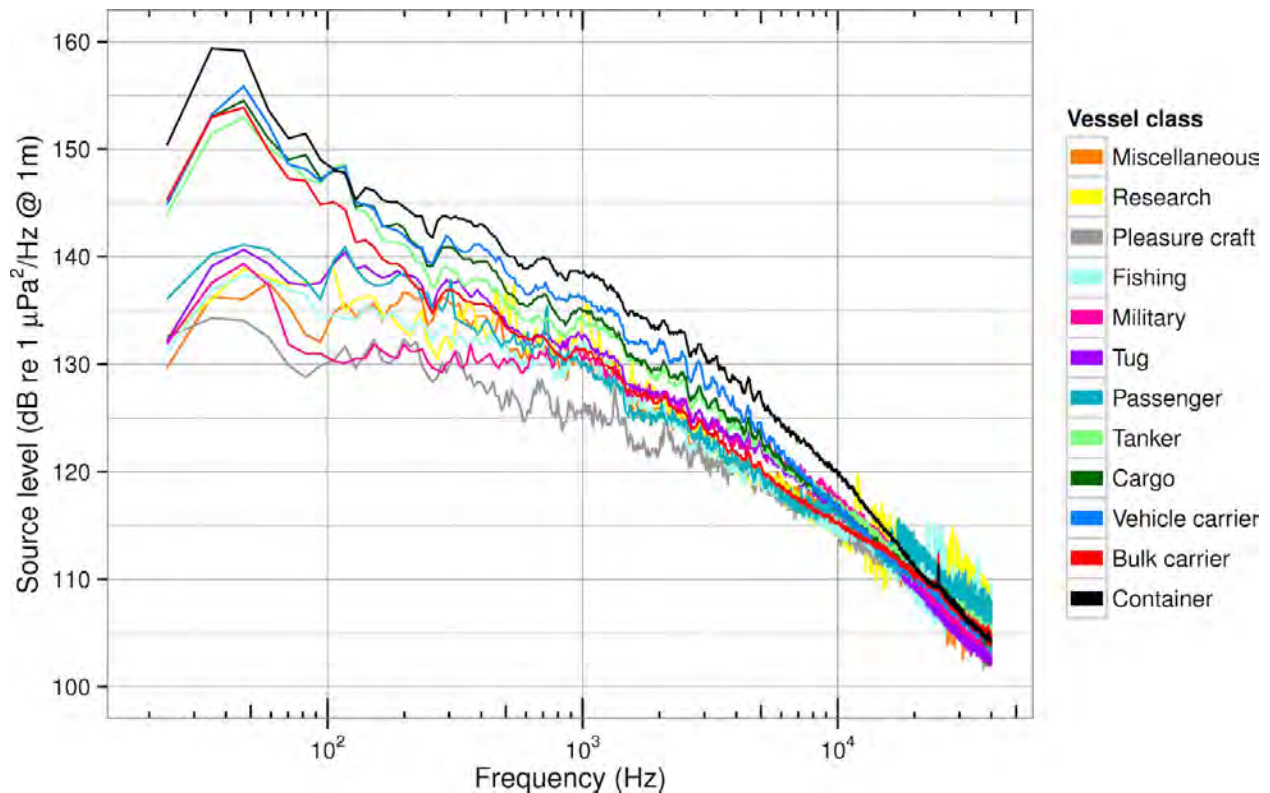
## The frequencies of ship noise overlap with SRKW signals and the hearing ranges of most marine mammals

The advent of the motorized vessel surely marked the beginning of significant anthrophony (sounds made by humans) in the acoustic ecology of the Salish Sea. Prior to that human vessels probably only radiated low-intensity, intermittent noise from paddles and creaking ropes, footsteps on hulls, or anchor chain clanking around a windlass.

In contrast, a vibrating steam or combustion engine mounted rigidly to a hull is a source of *continuous* low-frequency underwater noise. The shaft and bearings that transmit the engine's power to the propeller can generate intense noise (e.g. periodic squeaks), especially if they are not maintained. But the propeller itself is often the dominant source of noise from a motorized vessel, due to a process called cavitation -- the formation of underwater voids in low-pressure zones around the propeller that collapse violently as they move back into the higher-pressure zones. Cavitation creates surprisingly-intense continuous noise over a wide range of frequencies (50-100,000 Hz; Ross, 1976; Gray & Greeley, 1980; Arveson & Vendittis, 2000), including those where most marine life signals and listens.

These primary sources of vessel noise combine to generate a spectrum of noise -- a complex pattern of different amounts of acoustic power at different frequencies. The source spectrum for most ships has a peak near 50 Hz with a steep drop in power at lower frequencies and a more gradual (5-15 dB/decade) decrease in power at higher frequencies. Here is a plot of the median source spectrum for a variety of ship classes observed in Haro Strait (from Veirs et al., 2016) that shows this overall pattern:

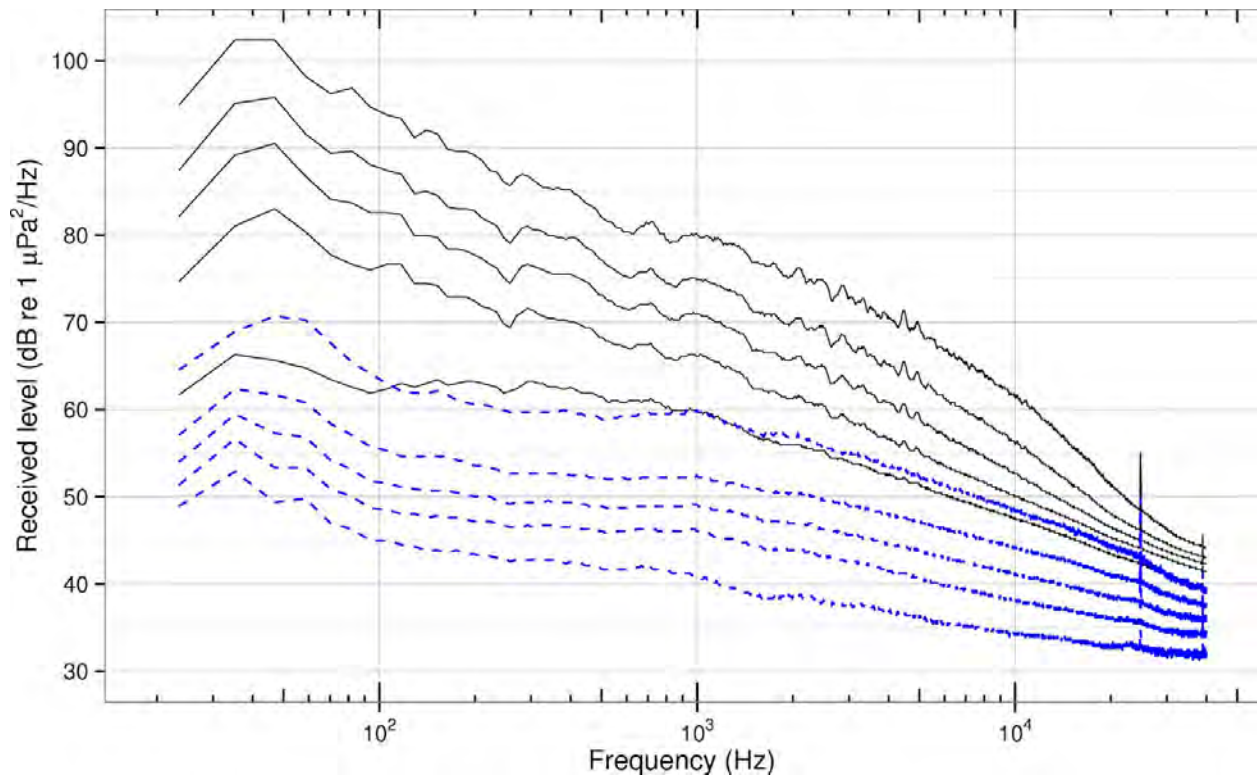




A similar pattern is apparent in other measurements of noise from ships that interact with the Port of Vancouver. For example, figure 4 of MacGillavry et al. (2016) shows peak power near 50 Hz for most ship classes at typical transit speeds, though they use  $\frac{1}{3}$ -octave bands so the peak is not as prominent.

For cetaceans with low-frequency calls like humpback whales, the combined noise from cavitation and hull-borne machine vibration that peaks near 50 Hz is the most likely to interfere. For high-frequency specialists like dolphins and porpoises, the cavitation noise may be the most impactful, particularly at close ranges to vessels. For southern resident killer whales, both the upper low-frequency noise and lower high-frequency noise from ships at typical ranges to whales in the Salish Sea overlaps with their signals and hearing sensitivity. At ranges greater than  $\sim 10$  km, another property of sea water -- frequency-dependent absorption -- tends to reduce cavitation noise above 10 kHz to background levels.

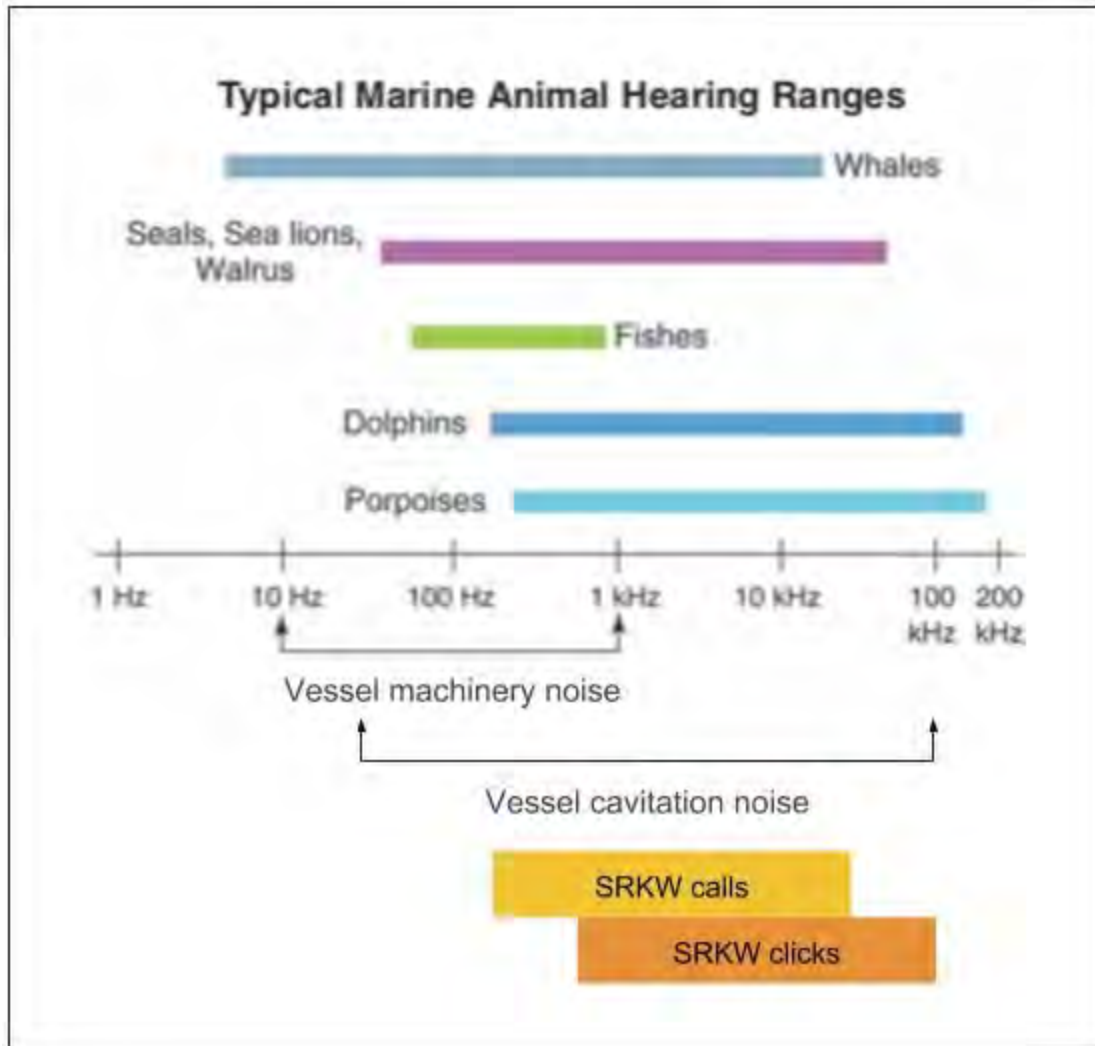
Most of the Salish Sea, however, consists of basins and channels that are rarely wider than  $\sim 10$  km, so both low- and high-frequency noise from vessels in the central shipping lanes reaches the shorelines. The following figure from Veirs et al. (2016) presents noise spectra from measurements made near the shoreline in Haro Strait, within the core summertime habitat of the SRKWs. The spectra of noise received when ships are transiting in the northbound shipping lane a couple kilometers away (solid black lines; 5, 25, 50, 75, and 95% percentiles) are elevated at all frequencies above the background noise levels (dashed blue lines; same percentiles) when ships and boats are not present.



Even at the highest frequencies measured (10,000-40,000 Hz), the median (central, 50% percentile) received ship noise is ~6-11 dB above the median background level. This means that not all the high frequency noise generated by the ship has been absorbed by the time it reaches a killer whale foraging along the west side of San Juan Island. At lower frequencies, in the range used by SRKW for communication calls (200 - 20,000 Hz), the median ship noise level that reaches the nearshore habitat of the SRKW is elevated 20-30 dB above the median background level.

Thus, in an urban estuary like the Salish Sea, there is overlap between the frequencies of ship noise, SRKW hearing sensitivity, and SRKW signals. With shipping lanes in major channels throughout SRKW critical habitat, the distances between ships and animals are often too short to absorb high-frequency component of cavitation noise. While most shorelines are less than 5 kilometers of a shipping lane, it is also worth remembering that most of the Salish Sea is less than 300 meters deep, so any animals or habitats located beneath the shipping lanes experience the emitted noise at ranges of less than 300 meters.

The following figure (adapted from Southall et al., 2018) illustrates this frequency overlap between close-range vessel noise and the signals emitted by Salish Sea marine life. The frequency ranges for SRKW signals are indicated for calls (yellow) and clicks (orange) relative to the frequency ranges for ship noise (machinery and cavitation).



The critical habitat of SRKWs overlaps with the spatial extent of mean monthly ship noise

The maps in this report illustrate the general spatial overlap between SRKW critical habitat and the spatial extent of mean monthly vessel noise modeled by the proponents. Most foraging areas commonly used by the SRKWs (e.g. Ashe et al., 2010) lie within 1-5 km of commercial shipping lanes.

The annual migratory movements of SRKWs overlap with the temporal distribution of ships

While there are temporal patterns unique to each class of ship, there is generally a high level of ship traffic throughout the year in the Salish Sea. Similarly, though the annual migratory patterns

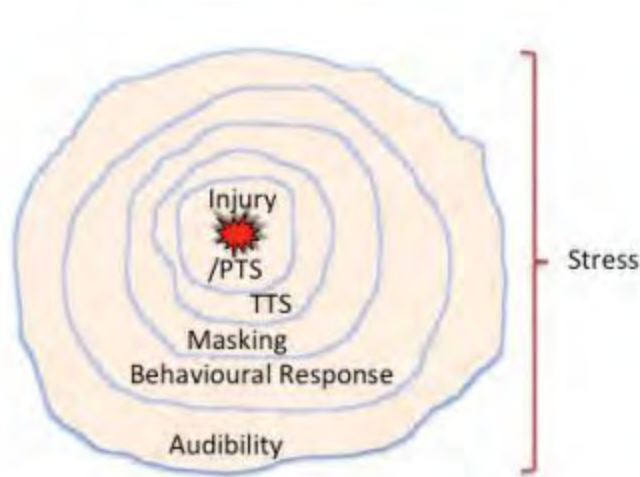
have been shifting to some extent in recent years, it is still generally true that the SRKWs are “resident” within the southern Salish Sea during the summers, and migrate along the outer coasts of the western U.S. and British Columbia during the other seasons.

## Potential acoustic impacts of ship noise on SRKWs

Thus, we have generally satisfied the criteria for an effect of ship noise on SRKWs, other marine mammals, and their habitats: the signal and noise overlap in frequency, time, and space. This allows us to continue, assessing in much greater detail the potential acoustic impacts of ship noise on SRKWs.

### General framework for bioacoustic impact assessment

The general framework for such bioacoustic impact assessments is illustrated by this diagram (Figure 1 of Erbe, 2013):



For a source emitting noise at a constant level (at the red center of the diagram), there are potential zones of bioacoustic impact around it that become less severe as the distance between the source and a receiver increases. Closest to the source is a zone where permanent deafening can occur (PTS = permanent threshold shift). Next is a zone of temporary hearing loss (TTS = temporary threshold shift), followed by zones where signals can be masked (drowned out by noise to the point of being unrecognizable) and behavior may be altered. Finally, there is a zone of audibility beyond which the receiver cannot hear the sound source. In all of these zones, including the outermost zone of audibility, the emitted sound (noise source) could induce physiological stress.

Many variables can change the extent of these zones over time. They shrink if the source becomes less intense. They also shrink if the species has less sensitive hearing at the frequencies emitted by the source.

Perhaps most importantly, recent research indicates that the extent of the behavioral response zones, and sometimes also the masking zone, can change dramatically depending on the context of the noise exposure (Ellison et al., 2012). Context may be behavioral; for example, a resident killer whale is more likely to change behavior upon noise exposure when they are foraging than when they are traveling. The context may also be physical; for example, the degree of masking may depend on the orientation of a whale to the noise source, if that animal has hearing sensitivity that varies with the direction of the incoming sound.

### Key bioacoustic impacts of ship noise on SRKWs

The typical noise levels from container ships received by SRKWs are not high enough to cause injury (acoustic trauma) or deafening (a permanent threshold shift). Similarly, temporary deafening is unlikely (NOAA, 2018). So, the key impacts to SRKWs of ship noise are masking of signals that are important to SRKWs -- calls, clicks, and environmental cues -- and behavioral changes. The environmental impact assessment of the Project focuses primarily on these two types of bioacoustic impact. The potential impacts of stress due to noise exposure remain unexplored, yet noise (and vessel disturbance) may play a role in SRKW endocrinology (Ayres et al., 2012) and we know that noise pollution can raise stress hormone levels in other cetaceans, like the North Atlantic Right whale (Rolland et al., 2012).

The Project proponents go to heroic efforts to refine the general spatio-temporal overlap described in this report and ultimately understand more specifically where and when SRKWs are likely to experience various levels of noise impacts from typical ships. The key finding of the Population Consequence of Disturbance Model was that **existing conditions** were predicted to “reduce the total number of minutes of foraging by 19.1 days (27,507 minutes) per animal per year” within the focused model area.

### The Salish Sea is already too loud for SRKWs

Those 19.1 days of lost foraging time are something the SRKWs cannot currently afford. That key finding by the Proponent and its manifestation in PCOD simulations (figure included below) that indicate that the probability of decline is near 50% adds to our understanding that the Salish Sea is already too loud for SRKWs.

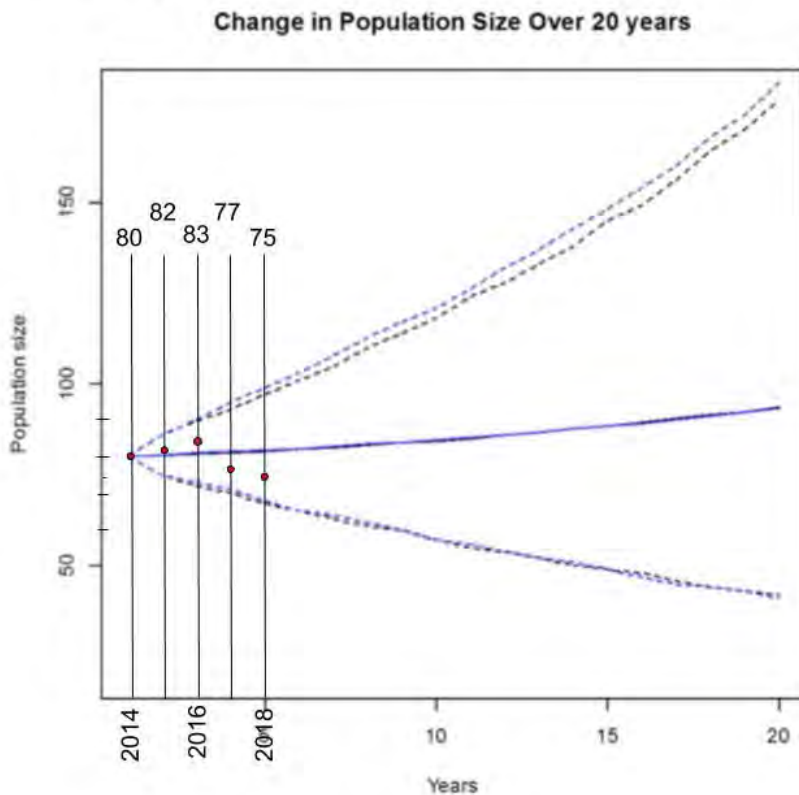
Other, independent studies have similarly concluded that ship noise and vessel disturbance is having a detrimental impact on SRKWs. Holt (2008) found that a large container ship (MV Hanjin Marseilles) at a range of 442 m was predicted to reduce echolocation from 400 m in quiet Haro Strait conditions to only 60 m. That’s a decrease of 85%. Williams et al. (2014) concluded that current levels of noise caused SRKWs to lose 62% of communication space while noise from busy ship traffic increased the loss to 97%.

For an apex predator that forages for scarce Chinook through a combination of echolocation clicks and social calls (some of which may coordinate foraging), such losses aren’t tolerable. A

85% decrease in echolocation range and a 62% loss of communication space from current noise conditions indicates the profound need for us to decrease noise levels from the status quo.

To illustrate the consequence of failing to take bold action to get more Chinook in SRKW mouths, I have overlain Figure 5 of the SRKW PCOD Model (Appendix 14-C) with the census totals for the SRKW population from the Center for Whale Research overlaid for the ~5 years since the model was run:

Figure 5 Estimates of Population Size (solid lines) Under Existing Conditions Based on the Effects of Disturbance in the LSA Over the Course of a Year and Assuming 3D Prey Search. Dashed lines are the 95% CI.



Each red dot represents the total number of SRKWs from 2014 through 2018. The recent and overall decreases should sound set off conservation alarm bells. It is time to run a scenario in which we more than mitigate current noise levels and begin recovering relevant salmon stocks. If we succeed, the PCOD simulations will reduce the probability of extinction from where it is now (~50%) to something more tolerable to a society that values wilderness icons, like <5%.

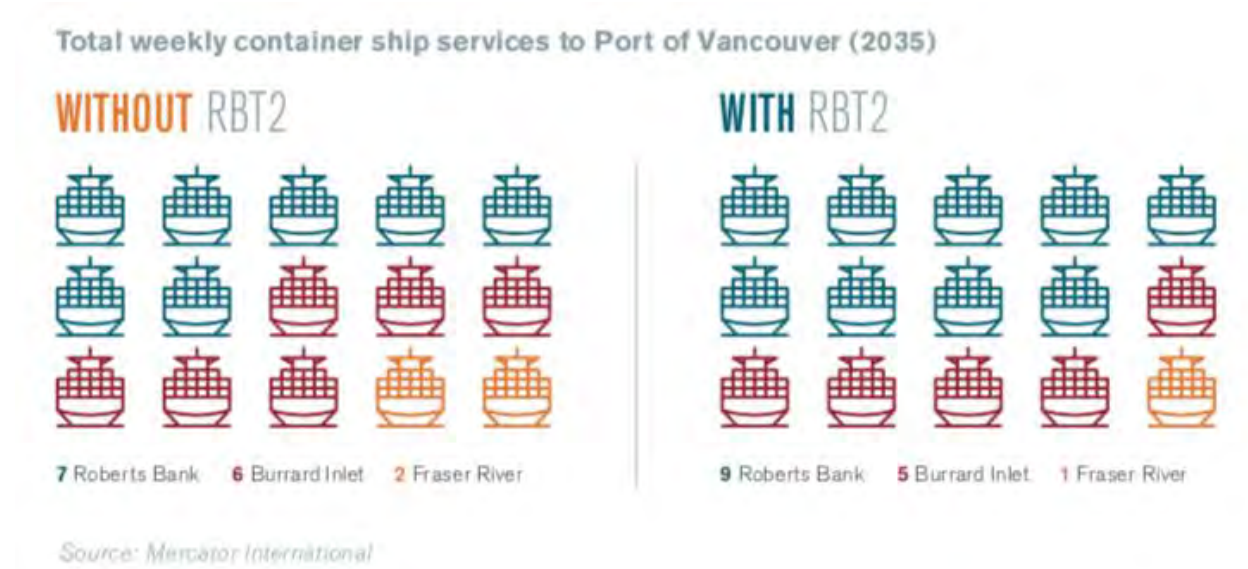


## 6. How will Project-related shipping affect the acoustic environment in the Salish Sea, and how will it affect marine species, such as the Southern Resident Killer Whales, and their Habitat?

Given the polluted status of the modern acoustic environment in the Project area, a modeling effort to predict increases in noise from the project isn't needed. **Any noise added by Project activities will worsen the current, unacceptably poor status of the acoustic environment.**

After the most-vigorous modeling effort to date, the Project documents conclude that not only would an increase in long-term mean noise levels occur as expected, but the increased noise could have significant impacts on SRKWs. As expected, the increase in noise from scenario S1 (status quo) to S2 in the focused model resulted in an "increase of 74 low-severity (5.0% increase) and 26 moderate-severity (4.2% increase) behavioural responses per year per SRKW individual". Overall, the PCOD scenario which included RBT2 and incremental vessel traffic associated with RBT2, in addition to existing and expected conditions (S2), increased the foraging time lost by approximately 5.3% resulting in 20.1 days lost in the FMA. That is essentially another day of lost foraging for a species that has already lost too much foraging time.

In the Container Vessel Call Forecast Study (Mercator 2018) and Ship Traffic Information Sheet ([Document 1362](#)), the proponents suggest that in the long-term (2035) predicted shifts in the container shipping industry to larger ships (>15,000 TEU) could result in a re-distribution of traffic between Vancouver ports. The re-distribution is depicted in this graphic in which each ship icon represents a weekly container ship service:



Whether or not the RBT2 is built, the number of services still totals 15. Because of the projected continuation of a decadal shift in the industry to larger ships (which are in essence a permanent convoy of smaller ships) the 2018 study suggests that the total annual container ship calls at Roberts Bank terminals would decrease between 2030 and 2035 (from 520 calls to either 364 without RBT2, or 468 with RBT2).

The Mercator report (2018) also predicts that the total annual calls in 2035 may be about the same as the current status quo (based on the total annual calls in 2017). As I mentioned in the previous section, the status quo noise levels are already too noisy. No net increase in ship noise (based on number of calls) in 2035 is not sufficient mitigation at this point, especially since in the interim (e.g. in 2030) the number of calls are predicted to be higher than in 2035 -- representing a net increase in ship noise.

Even if the number of calls remains the same in 2035 as it was in 2017, I continue to have doubts about the methods used in the EIS for estimating the increased source level of noise emitted by the larger (>15,000 TEU) containships. (See my attached comments regarding the EIS and Addendum.) The same number of calls with higher-than-predicted source levels could mean that was expected to result in no-net-increase actually is a net increase in ship noise.

Finally, the graphic above suggests to me that without the RBT2, the total calls of container ships to the Fraser River delta would decrease (with obvious associated reductions in environmental impacts) . With RBT2 there are 9 services to Roberts Bank in 2035; without RBT2 there are 7. If we include services to the Fraser River facility (which obviously must traverse the nearshore environment of the delta, as well as a portion of the lower Fraser River), there are 10 total services affecting the delta environment with RBT2 (10 = 9 to Roberts Bank and 1 to the Fraser facility); without RBT2 there are 9 (=7+2).

## 7. Please describe the magnitude and geographic extent of the acoustic impacts of Project-related shipping.

In their Underwater Noise Exposure and Acoustic Masking Study (Appendix 14-B), the Proponents estimate that noise from a large container ship “starts to reduce echolocation detection distance at ~2.5 km, which is 1 km further than when it starts to reduce call masking detection distance.” If we assume this is accurate (at least for the larger, more intense ships), then echolocation space of SRKWs is being decreased over much of their critical habitat. Given that the shipping lanes (including the traffic separation zone) are often a few kilometers across (between the outer edges of the lanes), echolocation could be decreased throughout any channels in SRKW critical habitat that host a central shipping lands and are less than 8 kilometers across (8 = 2.5 + 3 + 2.5). The geographic extent of call masking might encompass all such channels that are less than 5 km across.



## 8. Will the acoustic impacts of Project-related shipping be temporary, ongoing, or permanent?

The acoustic impacts of Project-related shipping will be ongoing as long as RBT2 ships transit SRKW habitat at their current source levels. The good news about underwater noise pollution is that it goes away nearly instantaneously when you quiet the source.

It is possible (but unlikely) that the impacts could turn out to be temporary. For example, the SRKW habitat could change; they could cease using the Salish Sea and therefore no longer overlap with RBT2 ships in space or time. Alternatively, the ships could be re-routed away from SRKW habitat and therefore alleviate ongoing impacts. And finally, impacts could be reduced over time through mitigation methods (ideally through permanent ship quieting technologies).

In one sense, the impacts of the Project-related shipping could be permanent. If noise from RBT2 container ships causes detrimental shifts in SRKW demography or accelerates the population's decline, the impacts on the population could be very long-lasting, or even lead to extinction (which is permanent).

## 9. What, if any, are the options to mitigate the impacts of Project-related shipping, including the impacts on the Southern Resident Killer Whales and their habitat? What is your opinion of the viability of these options and their likely effectiveness?

**The Project will definitely increase noise in the region's marine acoustic environment. The good news is that ship quieting technologies and techniques exist that could "more-than-mitigate" the impacts of the current noise levels, including any added by the Project.**

Building on a CSAS review to which I contributed and a related publication (Williams et al., 2019), I consider 11 mitigation measures below and rank them according to their likelihood to reduce sound exposure levels experienced by SRKWs ("effectiveness"). For each of the mitigation actions and measures, the uncertainties and limitations as well as the actions to address any uncertainties and limitations are listed (in the first table). Next, I assess combinations of these mitigation scenarios and rank them (in the second table) to evaluate the pragmatic combination of measures most likely to reduce noise exposure levels within SRKW habitat.

I used the following criteria to rank the status of noise management options.

1. Higher rankings were assigned to mitigation options likely to reduce global, rather than only local noise levels. In practice, this means I gave higher rankings to permanent removals or retrofits than to temporary operational mitigation methods (e.g., local speed limits). All other things being equal, this approach would allow Canada to make long-lasting improvements in acoustic habitat quality for SRKW, while also making progress toward international targets to reduce shipping noise globally.
2. Higher rankings were assigned to mitigation measures that are likely to be implemented quickly, thereby facilitating SRKW recovery as soon as possible. I assume that measures affecting a small fraction of the fleet would be implemented faster than actions that would require fleet-wide changes and/or 100% compliance.
3. Higher rankings were assigned to mitigation options that lend themselves to time- and area-based management tools, to allow adaptive management of mitigation measures targeted on SRKW habitat as policy-makers refine SRKW conservation objectives. For example, spatially explicit management tools could prioritize noise mitigation in areas that SRKW use preferentially for feeding.

## Ranking of single management options

In the table below, I rank noise management options based on their overall effectiveness in minimizing impacts of ship noise on SRKWs and other marine life. In addition to noting logistical constraints, uncertainties, and limits for each management option, I summarize what options could cause a 3 dB decrease in broadband noise levels, equivalent to halving the radiated power of the fleet that frequents the SRKW habitat. For example, a 3 dB reduction could be accomplished by removing ships that make up the 15% of the modern fleet that have the most intense source levels. (I call these ships “gross polluters” following the nomenclature under the California smog emissions standards for cars, in which a small proportion of agents cause a disproportionately large input to the pollutant.)

To gauge whether a noise mitigation measure is likely to cause a relatively large or small reduction in noise, I use a 3 dB placeholder value for a meaningful noise reduction. This 3 dB value is a placeholder until policy makers specify the level of risk they are willing to tolerate in light of SRKW recovery, but it happens to match nicely with two related processes. At a local scale, we are facing industrial development that may easily double traffic of large ships in the Salish Sea (Gaydos et al. 2015), which—all other things being equal—would theoretically cause a 3 dB increase in noise levels. A reduction of 3 dB would be required to offset these future inputs without causing a net increase in noise. Secondly, we note a recent pledge by Okeanos and a later endorsement by the International Whaling Commission (IWC Scientific Committee 2016) to reduce the inputs from individual ships. These international groups call for efforts to “reduce the contributions of shipping to ambient noise energy in the 10-300 Hz band by 3 dB in 10 years and by 10 dB in 30 years relative to current levels” (Wright 2008).

<b>Rank (1= best)</b>	<b>Management option</b>	<b>Actions to get -3dB</b>	<b>Logistics</b>	<b>Uncertainties &amp; limits</b>
1	Remove noisiest ships in fleet	Remove “gross polluters” (see text). Could cause reductions >3 dB.	15% of fleet affected	Can noisiest ships be removed? If removed and replaced, are noisiest ships replaced with mean or minimum noise level?
2	Retrofit noisiest ships in fleet	Reduce noisiest ships to below 175.4 dB	43% of fleet affected	Key retrofit actions are more effective at the design phase
3	Retrofit all ships in the fleet	Retrofit all ships so source level reduced by 3 dB for each ship	100% affected	Key retrofit actions are more effective at the design phase. Large industry disruption/cost for modest return.
4	Modify ship design	All new ships use best practices to reduce source level by 3-5 dB	1% increase in manufacturing costs	Applies to all new builds.
5	Remove and replace	Replace noisiest ships with ones with 3-5 dB lower source level	Combines options 1 and 4	May be challenges with ensuring SL of replacements meets reduction target
6	Speed limit	All ships must respect speed limit of 11.8 knots	83% of fleet affected; VTSS & Coast Guards monitor only for speeders. Reduces lethal risk of ship	Collateral impacts (e.g., navigational safety, oil spill risk).

			strikes for baleen whales.	Local, not global. Longer exposure to lower levels may be a concern, depending on noise metric specified in policy.
7	Convoy (grouping ships together)	Convoys (e.g. at 11.8 knot speed limit)	Could affect only fast ships, or certain classes; major impacts on stevedores and pilots	May be risk implications for collision and oil spill associated.
8	Real time ship traffic control (rerouting, slowing, or rescheduling) to avoid SRKWs	Area to be avoided only when SRKWs are present. Requires real-time monitoring and flexibility (on some time scale) for pilots/ships to adapt.	Unknown fraction of ships affected some unknown proportion of time. Depending on % of ships affected, less effective than "Remove" scenario (Ranked #1)	May displace oil spill / ship strike risks. Real-time monitoring may not be 100% effective.
9	Re-route ships (permanent)	Permanent change in shipping lane.	All ships affected 100% of the time. Depending on class of ships affected, may become equivalent to "Remove" scenario (Ranked #1)	Will habitats shift? Will this displace oil spill risk?
10	Reduce speed for all ships	All ships slow down 3 knots from current speed	100% affected; VTSS & Coast Guards monitor all; Citizen scientists could monitor AIS; Pilots Association	Local, not global; hard to enforce Longer exposure to lower levels is a concern
11	Move lanes sideways	Shipping lanes shifted 1-4 km from current	Coast Guard/IMO	Constrained by geography in Haro and

		position		Rosario Straits and Swiftsure Bank. May involve major disruption for <3 dB effect
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Slowing ships to reduce noise may have a variety of additional costs and benefits. Slowing ships down generally reduces noise levels, but it may also lower the risk of ship strike in baleen whales and possibly SRKW (Hatch et al. 2008). Slowing ships could also change navigational risks. A vessel traffic risk assessment conducted in Puget Sound during 2010 showed a 27% reduction in the risk of incidents (i.e., collisions and/or oil spills) when container ships were slowed to 17 knots from their mean speed of ~19 knots (Van Dorp & Merrick 2014).

Given the uncertainties and limitations of some scenarios, many of which rely on model predictions because they have never been implemented, I would advise Canada to take a multi-pronged approach to reach aspirational (~10 dB) noise reduction targets and to include a precautionary buffer to allow for imperfect compliance. The pragmatic, multi-pronged approach outlined here could guide a synthesis of multiple mitigation measures. This multi-pronged approach will (a) allow for aspirational reductions >3 dB in magnitude (i.e., thereby acknowledging that biologically relevant targets are not yet known and may require mitigation >3 dB); and (b) buffer against imperfect compliance rates, while still achieving a 3 dB reduction. For example, an 11.8 kt speed limit (3 dB reduction), removal of gross polluters (3 dB), retrofitting noisy ships (3 dB), and managing large ship traffic in a convoy approach could collectively result in a reduction >10 dB. This multi-pronged approach would allow Canada to exceed the IWC's most ambitious pledge -- a 10 dB reduction over 30 years (IWC Scientific Committee 2016).

Together, these two ranking tables could guide future models to predict population consequences of increased noise levels, or various mitigation scenarios, to SRKW. Some of these scenarios could explore how Canada could more-than-mitigate the impacts of the Project and dramatically and permanently reduce modern ship noise levels.

### Ranking table of combinations of management options

Rank (1 is best)	Management option	Achievable noise reduction (dB)	Logistics	Uncertainties & limits
4	Convoy with 11.8 knot speed limit	3 dB for 50% of time at Lime Kiln	Pilots Association, VTSS, Coast Guard	Compliance, safety, and enforcement
3	Removal of gross	6 dB	Remove "gross	Logistical

	polluters + retrofit for remaining		polluters” to reduce source level by >3 dB and retrofit rest of fleet to reduce source level by 3 dB for each ship	constraints with respect to time, resources, and industry responsiveness
2	Removal+retrofit+ slow all by 3 knots	9 dB	Logistics from #3 plus VTSS & Coast Guards monitor all; Citizen scientists could monitor AIS; Pilots Association	Compliance and enforcement with respect to the speed reduction
1	Removal+retrofit+ convoy at a speed to get >4 dB	>10 dB	Logistics from #3 plus convoy approach could impact only fast ships, or certain classes	Convoy coordination

**10. How will Project construction affect the Southern Resident Killer Whales and their Habitat?**

Any construction project that involves impact or vibratory pile driving has the potential to have short- and long-term impacts on nearby marine mammals, including SRKWs, and their habitat. The worst case scenario would be the exposure of a SRKW to high-intensity construction noise that could cause permanent or temporary deafening. The more likely impacts, however, would involve fish (which could have cumulative effects for the SRKWs, e.g. if herring and/or salmon are killed) or possibly an increase in local noise that could impact SRKW foraging and communication efficiency if they are hunting for Fraser River adult Chinook during the construction phase.

**11. What are the options to mitigate the impacts of Project construction on the acoustic environment, including the impacts on the Southern Resident Killer Whales and their habitat?**

If Canadians are really interested in helping the SRKWs recover, they should expand shipping capacity somewhere else. And ideally they should also move the existing persistent sources of noise and chemical pollution out of the active delta of Fraser river. The Fraser delta and estuary is the nearshore habitat where the SRKW’s primary summer prey -- Chinook salmon -- return as adults and rear as juveniles.

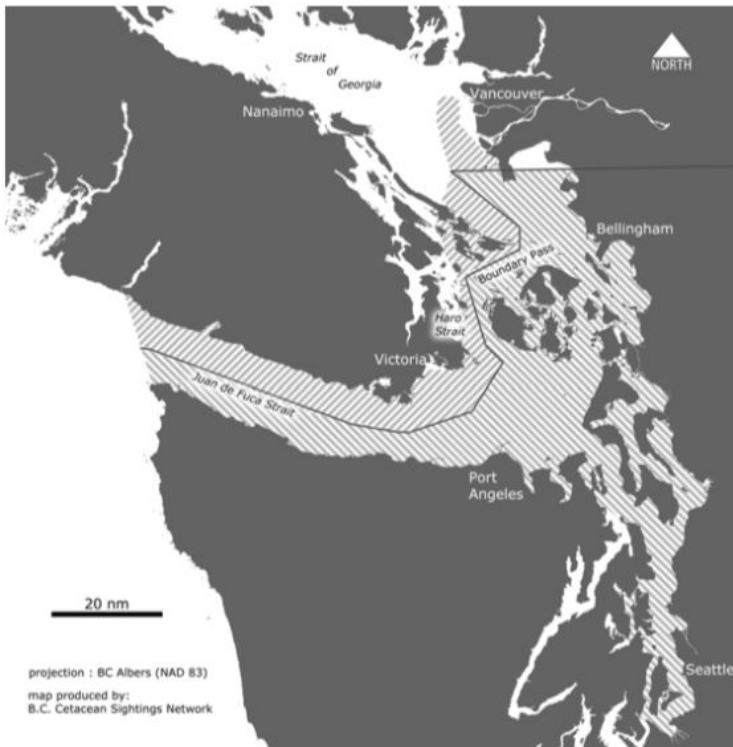
According to the [history prepared by the proponents](#) (section 2.1-2.2), the ecological importance of this nearshore environment was not a consideration back in the 1950s when the location was chosen for a major ferry terminal. In a rush to restore ferry service after a labor strike, the location was selected based on four factors: shortness of the route; proximity to the Massey tunnel; land that was already cleared and level; and the relatively short causeway length needed to reach water deep enough for the ferries. So, a ferry terminal was constructed *within* the estuary and delta.

While other areas were considered for a coal terminal, one was added just north of the ferry terminal in the 1960s. Though alternate locations like Boundary Bay were considered and impacts on marine life were considered (but not formally assessed), the current location was preferred for “remoteness from densely populated areas to minimize impacts from occasional air, water, or noise pollution.” As a point of reference, just as the coal terminal was being finished in 1970, the capture industry reached its zenith -- removing 15 killer whales from the Salish Sea that year.

In 1979, a proposal to expand the coal terminal was rejected because “the potential impacts on the Fraser River Estuary were too great.” The panel articulated that their primary concern was protection of the valuable Fraser River salmon fishery, highlighting that there was not sufficient estuarine habitat required to support juvenile salmonids. Nevertheless, a reduced expansion of the coal terminal was eventually allowed. Ironically, enough extra space opened up over time in the coal terminal to allow container shipping infrastructure to move in (first to pod 4 in 1995, then pod 3 in 2000) and eventually expand itself (by adding the third berth in ~2010).

Thus, the current Roberts Bank shipping terminal is located only a few kilometers from the southernmost channel of the Fraser River -- where inbound adult salmon approaching via the Strait of Juan de Fuca naturally enter the river. Extending to the northeast from the existing terminal, the new terminal (RBT2) would be even closer to the nearest river mouth (and the adjacent Alaksen National Wildlife Area). The decadal advancement of Canadian development is poised to continue -- towards the central delta of the river that feeds the SRKWs.

The importance of this geographic area (the Fraser River delta) is emphasized in the Canadian delineation of critical habitat for SRKWs in the following map (Figure 1 of CSAS, 2017). Note the arc of the critical habitat north from Point Roberts around the delta towards west Vancouver. In contrast, the marine areas on the sides of the delta (Burrard Inlet on the north and Boundary Bay on the south) are not designated as critical habitat for SRKWs.

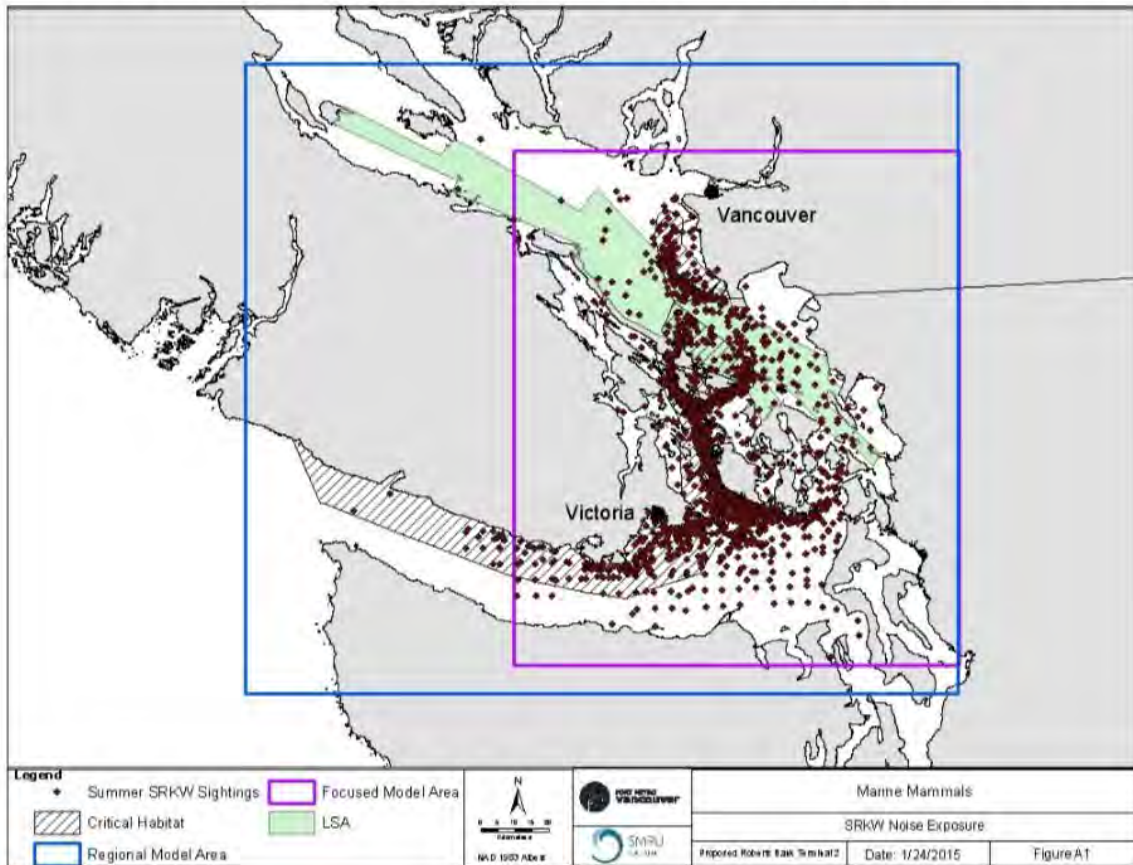


*Figure 1. Southern Resident Killer Whale Critical Habitat in Canada and the United States. The hatched area in US waters depicts the approximate Critical Habitat under the US Endangered Species Act*

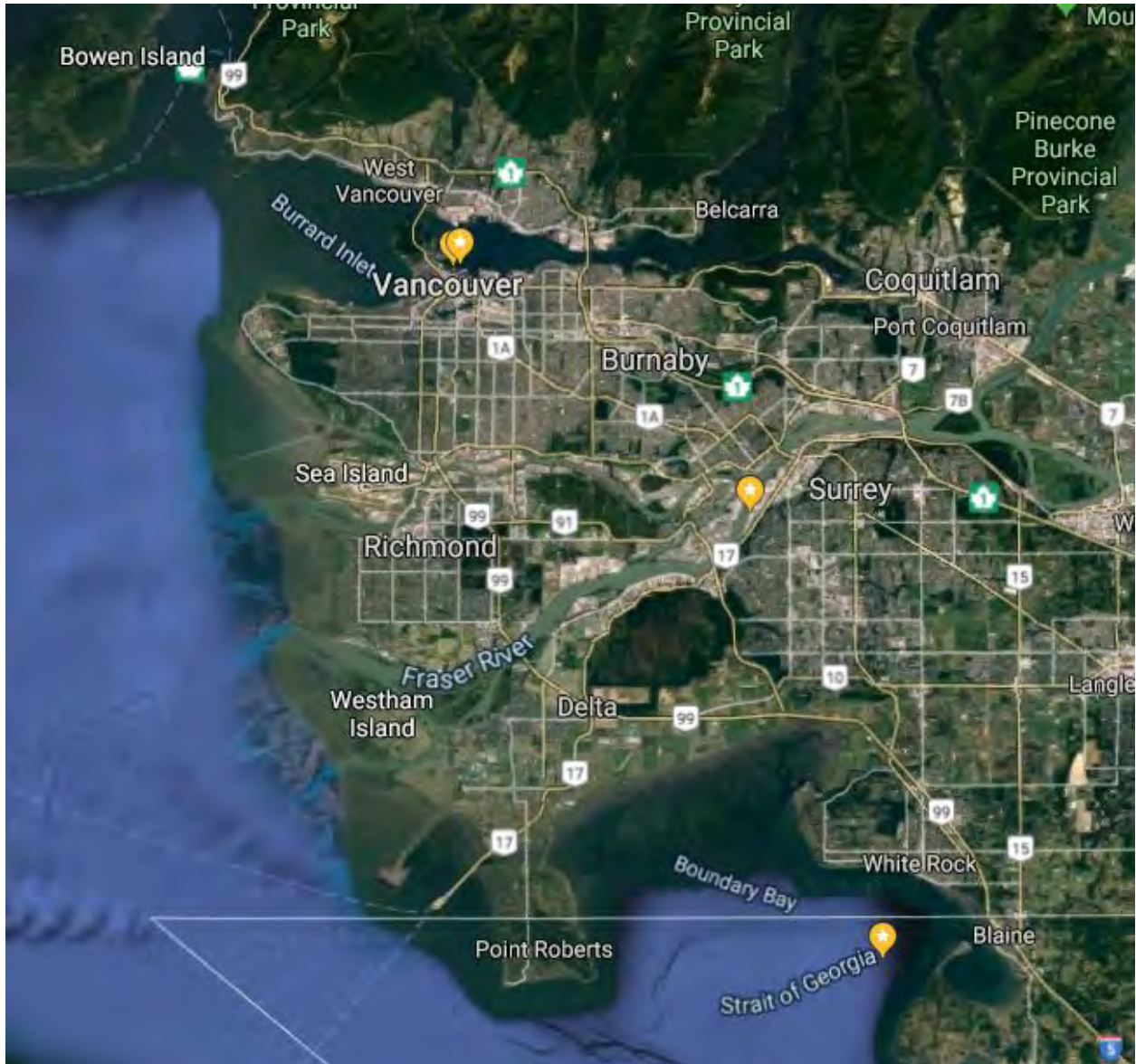
Another indication that the Fraser river mouth is important to the SRKWs, and not necessarily the outer edges of the delta, is Figure A1 (from Appendix 14-B) below. The highest density of summer SRKW sighting locations extends from the Strait of Juan de Fuca through Haro Strait, the Gulf Islands, and Boundary Pass to the mouth of the Fraser. Sightings on the outer edges of the delta are rare to non-existent. The most parsimonious ecological explanation for this pattern is that the SRKWs are foraging on adult Chinook as they return to the Fraser River.



Figure A 1 Summer SRKW Sightings Locations, SRKW Critical Habitat, Regional Model Area, Focused Model Area, and LSA



A precautionary approach to more than mitigating the potential impacts of increased (and extant) ships on SRKWs and on salmon in the Fraser delta would be to move all shipping terminals *outside* of the delta. Looking at the satellite map (below) from the SRKW's and Chinook salmon's perspective, Vancouver Harbour looks like much better location for shipping and coal terminals than the active Fraser delta. That harbour is well north of the modern Fraser River mouth and adjacent to the mooring area for commercial ships in Burrard Inlet. In that vicinity there is already substantial shipping infrastructure (Vanterm and Centerm) which could be expanded dramatically to accommodate both RBT2 and RBT1.



Alternatively, the containership (and coal) terminals could be moved to the south side of the Fraser Delta, on the far side of Point Roberts, within Boundary Bay. Positioned near White Rock, as far as possible from the Fraser river mouth but still in Canada, it might have the least impact on the nearby marine and estuarine environments.

There is evidence that such a move to restore natural habitat within the delta would benefit salmon, including Fraser Chinook upon which SRKWs depend in the summertime. For example, one peer-reviewed assessment of coal port impacts on juvenile salmon (including Chinook) emphasized that the “recent construction for expansion of the port has obliterated feeding areas, invertebrate communities, and possibly herring habitat from the local production system” (Levings, 1985).

Relocating the present-day terminals would also reduce impacts on the SRKWs -- both acoustic (e.g. the ships, their tending tugs) and cumulative. If the Tswassen ferry terminal was also relocated, it could dramatically reduce the risk that a SRKW is struck by a vessel, as may have happened in the [death of J-34](#) in the southern Strait of Georgia (the immediate vicinity of the Project). To optimally reduce SRKW strike risks (and reduce noise and other ferry impacts) near the Fraser river mouth, it would be prudent to route all Nanaimo-bound traffic through Horseshoe Bay and make a new ferry terminal (based e.g. in White Rock?) serve only travellers bound to/from Sidney and the southern Gulf Islands.

## Cumulative effects of the Project, particularly on Southern Resident Killer Whales

12. Please describe the cumulative effects of the Project-related shipping in combination with other human activity on the Salish Sea, including the cumulative effects on the Southern Resident Killer Whales and their habitat.

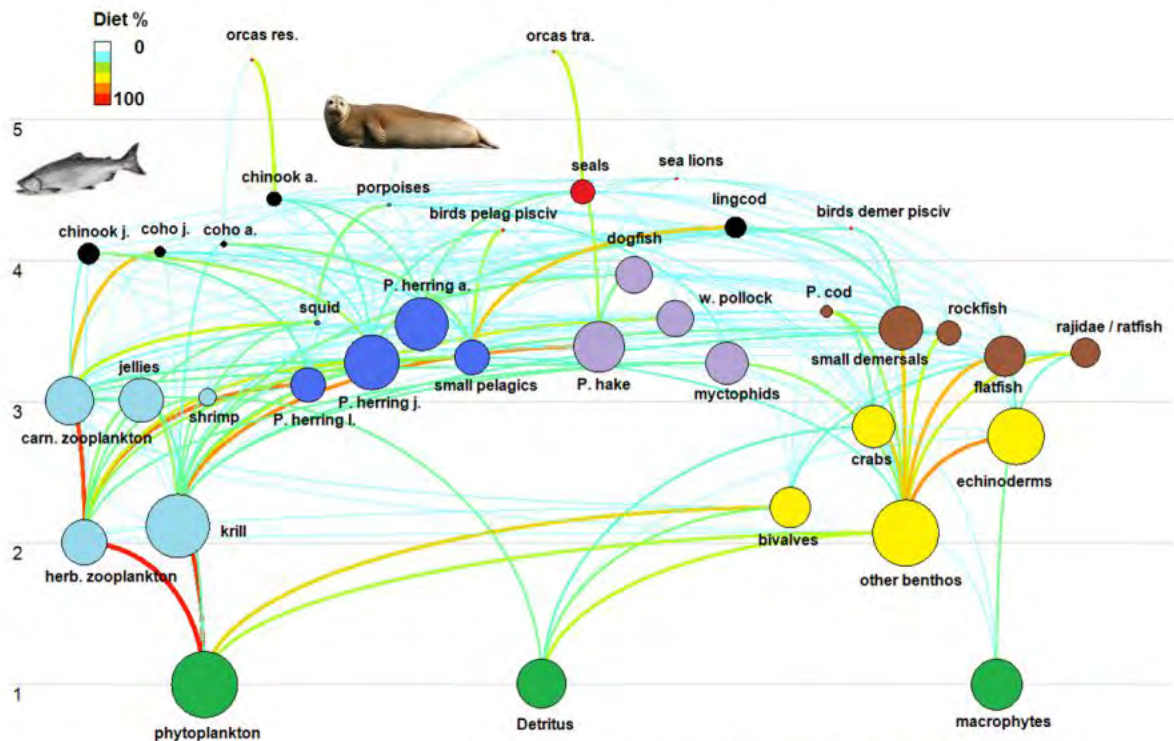
I have two main concerns regarding cumulative effects of the Project and other human activities within the Salish Sea. The first relates to the strong ecological connection between SRKWs (and other marine mammals), adult and juvenile Chinook salmon, and Pacific herring. The second involves vessel strikes on SRKWs, and the possible roles of ships and/or ship noise in those strikes.

### Pacific herring connections to Chinook salmon and SRKWs

The RBT2 Project could have a wide range of cumulative effects on the food web in the Strait of Georgia -- which is wonderfully complex, as depicted in this diagram (adapted by WDFW from Priekshot et al., 2012):



# Complex Food Web



Source: Strait of Georgia ecosystem model – D. Preikshot & I. Perry, Fisheries and Oceans Canada

The population dynamics of SRKWs (abbreviated as “orcas res.” in the food web diagram) are driven primarily by abundance of Chinook along the west coasts of the U.S. and British Columbia (Ford et al., 2010). During the spring and summer, adult Chinook returning to the Fraser River are the most important component of the SRKW’s diet (Hanson et al., 2010). Human fishers often troll for those adult Chinook using herring plugs, which I take as anecdotal evidence that returning Chinook prey upon herring. The food web diagram verifies this trophic connection among many others between both adult and juvenile Chinook (“chinook a.” and “chinook j.” in the diagram) and adult and juvenile herring (P. herring a.” and “P. herring j.” in the diagram). So, the condition of returning adult Chinook probably depends upon the availability of at least adult herring, and possibly also juvenile herring, along the Chinook migration route.

A different, but possibly more important connection between Chinook and herring is that herring predators, like harbor seals (the red dot in the food web), sea lions, and birds may switch from eating herring to consuming juvenile salmon when herring are scarce. In the region of the Project, just south of the Fraser River mouth, the Cherry Point herring population used to be the largest in Washington State. Historically, Cherry Point herring spawned from the north end of Bellingham Bay north to the Canadian border (Point Roberts). For reasons that are not yet clear, the Cherry Point stock is only at about 10% of its historic size. Because of this local

shortage the nearshore environment at the mouth of the Fraser is likely a habitat in which out-migrating Fraser Chinook smolts face elevated levels of natural predation.

All this means that any impacts of the Project on herring (or eel grass to which the herring attach their eggs when they spawn each spring) could have ecosystem effects which matter to the SRKWs (and other marine mammals who prey upon adult Chinook). Potential impacts of the Project on herring include: disturbance during construction (e.g. by pile emplacement); destruction of eelgrass beds during construction; and on-going disturbance by ship and tug noise near RBT2. There is emerging evidence that displacement of herring can be caused by underwater noise (e.g. Slotte et al., 2004).

Also related to these connections is a trend of transient (Bigg's) killer whales recently occupying the Salish Sea more than in the past, while there are fewer SRKWs (Shields et. al. 2018). Hence, SRKW's may not be necessarily always be controlling, and the impacts of ship's presence and noise on transient killer whales should not be ignored, especially given the complex ecological connections between residents and transients. For example, Bigg's killer whales prey mainly upon harbor seals while harbor seals prey upon not only salmon (adults and juveniles) and their prey (e.g. herring), but also key predators of juvenile salmon (like hake).

## Vessel strikes of SRKWs, and the potential role of ships and/or ship noise

Because the RBT2 will bring an increase in ship traffic or at least an increase in the size of ships frequenting the habitat of the SRKWs, I am concerned about the possible increased cumulative risk of ship strike on the SRKW population, especially given its current precarious condition. A deadly strike of another reproductive female could hasten the extinction of the SRKWs.

Since 2012, two SRKWs have been killed by something that caused "blunt force trauma." In [the case of J34](#) who stranded at Sechelt, B.C., in 2016, it is most-likely that he was killed somewhere in the southern Strait of Georgia -- an area where vessel traffic is high and where SRKWs forage for Chinook. Public opinion suggested that a vessel was probably the cause of the trauma. The necropsy report, though not yet formally released, basically reported that J34 was struck on the upper left side hard enough to have fractured his skull. In [the case of L112](#), who stranded in 2012, the trauma was similar as was the setting: she was most-likely killed near the Columbia River mouth -- an area where vessel traffic is high and where SRKWs are known to forage for Chinook.

Williams et. al. (2010) reports that 3-4 whales are struck per year in Canadian and US inland waters. Furthermore, Williams et. al. quantifies the increased probability of ship strike as shipping traffic changes. Also, in multiple cases of killer whale strikes since observations began in Johnstone Strait (Helena Symonds, pers. comm.) ship propellers have caused severe injury

or fatalities. Multiple examples of killer whale dorsal fins being severed or deformed suggest strikes by ships, rather than by boats. In the case of A21, a Northern Resident Killer Whale, we know that it was hit by the Comox ferry and did not survive (Ford et al., 2000).

While serious injuries to SRKWs from collisions with vessels are probably rare events, there is a disturbing trend of two individuals suffering from blunt force trauma in the last 7 years. It is possible we should expect such strikes to become more common if we continue to increase vessel traffic in the region -- from recreational boats to ferries and container ships. The cumulative impact of such vessel interactions may be complex; perhaps the persistent noise from ships makes it increasingly difficult for SRKWs to pick up on acoustic environmental cues -- like the buzz of an oncoming speed boat that normally could be avoided (under low background noise conditions).

### 13. What, if any, are the options to mitigate the cumulative effects on the Southern Residents and their habitat? What is your opinion of the viability of these options and their likely effectiveness?

In an ideal world, we would have an accurate ecosystem model of the Salish Sea integrated with PCOD models for all species that respond to important habitat characteristics like underwater noise. With such integrated models we could assess cumulative impacts on species of concern more easily and with greater confidence. We could also test the efficacy across of potential conservation actions across an ecosystem, rather than for individual species. Unfortunately, such models are only emerging now and are not yet integrated.

Given this state of affairs, I would like to offer a list of questions which arose during my assessment of the RBT2 Project, and especially the modeling of the population consequences of acoustic disturbance for SRKWs. While the proponents state they attempted to keep the PCOD model "simple," it still is complicated and within it are many assumptions and scientific uncertainties related to the complex bioacoustics of SRKWs and ship noise.

#### **General questions about the RBT2 SRKW PCOD model:**

- Why have the proponents not run a "more than mitigate" scenario (e.g. RBT2 goes forward and ships add noise, but other sources of noise in the SRKW habitat are dramatically lowered by a mitigation strategy like the slow-down of all ships, including new RBT2 ships)?
- A 50% chance of decline should be unacceptable. What reduction in noise exposure would generate less than a 5% chance of decline?
- Are vital rates in year N a function of vital rates in year N-1?
- Is the assumption of Chinook supply being constant reasonable? Have runs been done with better/worse Chinook supply? (How sensitive is the PCOD model to Chinook supply? Is it over-optimistic about prey-switching?)

- When the proponents write that “Therefore, while the model itself is robust, the results should be interpreted in the larger context of the limitations...” what does “robust” here mean? If the authors are saying that the results don’t change much with different scenarios, then they need to expand their scenarios. For example, they could run a scenario with much less shipping and see how the model responds.

Finally, the Project proponents rightly identify the limitations of using a monthly average of noise levels as an input for an SRKW PCOD model. They state that using an averaging time scale of minutes for a couple of days of representative acoustic data is important because “behavioural response and masking are driven by noise extremes, not averages.” I would even shorter time scales may be appropriate for estimating the statistical distribution of low-severity and moderate-severity behavioural responses and acoustic masking (for SRKW signals in ship noise) because there are significant variations of ship noise on time scales of seconds or even milliseconds (e.g. the “clattering” that is characteristic of many cavitating propellers) and because the SRKW signals also have a time scale of seconds (calls, whistles) or milliseconds (echolocation clicks and their echoes).

**Do you have any relationship with a party to this litigation that might affect your duty to be objective and impartial?**

**14. Before agreeing to give an expert report in this regulatory proceeding, did you have a relationship with the Proponent, or with any federal government department participating in the Hearing, such as Fisheries and Oceans Canada?**

I have had a working/financial relationship with DFO. I sub-contracted with Oceans Initiative to help produce a CSAS report regarding ship noise mitigation. That sub-contract included me traveling to Vancouver to present the results of our research at the [2017 CSAS meeting](#).

15. Before agreeing to give an expert report in this regulatory proceeding, did you have a relationship with the David Suzuki Foundation and Wilderness Committee, or with Raincoast Conservation Foundation or Georgia Strait Alliance? Please explain.

I've not had working/financial relationships with Georgia Strait Alliance. I worked under contract for the Rainforest Conservation Foundation from Oct 2018 - Jan 2019, preparing a report regarding potential threats of the Trans-mountain pipeline extension to SRKWs that they filed in a hearing about the project, but my agreement to provide a report to the RBT2 panel was signed a couple years before working with the Rainforest Conservation Foundation. I have had a relationship with the David Suzuki Foundation and Wilderness Committee through this RBT2 review process, including the agreement to provide an expert report to this regulatory proceeding, and to work on previous stages of the environmental review of the RBT2 project.



# Conclusions

The SRKW are one the most-studied marine mammal populations in the world. For almost 40 years, we know identified every individual, so know both the current population and many demographic parameters. We have categorized their calls and we know a lot about how they move throughout the year and what they eat.

Yet we are just beginning to understand how they use sound for complex essential tasks like foraging and how such endeavors are affected by ship noise, as well as other potential impacts of human human activities. We don't know for what any of their calls are used. We have no measurements of the intensity or directivity of their clicks (assuming instead that they are the same as those of NRKWs or similar to other dolphins). We don't know how well their main prey, Chinook salmon, senses sound pressure or particle motion. We can only infer how they hear (assuming key acoustic parameters like critical ratios, directivity index, and avoidance of masking in anisotropic noise). And we do not yet fully understand the importance of quiet time to SRKWs and the acoustic ecology of the Salish Sea.

The Project proponents have demonstrated that they are willing to make great efforts for new development to have no net increase in impacts on the SRKW population. Canada has slowed ships and demonstrated decreases in ship noise levels, but has not invested in studying how the SRKWs respond to such mitigation. Within the RBT2 assessment, great efforts have been made to measure ship noise, predict increases from the status quo under various development scenarios, and model the loss of communication and echolocation space from the remaining noise.

Despite these valiant efforts, we are struggling to decide as a society that we are unwilling to lose them. Perhaps individuals who have decided that too much would be lost lack the tools to communicate why. Or perhaps we all lack the wisdom to know exactly what -- beyond direct economic value -- would really be lost if our regional icons go extinct.

In the face of scientific uncertainty about SRKWs and our impacts on their complex marine ecosystem, we should take a precautionary approach. We should quiet their waters before adding more ships. We should ensure they have abundant, non-toxic salmon to eat and are on the road to recovery before we make their lives more difficult.

## References

- Arveson, P.T., Vendittis, D.J., 2000. Radiated noise characteristics of a modern cargo ship. *The Journal of the Acoustical Society of America* 107, 118–129.
- Ashe, E., Noren, D.P., Williams, R., 2010. Animal behaviour and marine protected areas: incorporating behavioural data into the selection of marine protected areas for an endangered killer whale population. *Animal Conservation* 13, 196–203. <https://doi.org/10.1111/j.1469-1795.2009.00321.x>
- Au, W.W.L., Ford, J.K.B., Horne, J.K., Allman, K.A.N., 2004. Echolocation signals of free-ranging killer whales (*Orcinus orca*) and modeling of foraging for chinook salmon (*Oncorhynchus tshawytscha*). *J. Acoust. Soc. Am.* 115, 901–909. <https://doi.org/10.1121/1.1642628>
- Au, W.W.L., Horne, J.K., Jones, C., 2010. Basis of acoustic discrimination of chinook salmon from other salmons by echolocating *Orcinus orca*. *The Journal of the Acoustical Society of America* 128, 2225. <https://doi.org/10.1121/1.3473697>
- Ayres, K.L., Booth, R.K., Hempelmann, J. a., Koski, K.L., Emmons, C.K., Baird, R.W., Balcomb-Bartok, K., Hanson, M.B., Ford, M.J., Wasser, S.K., 2012. Distinguishing the Impacts of Inadequate Prey and Vessel Traffic on an Endangered Killer Whale (*Orcinus orca*) Population. *PLoS ONE* 7. <https://doi.org/10.1371/journal.pone.0036842>
- Ellison, W.T., Southall, B.L., Clark, C.W., Frankel, A.S., 2012. A New Context-Based Approach to Assess Marine Mammal Behavioral Responses to Anthropogenic Sounds. *Conservation Biology* 26, 21–28. <https://doi.org/10.1111/j.1523-1739.2011.01803.x>
- Erbe, C., MacGillivray, A., Williams, R., 2012. Mapping cumulative noise from shipping to inform marine spatial planning. *The Journal of the Acoustical Society of America* 132, EL423–EL428. <https://doi.org/10.1121/1.4758779>
- Erbe, C., Williams, R., Sandilands, D., Ashe, E., 2014. Identifying Modeled Ship Noise Hotspots for Marine Mammals of Canada's Pacific Region. *PLoS ONE* 9, e89820. <https://doi.org/10.1371/journal.pone.0089820>
- Fearnbach, H., Durban, J., Ellifrit, D., Balcomb, K., 2018. Using aerial photogrammetry to detect changes in body condition of endangered southern resident killer whales. *Endangered Species Research* 35, 175–180. <https://doi.org/10.3354/esr00883>
- Ford, J.K.B., Ellis, G.M., Balcomb, K.C., 2000. *Killer Whales: The Natural History and Genealogy of *Orcinus Orca* in British Columbia and Washington State*. UBC Press.

- Ford, J.K.B., Ellis, G.M., Olesiuk, P.F., Balcomb, K.C., 2010. Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator? *Biol. Lett.* 6, 139–142. <https://doi.org/10.1098/rsbl.2009.0468>
- Gaydos, J.K., Thixton, S. & Donatuto, J., 2015. Evaluating Threats in Multinational Marine Ecosystems: A Coast Salish First Nations and Tribal Perspective. *PLoS one*, 10(12), p.e0144861.
- Gray, L.M., Greeley, D.S., 1980. Source level model for propeller blade rate radiation for the world's merchant fleet. *The Journal of the Acoustical Society of America* 67, 516–522. <https://doi.org/10.1121/1.383916>
- Hanson, M.B., Baird, R.W., Ford, J.K.B., Hempelmann-Halos, J., Van Doornik, D., Candy, J., Emmons, C.K., Gregory Schorr, Brian Gisborne, Katherine Ayres, Samuel Wasser, Kelley Balcomb-Bartok, John Sneva, Michael Ford, 2010. Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. *Endangered Species Research* 11, 69–82. <https://doi.org/10.3354/esr00263>
- Hatch, L. et al., 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: a case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. *Environmental management*, 42(5), pp.735–752.
- Hildebrand, J.A., 2009. Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series* 395, 5–20. <https://doi.org/10.3354/meps08353>
- Holt, M.M., 2008. Sound Exposure and Southern Resident Killer Whales: A review of current knowledge and data gaps. NMFS-NWFSC.
- IWC Scientific Committee, 2016. Report of the Workshop on Acoustic Masking and Whale Population Dynamics, Bled, Slovenia: International Whaling Commission.
- Lacy, R.C., Williams, R., Ashe, E., Balcomb III, K.C., Brent, L.J.N., Clark, C.W., Croft, D.P., Giles, D.A., MacDuffee, M., Paquet, P.C., 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. *Scientific Reports* 7. <https://doi.org/10.1038/s41598-017-14471-0>
- Levings, C.D., 1985. Juvenile salmonid use of habitats altered by a coal port in the Fraser river estuary, British Columbia. *Marine Pollution Bulletin* 16, 248–254. [https://doi.org/10.1016/0025-326X\(85\)90510-7](https://doi.org/10.1016/0025-326X(85)90510-7)
- MacGillivray, A., M. Wood, Z. Li, A. Allen, D. Hannay, D. Hannay, 2016. Regional Ocean Noise Contributors Analysis: Enhancing Cetacean Habitat and Observation Program (Technical report by JASCO Applied Sciences No. Document 01195 Version 3.0). ECHO Program of Vancouver Fraser Port Authority.

- Miller, P.J.O., 2006. Diversity in sound pressure levels and estimated active space of resident killer whale vocalizations. *Journal of Comparative Physiology A* 192, 449–459. <https://doi.org/10.1007/s00359-005-0085-2>
- NMFS, 2016. Southern Resident Killer Whales (*Orcinus orca*) 5-Year Review: Summary and Evaluation.
- NOAA, 2018. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0) 178.
- Preikshot, D., Neville, C.M., Beamish, R.J., 2012. Data and Parameters Used in a Strait of Georgia Ecosystem Model (Canadian Technical Report of Fisheries and Aquatic Sciences No. 3005). DFO.
- Rolland, R.M., Parks, S.E., Hunt, K.E., Castellote, M., Corkeron, P.J., Nowacek, D.P., Wasser, S.K., Kraus, S.D., 2012. Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society B: Biological Sciences*. <https://doi.org/10.1098/rspb.2011.2429>
- Ross, D., 1976. *Mechanics of underwater noise*. Pergamon Press.
- Slabbekoorn, H., Dooling, R.J., Popper, A.N., 2018. Man-Made Sounds and Animals, in: Slabbekoorn, H., Dooling, R.J., Popper, A.N., Fay, R.R. (Eds.), *Effects of Anthropogenic Noise on Animals*, Springer Handbook of Auditory Research. Springer New York, New York, NY, pp. 1–22. [https://doi.org/10.1007/978-1-4939-8574-6\\_1](https://doi.org/10.1007/978-1-4939-8574-6_1)
- Slotte, A., Hansen, K., Dalen, J., Ona, E., 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fisheries Research* 67, 143–150. <https://doi.org/10.1016/j.fishres.2003.09.046>
- Van Dorp, J.R. & Merrick, J., 2014. *Vessel Traffic Risk Assessment (VTRA): Preventing Oil Spills from Large Ships and Barges In Northern Puget Sound & Strait of Juan de Fuca*, George Washington University. Available at: [http://www2.seas.gwu.edu/~dorpjr/tab4/publications\\_VTRA\\_Update.html](http://www2.seas.gwu.edu/~dorpjr/tab4/publications_VTRA_Update.html).
- Veirs, V., Veirs, S., 2006. Average levels and power spectra of ambient sound in the habitat of Southern Resident orcas. NOAA/NMFS/NWFSC.
- Veirs, S., Veirs, V., Wood, J.D., 2016. Ship noise extends to frequencies used for echolocation by endangered killer whales. *PeerJ* 4, e1657. <https://doi.org/10.7717/peerj.1657>
- Veirs, S., Veirs, V., Williams, R., Jasny, M., Wood, J., 2018 in review. A key to quieter seas: half of ship noise comes from 15% of the fleet (No. e26525v1). PeerJ Inc. <https://doi.org/10.7287/peerj.preprints.26525v1>

- Williams, R., O'Hara, P., 2010. Modelling ship strike risk to fin, humpback and killer whales in British Columbia, Canada. *Journal of Cetacean Research and Management* 11, 1–8.
- Williams, R., Erbe, C., Ashe, E., Beerman, A., Smith, J., 2014. Severity of killer whale behavioral responses to ship noise: A dose–response study. *Marine Pollution Bulletin* 79, 254–260. <https://doi.org/10.1016/j.marpolbul.2013.12.004>
- Williams, R., Veirs, S., Veirs, V., Ashe, E., Mastick, N., 2019. Approaches to reduce noise from ships operating in important killer whale habitats. *Marine Pollution Bulletin* 139, 459–469. <https://doi.org/10.1016/j.marpolbul.2018.05.015>
- Wright, A.J., 2008. International Workshop on Shipping Noise and Marine Mammals, Hamburg, Germany: Okeanos - Foundation for the Sea. Available at: [http://www.sound-in-the-sea.org/download/ship2008\\_en.pdf](http://www.sound-in-the-sea.org/download/ship2008_en.pdf).

# Attachments

## Attachment A: C.V. for Dr. Scott Veirs

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## Scott R. Veirs, PhD, Oceanography, University of Washington

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### Education

- Sep 1998 – Jun 2003* **University of Washington Seattle**  
PhD, Oceanography  
Seattle, USA
- Sep 1995 – Jun 1997* **University of Washington Seattle**  
MSc, Oceanography  
Seattle, USA
- Sep 1988 – Jun 1992* **Stanford University**  
BS, Earth Systems  
Palo Alto, USA

### Thesis

Scott R Veirs: *Heat flux and hydrography at a submarine volcano: Observations and models of the Main Endeavour vent field in the northeast Pacific.* 06/2003, Degree: PhD, Supervisor: Russell McDuff

### Research Experience

- Jun 2003 – present* **Principal Investigator**  
Beam Reach, Killer whale bioacoustics  
Seattle, WA, USA
- Jun 1995 – Jun 2003* **Research Assistant, Teaching Assistant**  
University of Washington Seattle, School of Oceanography

## Skills & Activities

*Skills* Marine Sciences, Marine Mammal Research, Environmental Sustainability, Underwater Noise, Acoustics, Environmental Science, Oceanography, Open Science, Hydrophones, Sound, Whales, Audio, Marine Biology

*Scientific Memberships* Acoustical Society of America

*Interests* Open Science

## Publication Highlights

Scott R. Veirs, Val Veirs, Jason D. Wood: *Ship noise extends to frequencies used for echolocation by endangered killer whales*. PeerJ 02/2016; 4(3)., DOI:10.7717/peerj.1657

Marla M Holt, Dawn P Noren, Val Veirs, Candice K Emmons, Scott Veirs: *Speaking up: Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise*. The Journal of the Acoustical Society of America 02/2009; 125(1):EL27-32., DOI:10.1121/1.3040028

## Journal Publications

Scott Veirs, Val Veirs, Paul Cretu, Steve Hicks, Skander Mzali: *Orcasound app: An open-source solution for streaming live ocean sound to citizen scientists and cloud-based algorithms*. The Journal of the Acoustical Society of America 09/2018; 144(3):1776-1776., DOI:10.1121/1.5067854

Thomas Dakin, Janie Wray, Hermann Meuter, Jordan Wilson, Larry Peck, Scott Veirs, John P. Ryan: *An overview of non-governmental organization, passive acoustic, ocean observatory data available on the North East Pacific Coast*. The Journal of the Acoustical Society of America 09/2018; 144(3):1955-1955., DOI:10.1121/1.5068546

Val Veirs, Scott Veirs, Lauren McWhinnie, Patrick O'Hara, Gregory O'Hagan: *Orcasound lab: A soundscape analysis case study in killer whale habitat with implications for coastal ocean observatories*. The Journal of the Acoustical Society of America 09/2018; 144(3):1957-1957., DOI:10.1121/1.5068556

Rob Williams, Scott Veirs, Val Veirs, Erin Ashe, Natalie Mastick: *Approaches to reduce noise from ships operating in important killer whale habitats*. Marine Pollution Bulletin 07/2018; 139., DOI:10.1016/j.marpolbul.2018.05.015

Scott R. Veirs, Val Veirs, Jason D. Wood: *Ship noise extends to frequencies used for echolocation by endangered killer whales*. PeerJ 02/2016; 4(3)., DOI:10.7717/peerj.1657

Val Veirs, Scott Veirs, Jason Wood: *Shipping noise signatures*. The Journal of the Acoustical Society of America 05/2011; 129(4)., DOI:10.1121/1.3587664

Scott R. Veirs, Val R. Veirs: *Masking of southern resident killer whale signals by commercial ship noise*. The Journal of the Acoustical Society of America 04/2011; 129(4)., DOI:10.1121/1.3588646

- David Bain, Scott Veirs, Val Veirs: *Orca hearing weighted decibels: Underwater sound measurements appropriate to studies of Orcinus (killer whales)*. The Journal of the Acoustical Society of America 04/2011; 129(4)., DOI:10.1121/1.3588648
- Jason D. Wood, Peggy Foreman, Val Veirs, Scott Veirs: *Shipping noise and vocal compensation by Southern Resident killer whales: Haro Strait as a study case*. The Journal of the Acoustical Society of America 04/2011; 129(4)., DOI:10.1121/1.3588647
- Erica L. Beneze, Jason Wood, Scott Veirs, Val Veirs: *Are click rates in killer whales an indicator of group behavior and foraging hotspots?*. The Journal of the Acoustical Society of America 04/2011; 129(4)., DOI:10.1121/1.3588650
- Scott Veirs, Val Veirs, Jason Wood, Brian Moore, Bob McClure, Bob Otis: *Killer whale habitat use and prey fields from remote hydrophones and echosounders.*. The Journal of the Acoustical Society of America 05/2009; 125(4):2647., DOI:10.1121/1.4784131
- Marla M Holt, Dawn P Noren, Val Veirs, Candice K Emmons, Scott Veirs: *Speaking up: Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise*. The Journal of the Acoustical Society of America 02/2009; 125(1):EL27-32., DOI:10.1121/1.3040028
- Marla Holt, Val Veirs, Scott Veirs: *Investigating noise effects on the call amplitude of endangered Southern Resident killer whales (Orcinus orca)*. The Journal of the Acoustical Society of America 06/2008; 123(5):2985., DOI:10.1121/1.2932512
- Scott Veirs, Val Veirs, Jason D Wood: *Spatial confirmation of vocal communication between a killer whale calf and its natal family*. The Journal of the Acoustical Society of America 06/2008; 123(5):3362., DOI:10.1121/1.2933958
- MARLA M. HOLT, VAL VEIRS, SCOTT VEIRS: *Noise effects on the call amplitude of southern resident killer whales (orcinus orca)*. Bioacoustics 01/2008; 17(1-3):164-166., DOI:10.1080/09524622.2008.9753802
- Scott Veirs, Val Veirs: *Vessel noise measurements underwater in the Haro Strait, WA*. The Journal of the Acoustical Society of America 11/2006; 120(5):3382., DOI:10.1121/1.4781642
- Scott R. Veirs, Russell E. McDuff, Frederick R. Stahr: *Magnitude and variance of near-bottom horizontal heat flux at the Main Endeavour hydrothermal vent field*. Geochemistry Geophysics Geosystems 02/2006; 70(2)., DOI:10.1029/2005GC000952
- Val Veirs, Scott Veirs: *One year of background underwater sound levels in Haro Strait, Puget Sound*. The Journal of the Acoustical Society of America 04/2005; 117(4):2577., DOI:10.1121/1.4776892
- Richard E Thomson, Steven F Mihály, Alexander B Rabinovich, Russell E McDuff, Scott R Veirs, Frederick R Stahr: *Constrained circulation at Endeavour Ridge facilitates colonization by vent larvae*. Nature 08/2003; 424(6948):545-9., DOI:10.1038/nature01824
- S. R. Veirs, F. R. Stahr, R. E. McDuff, R. E. Thomson, D. R. Yoerger, A. M. Bradley: *Measurements and Models of Heat Flux Magnitude and Variance from the Main Endeavour Hydrothermal Vent Field*.
- Scott R. Veirs, Russell E. McDuff, Marvin D. Lilley, John R. Delaney: *Locating hydrothermal vents by detecting buoyant, advected plumes*. Journal of Geophysical Research Atmospheres 12/1999; 1042(B12):29239-29248., DOI:10.1029/1999JB900291



Alan C. Mix, W. Rugh, Nicklas G. Pias, S. Veirs, Leg Scientific Party: *Color Reflectance Spectroscopy: A Tool for Rapid Characterization of Deep Sea Sediments*. DOI:10.2973/odp.proc.ir.138.104.1992

R. E. Thomson, A. B. Rabinovich, S. F. Mihaly, S. Veirs, F. R. Stahr, R. E. McDuff, M. M. Subbotina: *Topographically Enhanced Subinertial Currents at Endeavour Ridge*.

Val Veirs, Scott Veirs: *Average levels and power spectra of ambient sound in the habitat of southern resident orcas*.

Val Veirs, Scott Veirs: *Salish Sea Hydrophone Network 2007-2008 progress report*.

## Conference Proceedings

Hervé Glotin, Paul Spong, Helena K. Symonds, Vincent Roger, Randall Balestrieri, Maxence Ferrari, Marion Poupard, Jared R. Towers, Scott R. Veirs, Ricard Marxer, Pascale Giraudet, James Pilkinton, Val Veirs, Jason Wood, John K B Ford, Thomas Dakin: *Deep learning for ethoacoustical mapping: Application to a single Cachalot long term recording on joint observatories in Vancouver Island*. 176th Meeting Acoustical Society of America; 09/2018, DOI:10.1121/1.5067855

Paul Spong, Helena K. Symonds, Hervé Glotin, Jared R. Towers, Lisa Larsson, Thomas Dakin, Scott R. Veirs, Elizabeth Zwamborn, James Pilkinton, Pascale Giraudet, Val Veirs, Jason Wood, John K B Ford: *Joint observatories following a single male Cachalot during 12 weeks —The Yukusau story*. 176th Meeting Acoustical Society of America; 09/2018, DOI:10.1121/1.5068557

Attachment B: Addendum gap report



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BEAM REACH  
MARINE SCIENCE & SUSTAINABILITY SCHOOL

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CONTRACT REPORT

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FOR DAVID SUZUKI FOUNDATION AND WILDERNESS COMMITTEE VIA  
ECOJUSTICE

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**Acoustic & cumulative effects of the  
Roberts Bank Terminal 2 Project on  
Southern Resident Killer Whales**

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October 27, 2016

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## 49 **1 Scope of work**

50 The overall scope of work is to review the sufficiency (completeness) and technical merit  
51 of the Shipping Addendum and additional related information provided by the Port on  
52 April 8, 2016. My review focuses on the assessment of acoustic and cumulative impacts  
53 on Southern Resident Killer whales (SRKWs).

## 54 **2 Were completeness comments addressed?**

55 On February 24, 2016, the CEAA requested additional information in a letter to the Port of  
56 Metro Vancouver. On April 8, 2016, the Port (now the Vancouver Fraser Port Authority)  
57 responded with additional information. I've reviewed the table of comments I provided  
58 in December, 2015, regarding completeness of the Addendum and determined whether or  
59 not each comment was addressed in the February 24 letter from the CEAA and/or the  
60 April 8 response from the Port. For all comments relevant to the SRKWs I found that my  
61 concerns about completeness were not addressed within either document.

## 62 **3 Assessment of the Shipping Addendum & related infor-** 63 **mation**

### 64 **3.1 Overview**

65 While the Addendum and related EIS documents state that existing ship noise levels are  
66 high and modeled behavioral responses and acoustic masking are significant, it downplays  
67 the potential (low- to moderate-severity) acoustic impacts of RBT2 by citing the PCOD  
68 prediction of no change to vital rates of SRKWs. It notes that the PCOD confidence  
69 intervals are large and that ship noise could be limiting SRKW recovery through reductions  
70 in foraging success. Furthermore it notes that cumulative acoustic impacts of current noise  
71 levels have not been assessed because noise from boats (i.e. whale watching vessels) is not  
72 included in the noise models.

73 However, in determining the significance of acoustic disturbance from the project to  
74 SRKWs, the EIS (in section 14.9.2.1) emphasizes that the ship calls associated with the  
75 project are small compared to the existing traffic (260 ship calls per year out of 12,706  
76 total commercial marine vessels transiting the waters near Roberts Bank in 2030). This  
77 leads to the both Addendum and EIS concluding that "acoustic disturbance from Project  
78 operation over and above existing conditions is unlikely to affect individual SRKWs such  
79 that the survival or recovery of the species is jeopardised."

80 Where will our marine species end up if all projects take this approach? A sustainable,  
81 responsible terminal development would incorporate sufficient mitigation to incrementally

82 reduce ecological impacts on marine life. Instead, this project proposes to increase the  
83 impacts, but only a bit. This is the mechanism – one more small cut – that underlies the  
84 notion of environmental death by a thousand cuts.

85 Overall, the impact assessment effort is admirable in this project. I believe there is an  
86 earnest effort to improve the accuracy of the assessment through refining its models, as well  
87 as their underlying assumptions and the parameterizing data. The modeling of acoustic  
88 impacts and effects, in particular, is advanced and innovative, but consequently so complex  
89 and novel that a second extension of the October, 2016, comment deadline would be  
90 required for me to fully understand and critique the methodology.

91 The biggest shortcoming of the acoustic assessment – in the Addendum for the RAA, as  
92 well as in the EIS for the LAA – is the averaging of noise levels over irrelevant time scales.  
93 In key parts of the methodology, averages are computed over a year or a month, rather  
94 than a shorter period appropriate to the impact being assessed. I note specific instances  
95 of this weakness in the notes I have provided below on both the acoustic and cumulative  
96 impacts on SRKWs.

97 One specific, overarching concern with the entire EIS and its Addendum is that the project  
98 lifetime appears to be underestimated. The modeled scenarios in both the EIS and Ad-  
99 dendum extend only to 2030, whereas the project lifetime has been stated to be at least  
100 40 years. (Page 17 of the [EIS Executive summary](#) notes: "Once the Project was oper-  
101 ational, and subject to ongoing availability and functioning of the terminal, Port Metro  
102 Vancouver would make regular payments to the infrastructure developer [to maintain  
103 RBT2] over a period of up to 40 years.") If RBT2 begins operations as early as 2020, it  
104 would thus be expected to continue operating at least until 2060. With this in mind, it is  
105 appropriate to use the [2016 Ocean Shipping forecast](#) to estimate shipping traffic and ship  
106 size distributions over the full lifetime of the project. This latest shipping forecast expects  
107 that container ships will exceed 400 m LOA and 20,000 TEU (with drafts that could still  
108 be accommodated by the RBT2), and even mentions the possibility of 24,000 TEU ships  
109 being berthed by the Port of Metro Vancouver under "careful management." These pro-  
110 jections indicate that the acoustic model assumptions are not conservative enough and  
111 that model scenarios should be extended (beyond the insufficient temporal boundary of  
112 the EIS) to at least the 2050 conditions characterized by the 2016 forecast – and possibly  
113 projected conditions in 2060. Would consideration of this latest forecast change the worst  
114 case scenarios explored in the EIS and Addendum?

115 To supplement these general problems, I list below the strengths and weaknesses of the  
116 assessment of first the acoustic, and then the cumulative impacts on SRKWs.

## 117 3.2 Potential acoustic impacts on SRKWs

### 118 3.2.1 Weakness: Use available data to validate projected spectrum source 119 levels for largest container ships

120 [Reference Addendum section 7.6.2.2]

121 Regarding Triple-E class contain ships the Addendum (Section 7.6.7.1) states erroneously  
122 that there is an “absence of source level measurements for this class of vessel.” Figure 7  
123 of [McKenna et al. \(2013\)](#) indicates that they have source spectra for at least 3 container  
124 ships that are 350-400 m long.

125 The Addendum should use the most-recent published, peer-reviewed data to verify the  
126 assumption that adding 1.67 dB will accurately adjust spectrum levels from the measured  
127 representative ship (338 m) to a Triple-E class (367 m) ship. New Panamax container  
128 ships are 335-397 m long and carry up to 15,000 Twenty-foot Equivalent Units (TEU);  
129 Triple-E ships are of similar length, but carry up to 18,000 TEU. The class of the largest  
130 ships measured by [McKenna et al. \(2013\)](#) should be ascertained and utilized.

### 131 3.2.2 Weakness: Clarify the distribution or derivation of source spectra for 132 container ships

133 [Reference Addendum section 7.6.2.2]

134 Container ship source levels have a wide range of broadband values distributed about the  
135 mean. [McKenna et al. \(2013\)](#) reports a range of  $\pm 15$  dB. Therefore, the louder ships likely  
136 to be in the distribution should be used to evaluate the likely most severe impacts (e.g.  
137 on SRKWs). A ship that is 15 dB louder than the average ship produces about 30 times  
138 the acoustic power underwater.

139 The Addendum should include a clear characterization of the distribution of container ship  
140 source spectra. The derivation of the “conservative” source level estimates for model and  
141 representative ships is not clear in section 7.6.2.2 or the references it makes (to Section  
142 7.6.3.1 and Appendix 7.6-A).

143 Some clarification is offered on page 6 of another technical document (Appendix 9.8-B:  
144 RBT2 – Vessel Traffic Underwater Noise Study), but it is not sufficient for me to determine  
145 the actual 1/3-octave band source levels that were finally utilized in the acoustic models. It  
146 is disconcerting that the derivation apparently involved extrapolation both at low ( $< 50$  Hz)  
147 and high ( $> 8,000$  Hz) frequencies. Thus, I am left unable to assess the assertion that the  
148 acoustic models are using a “conservative” estimate of the (largest) container ship source  
149 level.

150 **3.2.3 Weakness: Ambient noise measurements are contaminated with low-**  
151 **frequency pseudo-noise**

152 [Reference Addendum section 7.6.4.1]

153 Some noise measurements incorporated into the Addendum (and EIS) were made when  
154 tidal current flowing past the cable which supported the hydrophone was strong enough  
155 to cause noise at frequencies that overlap with ship noise. Such "pseudo-noise" can bias  
156 key measurements that the acoustic assessment relies upon.

157 The Addendum should re-assess sound pressure level statistics, particularly at low-frequency  
158 (<200 Hz). If it is not possible to re-acquire ambient noise recordings using a mooring  
159 design that does not introduce pseudo-noise associated with tidal currents, then the ac-  
160 knowledged contamination of at least some of the acoustic records by pseudo-noise should  
161 shift analysis away from annual or monthly means and towards assessing ship and back-  
162 ground levels only during low-velocity tidal periods, e.g. via the methods of [Bassett et al.](#)  
163 (2012). Such an approach will make the acoustic models more accurate.

164 **3.2.4 Weakness: Fill gaps in VTOSS data to match spatial resolution with**  
165 **appropriate time scales**

166 [Reference Addendum section 7.6.7.1]

167 The Addendum acknowledges gaps in the VTOSS data. These should be filled with gap-  
168 free ship track data (e.g. archived AIS data from 2012, possibly supplemented with data  
169 from more recent years). While VTOSS data errors may average out over months, they  
170 could cause inaccuracies in assessments of SPL averages over shorter time scales (as re-  
171 quested elsewhere in these comments).

172 **3.2.5 Weakness: Use best available science when estimating source level of**  
173 **largest container ships**

174 [Reference Addendum section 7.6.7.1]

175 [McKenna et al. \(2013\)](#) reports that ship length is the second most predictive covariate of  
176 broadband and octave-band source level and her Fig. 4 suggests slope is about 0.015 dB/m  
177 of LOA (for broadband levels between 20 and 1,000 Hz). In opposition to this, the Adden-  
178 dum states that there is no relationship between merchant ship length and source level,  
179 citing the much older study by [Scrimger and Heitmeyer \(1991\)](#).

180 The Addendum should include recent peer-reviewed literature when justifying the estima-  
181 tion of Triple E-Class source levels. It should use existing data (e.g. [McKenna et al., 2013](#))  
182 to assess whether scaling container ship noise by vessel length works for existing source  
183 level measurements of different sized container ships.



### 184 **3.2.6 Weakness: Single source level applied to all sizes of container ships**

185 [Reference: 103688E.pdf, pages 7.6.6-7.6.7, sections 7.6.3.1; technical reports]

186 The noise models applied a single source level to all sizes of container ships after citing  
187 [Scrimger and Heitmeyer \(1991\)](#) regarding correlation of ship source level with ship type,  
188 rather than ship size. It is difficult to ascertain from the Addendum and related documents  
189 what actual source level was used. I had to dig all the way back into an EIS technical doc-  
190 ument (RBT2-Ship-Sound-Signature-Analysis-Study-TDR1.pdf) to begin to understand  
191 what actual source levels were used to characterize container ship noise. There I found  
192 a comparison of two different measurements of three container ships (from TWMBR and  
193 AMAR data sets) that implies that the broadband source levels determined from the  
194 AMAR data were 206, 203.9, and 200.5 dB re 1  $\mu\text{Pa}$  @ 1 m. These levels greatly exceed  
195 other estimates for individual container ships in the peer-reviewed literature ([Veirs et al.,](#)  
196 [2016](#), [McKenna et al., 2013](#), [Bassett et al., 2012](#)). As an aside, this constitutes evidence  
197 that the AMAR recordings are contaminated with low-frequency noise.

198 Containship source spectrum levels vary by 10-15 dB re 1  $\mu\text{Pa}^2/\text{Hz}$  @1 m while mean  
199 broadband source levels have a standard deviation of  $pm4$  dB re 1  $\mu\text{Pa}$  @ 1 m ([Veirs et al.,](#)  
200 [2016](#)). A truly conservative methodology would: take the upper bound of the variation  
201 around the mean or the 95% quantile spectrum levels to characterize the current container  
202 ships frequenting the Port; extrapolate it upward adjustment (e.g by 1.67 dB) to the  
203 maximum size class of container ship expected at RBT2; and then further extrapolate to  
204 the length of the largest ships projected to utilize the Port in 20150 (per the 2016 shipping  
205 forecast).

### 206 **3.2.7 Weakness: Monthly average sound pressure levels aren't relevant to** 207 **assessing effects on SRKWs**

208 [Reference: 103688E.pdf, pages 7.6.6-7.6.7, sections 7.6.3.1, 7.6.5.1]

209 The relevant time scale for assessing behavioral change due to a change in average SPL  
210 should be similar to the duration of an organism's exposure to the ship's noise – e.g minutes  
211 for a typical passing ship, not days or months. This has recently been articulated in draft  
212 guidance from [NOAA \(2013\)](#): “Overall dB rms levels should be based on short enough  
213 time windows to capture temporal variation in sound levels.”

214 The Addendum and related information fail to provide statistics that summarize acous-  
215 tic environment at shorter (e.g. 1-minute) time scales. Instead it offers only monthly  
216 or seasonal averages of SPL (which are not relevant to many potential effects on marine  
217 organisms). When assessing the change due to +1.5 additional container ships per day,  
218 summary statistics should include daily metrics like those quantified in the main EIS Ap-  
219 pendix 14-B (e.g. % reduction in daily “quiet” time), or even shorter-time-scale means for  
220 those species that have brief-duration behaviors linked to vital rates (like SRKW foraging

221 encounters).

222 When a SRKW is echolocating and/or calling while in pursuit of a Chinook salmon,  
223 the relevant time scale for averaging the ambient noise levels is seconds or minutes, not  
224 months or seasons. A monthly average SPL may greatly underestimate the relevant level  
225 and therefore the masking potential of ship noise.

### 226 **3.2.8 Weakness: Baseline distribution of vessel sizes not provided**

227 Table 4-3 (EIS Addendum 4.2.1.1) or a new table should present current vessel size distri-  
228 butions (e.g. 2012 data) in addition to the projected distributions for 2025 and 2030.

229 Section 17.3.2 requires “description of the types and sizes of vessels currently operating  
230 in the region.” The size distribution of the shipping traffic (at least the container ships)  
231 currently associated with PMV terminals is important for referencing potential increased  
232 effects of the Project. Without this information it is impossible to correlate vessel size  
233 with potential effects (e.g. due to not only underwater noise, but also wakes, oil spill risks,  
234 etc.).

235 As I mentioned in the overview, a new table should also be expanded to include vessel  
236 sizes and size distributions not just for 2025 and 2030, but for the project lifetime – at  
237 least out to 2050, the latest year included in the 2016 shipping forecast.

### 238 **3.2.9 Strength: The terminal expansion is sited in an area of chronic under-** 239 **water noise pollution**

240 While the location of the proposed terminal expansion is problematically within habitat of  
241 the SRKWs and the acoustic impacts of the associated shipping traffic may be significant,  
242 an advantage of the proposed site is that it already polluted acoustically. Extant sources  
243 of underwater noise include ships associated with the adjacent coal terminal and extant  
244 container terminal, nearby Tsawwassen ferries (berthed or in transit), and the shipping  
245 lanes in the Strait of Georgia (center of traffic separation zone 6 km away; near edge of  
246 northbound lanes 3 km away).

247 Table 8 of “RBT2 – Ambient Noise Measurements” shows that the long-term mean re-  
248 ceived sound pressure levels at Roberts Bank are about 120 dB re 1  $\mu$ Pa compared to  
249 110 dB re 1  $\mu$ Pa in Haro Strait.

### 250 **3.2.10 Weakness: Movement data does not allow assessment of Rosario Strait** 251 **as alternative route to mitigate risks for SRKWs**

252 Table 4-2 (EIS Addendum section 4.1.1) should include any 2012 movement data for seg-  
253 ment F (through Rosario) for all vessel classes. The number of container ships movements

254 through Segment B (Haro Strait) in 2012 should be broken down for each PMV terminal  
255 by: (a) inbound for a PMV terminal directly from the Pacific, (b) bound for a PMV ter-  
256 minal from Puget Sound, (c) bound for Puget Sound from a PMV terminal, (d) outbound  
257 from a PMV terminal directly to the Pacific.

258 Section 4.1.1 mentions the historic routing of container traffic between Vancouver and  
259 Puget Sound via Rosario Strait. The requested information is needed to determine whether  
260 Haro Strait traffic and associated effects could be mitigated by re-activating Rosario Strait  
261 transits. Section 17.2.2 specifically calls for “alternatives considered, such as different  
262 routing, frequency and vessel types.” The relevance of such information is implied in  
263 Addendum section 4.2.1.6 for projected RBT2 traffic (but not current traffic): “almost  
264 100% of the ship calls will also visit one of the PNW U.S. ports of Seattle or Tacoma as  
265 part of their voyage. This accounts for one additional movement through Segment C for  
266 each such voyage with a total of 780 movements through Segment C and 520 non-Project  
267 associated movements through Segment G.”

268 In presenting projected vessel calls and movements through 2030 [WorleyParsons Canada](#)  
269 (2011) note such direct transits to/from U.S. ports, but do specify the routes taken.

270 “Deltaport in 2010 had a split service that called twice at the terminal: the  
271 first call to discharge import containers and the second call to load export con-  
272 tainers. Between the Deltaport calls, the vessel visited a U.S. Pacific North-  
273 west port. The split service adds 52 vessel calls and 104 movements for 2010.  
274 Although unusual, this practice was assumed to persist at Deltaport in all  
275 projection years so as not to understate potential ship movements. The ship  
276 movements in the summary table reflect this service.”

277 The route taken during these historic movements should be included, in part to understand  
278 the feasibility of mitigating impacts on SRKWs by avoiding their core summertime habitat  
279 in Haro Strait.

### 280 3.3 Potential cumulative impacts on SRKWs

#### 281 3.3.1 Weakness: Fuel spill risks in the Fraser River delta and SRKW critical 282 habitat

283 Increasing shipping traffic in or near the Fraser River Delta, as opposed to other terminals,  
284 poses potential cumulative impacts on SRKWs. In addition to direct ecological impacts  
285 of the new terminal during construction (to the seabed northwest of the coal terminal)  
286 and acoustic impacts of the additional ships (discussed previously), the additional traffic  
287 would raise likelihood of a bunker fuel spill that could disperse into the Delta.

288 The new terminal would be located 5.5 km offshore of the current adjacent Delta shore-  
289 line which includes habitat for juvenile salmon and other species which ultimately feed  
290 the SRKWs. The southern arm of the Fraser River meets the Strait of Georgia 6 km

291 north of the proposed terminal site. In a spill scenario with southerly wind, a rising tide,  
292 and minimal seasonal outflow, the wind-driven and estuarine circulation in the area could  
293 hypothetically carry fuel up-river into the Fraser Delta where subsequent tidal exchange  
294 could disperse it throughout the lower Delta, including the Alaskan National Wildlife Area,  
295 South Arm Marshes, and Deas Island Park. The time of year when this risk would be  
296 highest would be during a strong rising tide in early spring (February-April) – when win-  
297 tertime southerlies are still prevalent, the Fraser’s spring freshet has not begun in earnest  
298 ([Davenne and Masson, 2001](#)), salmon smolt out-migration is underway for Fraser Chinook,  
299 and herring are spawning in nearshore environments of the Salish Sea (see Table 13-4 of  
300 the EIS).

301 If expansion were shifted to Cen-Term or VanTerm, and/or traffic re-routed to Johnstone  
302 Strait and Discovery Passage, risks would shift away from Delta and SRKW critical habitat  
303 (as defined in the U.S.). Rosario has fewer protected areas and was used historically for  
304 container ships transiting between Vancouver and Puget Sound ports (Addendum page  
305 4-3 to 4-4).

306 Another alternative that could reduce such risks to the Fraser River Delta is to create a  
307 terminal in Boundary Bay. Such a site would be more likely to contain a spill beyond the  
308 Delta, especially in the prevailing southerly winter winds. Any reductions in risks to the  
309 Delta would need to be weighed against the likely impacts to Boundary Bay ecosystems,  
310 including the local herring habitat. Additionally, the relative importance to SRKWs of  
311 the Delta versus Boundary Bay would need to be assessed, though the current Canadian  
312 critical habitat map does not include the Bay ([Fisheries and Oceans Canada, 2011](#)).

### 313 **3.3.2 Weakness: Potential air pollution impacts not assessed for SRKWs**

314 Air quality impact modeling should include a 3-dimensional puff model parameterized with  
315 wind data. This would allow estimation of increased exposure of SRKWs breathing ship  
316 exhaust at the sea surface. Plumes from ships and the associated air pollution near the  
317 sea surface are commonly observed near shipping lanes, including at the proposed site of  
318 the new terminal.

### 319 **3.3.3 Weakness: Wave model predictions should be validated to confidently 320 predict impacts on forage fish, including those in food chain that sup- 321 ports SRKWs**

322 The wave height model seems unrealistic (from diver’s perspective). The largest amplitude  
323 modeled surface waves are substantially lower than are commonly observed as ship wakes  
324 arrive at the shorelines of the Salish Sea. This discrepancy should be resolved by validating  
325 the model with field data.

326 If additional container ships are randomly distributed (i.e. not grouped with existing ship

327 traffic), the projected increase of +1.5 ships/day means 3 extra daily disturbances year  
328 round in the nearshore environment (e.g. to forage fish eggs). The potential impact on  
329 forage fish that feed SRKW prey, and the cumulative effect on SRKWs themselves, should  
330 be assessed using new versions of the wave height models – ones that have been validated.  
331 The resulting wave height predictions should then be used as inputs to an ecological model  
332 that examines the effect of nearshore disturbance on forage fish, juvenile and adult salmon  
333 that prey upon them, and the SRKWs that consume the adult salmon.

#### 334 **3.3.4 Weakness: Temporal distribution of ships not specified in models**

335 [Reference Addendum section 7.6.5.1]

336 Worst case models should assume that additional ships are distributed at extremes: either  
337 evenly spaced between or coincident with current and projected non-RBT2 traffic. For  
338 example, assume that the +1.5 additional ships per day will cause 3 new ship wakes to  
339 impact shorelines in two extreme ways: (a) wakes arriving at the shoreline in the middle  
340 of periods which would otherwise have been calm; and (b) wakes arriving simultaneous to  
341 existing or projected non-RBT2 wakes, thereby increasing their impact.

342 How were the additional 260 RBT2 ships distributed temporally in each Addendum model?

#### 343 **3.3.5 Strength: Mitigation of construction noise which could affect SRKW** 344 **hearing and therefore cause cumulative effects during operation**

345 Section 14.7.1.1 summarizes mitigation plans during construction, including marine mam-  
346 mal monitoring in buffer areas by observers and hydrophones. To prevent the inadvertent  
347 exposure of SRKWs to construction noise, and possible temporary or permanent thresh-  
348 olds shifts in their hearing that could cause cumulative effects (e.g. reduced foraging or  
349 communication success of SRKWs during and near RBT2 operations), construction and  
350 such monitoring should take place during daylight hours when visibility is sufficient, and  
351 ideally outside of the summer months when SRKWs are most prevalent in the LAA.

## Bibliography

- 352
- 353 C. Bassett, B. Polagye, M. Holt, and J. Thomson. A vessel noise budget for Admiralty In-  
354 let, Puget Sound, Washington (USA). *The Journal of the Acoustical Society of America*,  
355 132(6):3706–3719, 2012. doi: 10.1121/1.4763548. URL [http://link.aip.org/link/  
356 ?JAS/132/3706/1](http://link.aip.org/link/?JAS/132/3706/1).
- 357 E. Davenne and D. Masson. Water Properties in the Straits of Georgia and Juan  
358 de Fuca. Technical report, 2001. URL [http://www.pac.dfo-mpo.gc.ca/science/  
359 oceans/cotesud-southcoast/JdFG\\_e.pdf](http://www.pac.dfo-mpo.gc.ca/science/oceans/cotesud-southcoast/JdFG_e.pdf).
- 360 Fisheries and Oceans Canada. Recovery strategy for the northern and southern resident  
361 killer whales (*Orcinus orca*) in Canada. Technical report, Fisheries and Oceans Canada,  
362 Ottawa, 2011. URL [http://www.sararegistry.gc.ca/virtual\\_sara/files/plans/  
363 rs\\_Resident\\_Killer\\_Whale%20\\_0308\\_e.pdf](http://www.sararegistry.gc.ca/virtual_sara/files/plans/rs_Resident_Killer_Whale%20_0308_e.pdf). OCLC: 244008941.
- 364 M. F. McKenna, S. M. Wiggins, and J. A. Hildebrand. Relationship between container  
365 ship underwater noise levels and ship design, operational and oceanographic conditions.  
366 *Scientific Reports*, 3, May 2013. ISSN 2045-2322. doi: 10.1038/srep01760. URL [http:  
367 //www.ncbi.nlm.nih.gov/pmc/articles/PMC3641522/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3641522/).
- 368 NOAA. Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine  
369 Mammals: Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold  
370 Shifts, Dec. 2013.
- 371 P. Scrimger and R. M. Heitmeyer. Acoustic source-level measurements for a variety of  
372 merchant ships. *The Journal of the Acoustical Society of America*, 89(2):691–699, 1991.  
373 doi: 10.1121/1.1894628. URL <http://link.aip.org/link/?JAS/89/691/1>.
- 374 S. Veirs, V. Veirs, and J. D. Wood. Ship noise extends to frequencies used for echolocation  
375 by endangered killer whales. *PeerJ*, 4:e1657, Feb. 2016. ISSN 2167-8359. doi: 10.7717/  
376 peerj.1657. URL <https://peerj.com/articles/1657>.
- 377 WorleyParsons Canada. Projections of Vessel Calls and Movements at  
378 Deltaport and Westshore Terminals. Technical report, Nov. 2011.  
379 URL [http://www.robertsbankterminal2.com/wp-content/uploads/  
380 Projections-of-Vessel-Calls-and-Movements-at-Deltaport-and-Westshore-Terminals.  
381 pdf](http://www.robertsbankterminal2.com/wp-content/uploads/Projections-of-Vessel-Calls-and-Movements-at-Deltaport-and-Westshore-Terminals.pdf).

Attachment C: Sufficiency report

# Roberts Bank Terminal 2 Project Environmental Impact Statement

## Comments on sufficiency of Information Requests

**Participant: Dr. Scott Veirs**

**Organization (if applicable): Beam Reach Marine Science & Sustainability (SPC)**

### SCOPE OF WORK

Determine if gaps have been addressed and there is now sufficient information on shipping noise impacts and cumulative effects to proceed to hearing.

Do the Proponent's responses to IR Packages 1-13, when considered in combination with the EIS, the Marine Shipping Addendum, and other information contain sufficient information to allow the review panel to conduct a technical review of the Project?

---

## General Comments

### Expertise

I am Dr. Scott Veirs a marine biologist and oceanographer, with expertise in underwater acoustics including the impact of ocean noise on marine mammals. I have been retained on behalf of the Western Canada Wilderness Committee and David Suzuki Foundation to assist them in the Roberts Bank Terminal 2 review.

### Overview

I find that the majority of the Information Request Packages that I have reviewed (see appended list) provide sufficient information to proceed with a hearing. However, there are a few Packages that are insufficient. I have briefly highlighted the insufficient packages in this Overview section and subsequently provide notes on each within my detailed comments.



## Highlighted insufficiencies regarding acoustic impacts on SRKWs

- My main concern with respect to acoustic impacts on SRKWs is with IR04. In the most relevant sections (IR04-11 and -13), it would be helpful if the Proponent could further explain how “ship source level measurements presented in McKenna et al. (2013) would predict a smaller, less conservative adjustment of +0.5 dB for a Triple-E class container ship,” ideally by providing a plot which indicates where the reference ship lies in the distribution of the McKenna data. I am also interested in knowing whether the Proponent could provide their own estimates of source levels for containerships that have been measured (more recently than the McKenna data) with the ECHO underwater listening stations in order to (a) verify that the power law of Ross (1976) provides accurate estimates of modern, local, extant containship source levels prior to using it to project source levels of larger, future ships, and/or (b) refute the extrapolated values I have derived for such larger, future ships using the median data of McKenna (2013). Without clarity on how the +1.67 dB estimate was derived, it is difficult to be sure that the noise modeling is as conservative and precautionary as the Proponent asserts.
- IR01-05 should provide more information about the historic (and potential future) use of Rosario Strait in trans-border-bound containership traffic. The Panel’s consideration of possible mitigation measures (primarily for acoustic impacts in Haro Strait) could benefit from additional data on the logistics and costs for pilots (both U.S. and Canadian) when Rosario Strait was used for trans-border-bound containership traffic, as well as further details about the routes taken, the nature of the “one-way passage restrictions,” and any incidents that occurred due to the slightly less-wide Strait. (The narrowest point in Rosario is ~2.7 km vs 3.6 km in Haro/Boundary.) Also, the Proponent’s Table IR1-05-03 indicates that re-activation of trans-border-bound traffic in Rosario Strait would involve all containership traffic (because all ships are bound for ports in both Puget Sound and Vancouver), thereby potentially halving the noise impacts in Haro Strait where SRKW foraging is relatively concentrated during the summertime.

## Highlighted insufficiencies regarding cumulative impacts on SRKWs

- Within IR5-15, 26, and 27 there is insufficient information about the relative sensitivity of herring and eulachon. To verify the assumption that herring are “controlling” -- more sensitive to noise than other fish species -- it would be valuable to ask the Musqueam: are the herring more ‘skittish’ than they observe the eulachon to be in response to noise?
- IR5 - 32 and 41 fail to provide the best available information regarding transient killer whale occupancy of the Salish Sea which may cause some cumulative effects on southern residents to be underestimated or missed.

I end this overview of my comments by pointing out that I believe there are still gaps existing related to my comments on completeness in 2015 and 2016 (beyond what has been provided through the Information Requests of the Panel). To illustrate this, I’ve provided a checklist of incompleteness I indicated, along with some notes regarding progress I am observing towards completeness. Thus far, however, only one box is checked out of nine...

---

## Insufficiencies in the Information Request Responses

My detailed comments for each Package are provided below. They often follow relevant quotes and/or figures from the Proponent's response.

### Package IR-1

#### IR1-05 Marine Shipping: movements

- "Rosario Strait route has not been used by trans-border-bound container vessels for approximately 10 years."
- Prior to 2010, how were these trans-border container ships handled? Were there pilot stations in other locations (e.g. Pt. Roberts? Or just Seattle?), or was the cost of having both a Canadian and U.S. pilot aboard just part of doing that business? Why did the change in routing occur?
- "Passage by container ships through Rosario Strait to, or from, Canadian terminals would require dual pilots (one Canadian and one American) to be on board for the entire voyage since this route does not pass the normal pilot stations at Victoria and Port Angeles... This re-routing would increase shipping costs significantly."
- The proposed RBT2 would be located only ~2 km from the U.S./Canadian border. Is it possible that VFPA container ships bound for Puget Sound could have a U.S. pilot handle those 2 km? Or could Canadian tugs handle the ship until it at the border and a U.S. pilot is aboard? Alternatively could a Canadian pilot go the first 2 km and then be replaced with by a U.S. pilot?
- For northbound traffic, could a U.S. pilot board the vessel in Seattle or Tacoma, and then follow a cost-effective procedure to safely cross the final 2 km to the RBT2 facility?
- What would be the change in cost for the Canadian and U.S. Pilot Associations (and the affected shipping line) if such a whale-benefiting mitigation were to be implemented?
- "Rosario Strait is very narrow and includes one-way passage restrictions."
- Please specify whether the constrictions were a problem when Rosario Strait was used by containerships (before 2010?), the beams and lengths of those ships, and the nature of the one-way passage restrictions.
- The length, beam, and draft of the New Generation IIB (20,000 TEU) container ship are expected to be 450, 61.5, and 16.5 meters, respectively. In comparison, large containerships that likely used Rosario historically were Panamax or New Panamax ships which both have length, beam, and draft of 366, 49, and 15.2 meters. The changes in beam would only be ~12.5 meters in a channel kilometers across. And the increase in draft would be only 1.3 meters.

- The narrowest point is 2.7 km (between Decator and Cypress Islands) In comparison, the narrowest part of Haro Strait and Boundary Pass is 3.6 km (between Turn Point and Rum Island). The bulk of Rosario Strait is about 5 km wide, which is comparable to the width of many restrictions along the Haro-Boundary route (e.g. Sidney to Henry, Moresby to Stuart, South Pender to Stuart, Saturna to Skipjack, or East Point to Patos).
- Table IR1-05-03 (extract below) indicates that \*all\* container ships that visit Deltaport also visit Puget Sound ports. I also note that Fraser Surrey Dock traffic only goes “counter-clockwise” (entering Puget Sound first, then Canadian waters, before returning to the Pacific), likely due to a shipping service which imports first to the U.S. and then exports from Canada.
- This means that if all ships used Rosario Strait, then containership traffic in Haro Strait could be halved.
- Furthermore, if incentives could cause more lines to visit Puget Sound first and then Vancouver, then most Haro Strait traffic would be southbound -- effectively shifting the noise sources laterally ~2 km further away from key SRKW foraging areas along the west side of San Juan Island.
- Even if this pattern was only followed during the summer (when SRKWs frequent Haro Strait and Boundary Pass) or even only when SRKWs were present in Haro, it seems like an important mitigation option to consider further.
- Note the consistent symmetry in this extract from Table IR1-05-03:

Direction/Last Port of Call	2012 Vessel Movements for Port of Vancouver Container Terminals				
	Centerm	Fraser Surrey Docks	Vanterm	Deltaport	2012 Total Movements All Terminals
a. To Terminal Directly from Pacific	57	0	63	119	239
b. To Terminal From Puget Sound	183	84	177	149	593
c. To Puget Sound from Terminal	57	0	63	119	239
d. To Pacific from Terminal	183	84	177	149	593
<b>Total Movements<sup>a,b</sup></b>	<b>480</b>	<b>168</b>	<b>480</b>	<b>536 (538)</b>	<b>1,664 (1,580)</b>

## Package IR-3 Ecosystem Model

### IR3-05 Exchange with Adjacent Ecosystems

- Reviewed, but no comments on in/sufficiency

## Package IR-4

### IR4-01 Vessel Traffic Projections: container ship sizes

- Reviewed, but no comments on in/sufficiency

### IR4-02 Vessel Traffic Projections: air pollution and wake/wave effects

- Reviewed, but no comments on in/sufficiency

### IR4-03 Vessel Traffic Projections: George Massey Bridge/Tunnel

- Reviewed, but no comments on in/sufficiency

### IR4-04 Vessel Traffic Projections: segment G details

- Reviewed, but no comments on in/sufficiency

### IR4-05 Vessel Traffic Projections: small vessels

- Reviewed, but no comments on in/sufficiency

### IR4-06 Vessel Traffic Projections: Fraser-Surrey coal/bulk dock

- Reviewed, but no comments on in/sufficiency

### IR4-07 Vessel Traffic Projections: non/peak traffic at various facilities

- Reviewed, but no comments on in/sufficiency

### IR4-08 Vessel Traffic Projections: tug & ferry movement details

- Reviewed, but no comments on in/sufficiency

### IR4-09 Vessel Traffic Projections: vessel movement for excluded projects

- Reviewed, but no comments on in/sufficiency

### IR4-10 Underwater noise: ECHO program

- Reviewed, but no comments on in/sufficiency

## IR4-11 Underwater noise: estimating Triple-E-class ship source levels

The response states "...ship source level measurements presented in McKenna et al. (2013) would predict a smaller, less conservative adjustment of +0.5 dB for a Triple-E class container ship."

However, figure 3 from McKenna et al., 2013, depicts median values for repeat-transit container ships with lengths up to 350 meters:

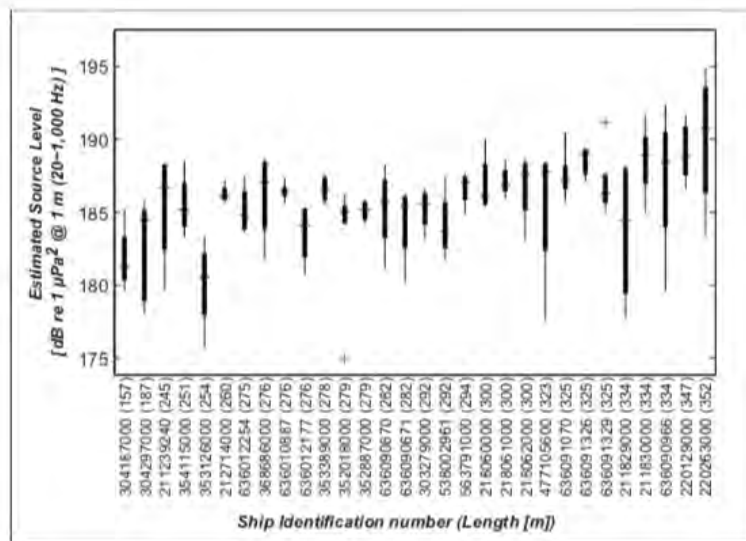
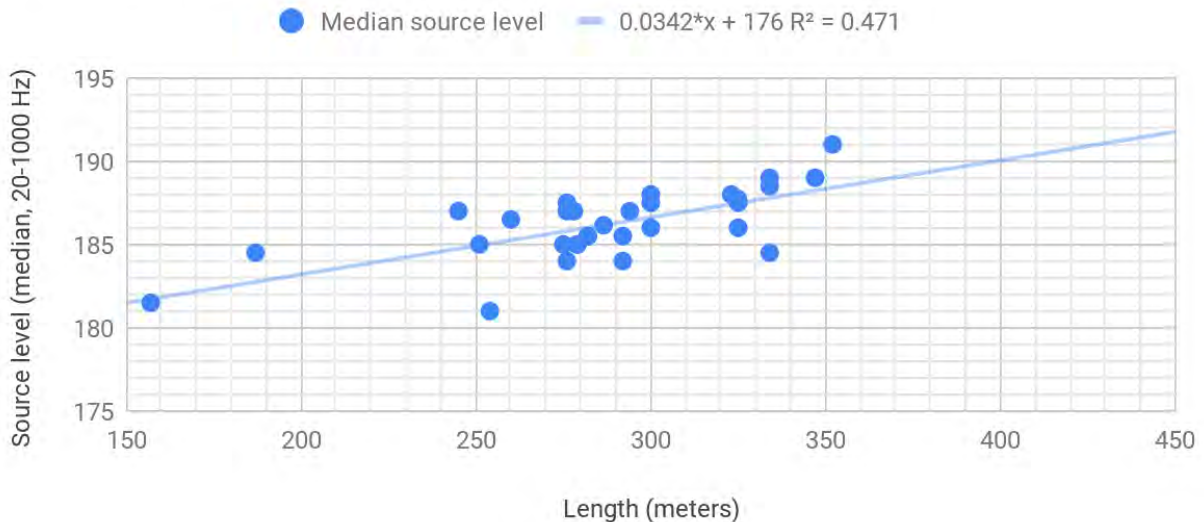


Figure 3 | Variability individual container ship estimated SL from ships that transited on four or more different occasions. Boxes bound the 25<sup>th</sup> and 75<sup>th</sup> percentiles with the horizontal line at the median. Ends of the vertical whiskers are the highest and lowest values of the data set that are within 1.5 times the inter-quartile range of the box edges. The plus signs represent data outside the range of the whiskers.

These data are median source levels derived from multiple measurements made during at least 4 distinct transits of the same ship. If we plot the median values versus the associated ship's length, we see a linear relationship with a slope of +3 dB per +100 meters:

## McKenna+2013 repeat-transit containership data (median source level vs length)

Means: 186.2 dB re 1uPa<sup>2</sup> @1m, 286.5 meters



The best-fit trend line to these data (20-1000 Hz median band levels) indicate that a 400-meter-long containership (length of a Triple-E class vessel specified in the response by the Proponent) would be expected to have a source level of 190.0 dB re 1uPa<sup>2</sup> @1m, which is +3.8 dB above the overall mean value for this data set (186.2 dB re 1uPa<sup>2</sup> @1m). Even if the mean of vessels with lengths of 300-350 m (187.7 dB) is used as the reference, the estimated source level of a Triple-E (400 m long) vessel would be +2.3 dB.

Thus, I understand neither how the value of +0.5 dB was computed, nor how the Proponent's adjustment of +1.67 dB can be considered conservative and precautionary. The decibel scale is logarithmic, so an adjustment of ~2.3 or 3.8 dB is distinct enough from +1.67 that a re-assessment of the conservativeness of the noise modeling is warranted, even after considering the Proponent's response regarding key model assumptions being precautionary.

*The Response cites this document as +1.67 dB adjustment being "probably the best information available" -- CEAR Document #959 From Fisheries and Oceans Canada to the Review Panel re: Response to Information Requests issued by the Review Panel on April 5, 2017 (See Reference Document 951).*

I have reviewed the CEAR document #959 and see that it makes no use of available modern data (e.g. the linear plot of modern containership medians that I have provided). [The DFO response](#) to the Panel states: "There is a link between SL and vessel length and the Proponent is assuming a second-power law dependency as suggested by Ross (1976) to scale the SL from an observed container vessel to the anticipated Triple E-class container ships expected in

the future. Assuming that these larger ships will be about 21% longer than the present one, the second-power law indicates that this will increase the SL of these vessels by 1.67 dB.”

#### IR4-12 Underwater noise: berthed container ship source level

- Reviewed, but no comments on in/sufficiency

#### IR4-13 Underwater noise: source level of 22-24,000 TEU vessels

- Using the Proponent’s lengths for these larger capacity vessels (430 and 450 meters, respectively), the length-vs-source-level regression of McKenna+2013 data suggests the source levels for the bigger ships would be 191.0 and 192.0 dB re 1 uPa @1m, respectively. If the same extrapolation method that was used to estimate the Triple-E class source level was applied to these larger ships, the expected additional level above the measured mean source level (for ships up to 267m long) would be +4.3 or +5.8 dB. Since a 3 dB increase is equivalent to a doubling of acoustic intensity and a 6 dB increase indicates that a quadrupling of intensity, these would be much more impactful ships that thus further call into question how conservative we should take the noise modeling results to be.
- **The response states:** “The forecast of these larger vessel classes calling at RBT2 after 2030 is dependent on global market and trade conditions, and thus, is speculative.”
- In assessing the longest-term environmental impacts of the project, we should assume the worst case (noise) scenario. That scenario is much larger ships with proportionally higher source levels -- possibly 200-400% of the intensity of the Triple-E class (if my linear extrapolation is accurate) -- likely outweighing any benefit of needing fewer voyages due to the larger ships’ increased capacity (only 120-131% higher than the Triple-E capacity of 18,340 TEUs).

#### IR4-14 Underwater noise: small vessel noise contribution (table)

- Reviewed, but no comments on in/sufficiency

#### IR4-15 Underwater noise: impact pile driving

- Reviewed, but no comments on in/sufficiency

### Package IR-5

#### IR5-01

- Reviewed, but no comments on in/sufficiency

#### IR5-01a Anchorage clarifications and maps/tables

- Reviewed, but no comments on in/sufficiency

#### IR5-15

- Claim: "Because eulachon do not have a swim bladder (Phleger 1998, Bone and Moore 2008), they are considered less sensitive to underwater noise than Pacific herring. Therefore, the assessment of underwater noise-related effects on Pacific herring is considered conservative."

#### IR5-26

- (pg. 276) "Atlantic herring would react to underwater noise that exceeds 165 dB (i.e., 90 dB above the species' hearing threshold of 75 dB). Thus, 90 dBht was determined to be the loudness level above which behavioural effects would manifest regardless of species."
- (pg. 277) Musqueam First Nation assertion that eulachon are skittish suggests that eulachon may respond at the 90 dBht (herring) level where behavioural effects manifest. An audiogram and then a dBth (eulachon) calculation is needed to assess eulachon response.

#### IR5 - 27

- The proponents again claim here that herring are controlling over eulachon. Have the Musqueam have noticed if the herring are 'skittish' as they say eulachon are... That might help understand if herring really are controlling.

#### IR5 - 32

- Insufficient information provided
- (pg. 432) The "use of SRKW as the representative species for transient killer whales provides a more conservative assessment, as transient killer whales occur less frequently than SRKW in the local assessment area."
- Recent studies show that more transient (Bigg's) killer whales have recently occupied the Salish Sea more than in the past, while there are fewer SRKWs (Shields et. al. 2018). Hence, SRKW's may not be controlling and the impacts of ship's presence and noise on transient killer whales should not be ignored, especially given the complex ecological connections between residents and transients. For example, Bigg's killer whales prey mainly upon harbor seals while harbor seals prey upon not only salmon (adults and juveniles) and their prey (e.g. herring), but also key predators of juvenile salmon (like hake).

#### IR5-40

- Reviewed, but no comments on in/sufficiency

#### IR5-41

- Insufficient information provided



- Williams et. al. (2010) reports that 3-4 whales are struck per year in Canadian and US inland waters. Furthermore, Williams et. al. quantifies the increased probability of ship strike as shipping traffic changes.
- Also, in multiple cases of killer whale strikes since observations began in Johnstone Strait (Helena Symonds, pers. comm.) ship propellers have caused severe injury or fatalities. Multiple examples of killer whale dorsal fins being severed or deformed suggest strikes by ships, rather than boats.
- The results of Williams et al. (2010) and other observations of ship strikes, particularly of resident killer whales, should be collated and incorporated.

#### IR5-42 through 52

- Reviewed, but no comments on in/sufficiency

#### Package IR-6 Air Quality

#### Package IR-7 through 10

- Potentially relevant, but not yet reviewed

#### Package IR-11

##### IR11-01

- Reviewed, but no comments on in/sufficiency

##### IR11-02 through 10

- Potentially relevant, but not yet reviewed

##### IR11-12

- Potentially relevant, but not yet reviewed

#### Package IR-12

##### IR12-05 In-air noise

- Potentially relevant, but not yet reviewed

#### Package IR-13 Mitigation Measures

##### IR13-30 Mitigation measures

- Reviewed, but no comments on in/sufficiency

## Insufficiencies in “other information”

- Potentially relevant, but not yet reviewed

## Were 2015 and 2016 SRKW noise and cumulative impact gaps identified by SV sufficiently filled?

### 2015 completeness requests

- Size distribution of 2012 ships (at least containerships)
- Vessel movement breakdown by source & destination
- Noise statistics on time scales that are relevant to SRKW behavior
- Use all available data to verify that extrapolating SL by length is accurate
- Use all available data to verify that 1.67 is an accurate way to adjust spectrum levels (from 338 to 367m)
- Show distribution of container ship spectra along with “representative” spectrum (338m ship)
- Ensure noise (RMS) values are not contaminated by low frequency tidal pseudo-noise
- Use ship movement data (AIS, not only VTOSS) with resolution that matches acoustic averaging period (seconds or minutes, not months)
- Consider impacts on Bigg’s whales, and ecosystem interactions with SRKWs and their prey
- Assess acoustic impacts on humpback signals (echolocation and communication)
- Clarify how additional 260 transits were distributed temporally

### **NOTES related to my completeness requests:**

Re size distributions: I see from here this projection of sizes for 2025-2035, but not (yet) the 2012 distribution:

**Table 2 Projected Vessel Numbers by Size Class and Distribution of Vessel Capacity (as percentage) for 2025, 2030, and 2035**

Vessel Capacity Range (TEUs)	2025 <sup>a</sup>		2030 <sup>a</sup>		2035 <sup>b</sup>	
	Number	Percent	Number	Percent	Number	Percent
4,000 – 5,999	21	8	8	3	8	3
6,000 – 7,999	8	3	8	3	8	3
8,000 – 10,000	182	70	169	65	169	65
10,000 – 15,000	49	19	75	29	75	29
>15,000 <sup>c</sup>	0	0	0	0	0	0
<b>Total</b>	<b>260</b>	<b>100</b>	<b>260</b>	<b>100</b>	<b>260</b>	<b>100</b>
<b>Average Ship Size (TEUs)</b>	<b>8,815</b>	<b>n/a</b>	<b>9,365</b>	<b>n/a</b>	<b>9,365</b>	<b>n/a</b>

**Source:**

- a. Percent information from Seaport 2014. Numbers have been calculated based on the total calls and percent projections.
- b. Vessel numbers and the distribution of vessel capacity projections in 2035 are expected to be similar to 2030.
- c. This size class was not provided in Seaport 2014, but ultra-large vessels are not expected to call at RBT2.

## References

- Shields, M.W., Lindell, J., Woodruff, J., 2018. Declining spring usage of core habitat by endangered fish-eating killer whales reflects decreased availability of their primary prey. *Pacific Conservation Biology* 24, 189. <https://doi.org/10.1071/PC17041>
- Williams, R., O'Hara, P., 2010. Modelling ship strike risk to fin, humpback and killer whales in British Columbia, Canada. *Journal of Cetacean Research and Management* 11, 1–8.

# TAB B



April 2019

Debra Myles  
Review Panel Manager, Roberts Bank Terminal 2 Project  
c/o Canadian Environmental Assessment Agency  
160 Elgin Street, 22nd Floor, Ottawa ON K1A 0H3

Dear Ms. Myles,

**Re: Roberts Bank Terminal 2 Assessment**

The Raincoast Conservation Foundation is concerned about the impacts of the proposed project on the marine environment and in particular on endangered marine species such as the Southern Resident Killer Whale. We have retained David Scott, a fisheries biologist with particular expertise in salmon, to review the proponent's responses to information requests in regards to the sufficiency and technical merit of the assessment as it pertains to Fraser River Chinook salmon. The potential for adverse effects on Chinook salmon marine survival is of direct significance due to their importance as prey items for endangered Southern Resident Killer Whales, their importance in commercial, recreational and First Nations fisheries, and their current declining status.

Please see attached for a review of the potential impacts of the project on juvenile Chinook salmon in the Fraser estuary and a discussion of the limitations of the Environmental Impact Statement and the proponent's responses to Information Requests in regard to their ability to predict potential impacts on juvenile Chinook productivity.

Sincerely,

A handwritten signature in black ink that reads "Chris Genovali". The signature is written in a cursive, flowing style.

Chris Genovali

Executive Director

Raincoast Conservation Foundation

**Participant:** David Scott

**Organization (if applicable):** Raincoast Conservation Foundation

**Expertise:**

I am David Scott a fisheries biologist, with particular expertise in salmon. I have been retained on behalf of the Raincoast Conservation Foundation to assist them in the Terminal 2 review, particularly as it pertains to effects on juvenile Chinook salmon. My knowledge and experience regarding juvenile Chinook use of the Lower Fraser River and estuary comes from studying juvenile salmon in this area for the past 7 years since 2012. My education includes a Bachelor of Science with High Honours in Biology from the University of Regina awarded in 2010. I then began studying juvenile salmon in the Lower Fraser River in 2012 when I began my Masters degree studying Resource and Environmental Management at Simon Fraser University under the supervision of well-known salmon ecologist Dr. Jonathon Moore. During my time at SFU I was involved with several research projects in the Lower Fraser River including my masters project which investigated the impacts of flood control infrastructure on juvenile salmon use of rearing habitats in the Lower Fraser with a particular focus on juvenile Chinook. In December 2014 I graduated with a Masters in Resource Management.

Following the completion of my degree I was hired on contract by the Raincoast Conservation Foundation to provide written evidence for the National Energy Board joint review of the Trans Mountain Expansion project with a focus on potential risk to juvenile salmon in the Lower Fraser River and estuary. In 2016, as a contract employee with Raincoast, I lead the beginning of a juvenile salmon research project in the Fraser estuary which is now in its fourth consecutive season. Our research involves repeated sampling of juvenile salmon habitats throughout the Fraser estuary including at Roberts Bank, with a sampling intensity of two sampling rounds at each site per month from April to July each year, typically consisting of 8 sampling rounds per site. This has resulted in a vast amount of time spent on the water in the Fraser estuary each year during the juvenile salmon outmigration and residency period, and as such I have acquired directly relevant and thorough knowledge of juvenile salmon usage patterns in this area. In 2017 I lead a successful application to the Coastal Restoration Fund and currently lead our 2.7-million-dollar restoration initiative to restore connectivity in the Fraser estuary by creating openings in structures such as jetties and causeways. In early 2019 we completed phase 1 construction of three breaches of the Steveston Jetty, restoring migratory pathways for juvenile salmon on Sturgeon Bank. In the fall of 2018, I began full time doctorate studies at the University of British Columbia under the supervision of Dr. Scott Hinch and my ongoing research will continue to focus on improving our understanding of juvenile Chinook use of the Fraser estuary.

## **I. The Fraser River estuary's role and condition in relation to salmon**

### **1.1. The ecological importance of the Fraser River estuary, in particular for salmon.**

The Fraser River is one of the world's great rivers, running over 1300 km in length, with a watershed encompassing one quarter of British Columbia (Milliman 1980; Richardson et al. 2000). From the headwaters in the Rocky Mountains hundreds of tributaries combine as the river moves across British Columbia towards the ocean to deliver an enormous amount of freshwater (avg. 3,410 m<sup>3</sup> per second), and sediment (approximately 17 million tonnes/year), into the Lower Fraser and Salish Sea (Milliman 1980; McLean et al. 1999). As these streams combine the nature of the river changes, creating the diversity of habitats which salmon have adapted to thrive in. As a snowmelt driven system, spring

brings a corresponding increase in river flows. In the Lower Fraser this results in a rise of several meters, temporarily connecting and creating habitats in the few areas where the river is unconstrained by dikes and armoring.

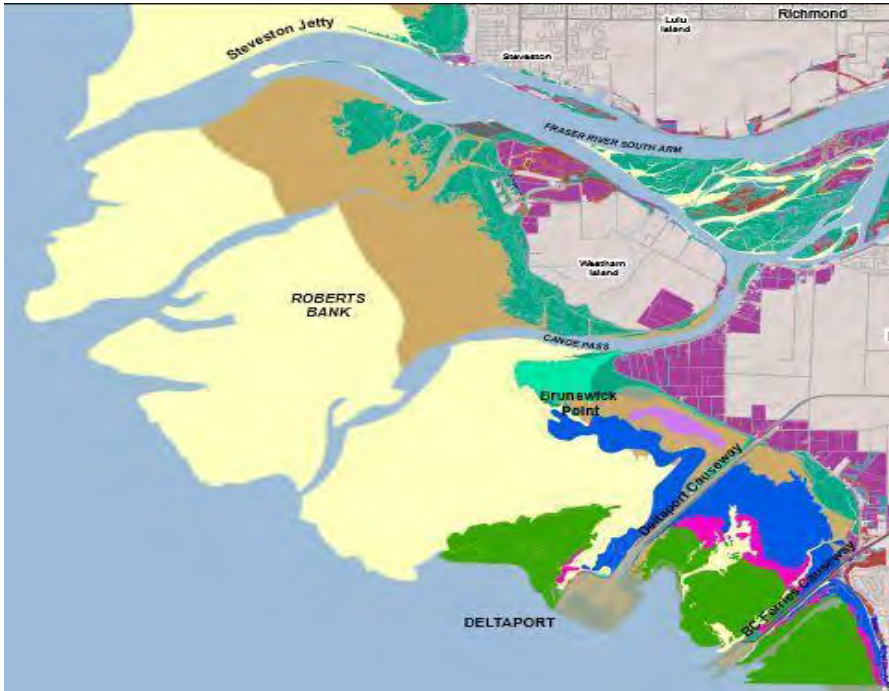
The salmon populations that exist in the Fraser today began to colonize the watershed after the last glaciers retreated between 9,500 and 9,000 years ago (Shaepe 2001). Since then salmon have spread throughout the watershed, evolving over time with the unique local conditions in each stream, using their homing ability to migrate back to their natal stream as adults (Taylor 1991). On European arrival, the Fraser was the most productive salmon river in the world, boasting populations of Chinook, chum, coho, pink and sockeye that were counted in the millions and originated from more than 1070 spawning populations distributed through the mainstem and tributaries (Slaney et al. 1996). Despite intense harvest and development pressures, the Fraser continues to support runs of all five economically important salmon species, producing over 50% of Canada's wild Pacific salmon (Levy and Northcote 1982; Northcote and Atagi 1997; FRAP 1999). However most salmon populations from throughout the watershed have declined, resulting in greatly reduced abundances and strictly managed fisheries.

The Fraser was once the world's most productive salmon basin, and still produces more salmon than any other river in British Columbia (Northcote & Atagi 1997), while also being the site of one of Canada's largest cities (Vancouver) and most active port. All of the salmon that spawn in the Fraser watershed use the Lower Fraser and estuary as a migration corridor. Many further rely on the lower river, its tributaries and estuary for rearing, spawning and feeding. We define the Lower Fraser as the section of river flowing west from Hope, past Mission, through Metro Vancouver, and into the estuary where it meets the ocean. Despite the Lower Fraser watershed representing less than 5% of the total area of the entire Fraser Basin, this area supports more than half of the Fraser River's chinook and chum, 65% of its coho, 80% of its pink and significant stocks of sockeye salmon (DFO 1995, 1996).

The lower river and delta below New Westminster empties directly into the southern Strait of Georgia via the North and Main arms, creating a fresh-saline mixing zone that is the estuary of the Fraser River. The inner estuary consists of the North Arm, which splits further around Sea Island into the North and Middle Arms, and the Main Arm which splits around the Woodward Island marsh complex into the Main Arm and Canoe Pass. The outer estuary is made up of Sturgeon and Roberts Bank, which are further divided by several jetties and causeways which alter the path of water, sediment and fish. These areas provide a variety of habitats including marsh, sand/mud flats, and eelgrass that differ in salinity, sediment type, and water depth, and in their ability to support salmon (Harrison et al 1999).

All Pacific salmon migrate through estuaries twice during their lifespan and many will reside for days to months during their downstream migrations (Weitkamp et al. 2014, Moore et al. 2016). Chinook and chum salmon which migrate downstream in their first year of life as fry are known to rear in estuaries from a few days up to a few months for some Chinook populations (Levings et al. 1989, Volk et al. 2010, Carr-Harris et al. 2015). In the Fraser estuary juvenile Chinook, chum and pink salmon have been shown to rear in high densities in marsh habitats (Levy and Northcote 1982), but very little information exists regarding their use of Roberts Bank. Today, much of the estuarine habitat in the Fraser has been lost, and numerous large barriers interrupt the movement of fish and disconnect ecosystems, with uncertain implications for salmon.





Source: Port Metro Vancouver

Figure 1. Habitat types in the Fraser estuary at Roberts Bank rendering of proposed terminal 2 (sand flat, mud flat, eelgrass, intertidal marsh). From FREMP backgrounder part 1.

Backgrounder part 1, prepared by Northwest Hydraulic Consultants and GL Williams & Associates Ltd. 2009.

Figure 2. Port of Vancouver artist rendering in relation to existing Deltaport

Chinook salmon populations from throughout the Fraser are vulnerable to impacts from changes to the estuary depending on population, CU, and life stage. Mature Chinook migrate through the Lower Fraser to their natal streams to spawn in three run timing groups spanning from February to November (DFO 1995). The Harrison River Chinook population (Lower Fraser River Fall CU) is one of the largest runs in North America, often making up the majority of Fraser chinook returns (CTC 2017; DFO 1995). This population has a unique life history that makes them most vulnerable to impacts of



changes to habitat productivity in the estuary. Harrison River Chinook fry migrate downstream immediately after emergence to the Lower Fraser and estuary where they rear, feeding and growing primarily from April to June (can be up to 6 months) before ocean entry (DFO 1995; Levy and Northcote 1982; Murray and Rosenau 1989). This life history strategy of migrating to the ocean in the first year of life is called “ocean type”, whereas other Chinook which remain in freshwater for a full year before ocean entry are known as “stream type”. Ocean-type Chinook from throughout the watershed also utilize the Lower Fraser and estuary in the spring months as juveniles (DFO 1995). There are also three CUs of stream-type Chinook populations which occur in Lower Fraser tributaries where they are present as juveniles throughout the year (DFO 2013). Stream-type Chinook from upper and middle parts of the watershed are also present in the estuary from April to June during their migration to the ocean. The most vulnerable salmon populations to changes to habitat in the estuary are ocean-type Chinook due to their extensive use of Fraser estuary habitats as juveniles prior to ocean entry.

Research in the Fraser estuary and other estuary systems across the Pacific Northwest have demonstrated the importance of estuary rearing for juvenile Chinook salmon with “ocean type” life histories. In the Fraser, Levy and Northcote (1982) demonstrated high densities of Chinook rearing in tidal marsh channels, and hypothesized that growth in the estuary was greater than upstream freshwater habitats. Moore et al. (2016) described estuaries as important stop-over habitats for juvenile salmon and found that in the Skeena estuary 25% of juvenile Chinook salmon spent at least 33d in the estuary. Larger Chinook salmon resided in the estuary for longer durations, growing at an estimated 0.5 mm d<sup>-1</sup>, evidence that estuary residency provides growth opportunities (Moore et al. 2016). In the Columbia estuary McNatt et al. (2016) found many juvenile Chinook salmon remained in the marsh for 2–4 weeks and increased in length by 10–20 mm, with an average growth rate of 0.53 mm/d. The ability for juvenile Chinook to grow quickly during this estuary residence period is incredibly important as size at ocean entry is thought to be a major determining factor in early marine survival (Woodson et al. 2013). Based on these previous studies it seems likely that growth occurring in estuary habitats is important to the early marine survival of ocean-type Chinook in the Fraser River.

Investigations regarding juvenile Chinook use of Roberts Bank have been limited and did not occur until after construction of the original Deltaport causeway in 1969 (Greer et al. 1980; Levings et al. 1983; Triton 2004; Martel 2009; Archipelago 2014). Levy and Northcote (1982) sampled in the South Arm marshes of the estuary in 1979 and demonstrated high densities of juvenile salmon in tidal marsh channels, however recent studies conducted at Roberts Bank (Triton 2004; Martel 2009; Archipelago 2014) although documenting juvenile salmon presence, have captured relatively few juvenile salmon compared to the vast number emigrating from the river. Due to the presence of the terminal prior to any baseline studies it is difficult to interpret the relatively low number of juvenile salmon using the productive eelgrass beds of the inter-causeway area.

## 1.2. Current ecological condition of the Fraser River estuary, in particular in the context of its ability to function as salmon habitat and support healthy populations of wild salmon.

Prior to the arrival of Europeans, the Lower Fraser watershed was much different than it appears today. Nearly two-thirds of the land base of the Lower Fraser was forested, and the remainder

comprised of wetlands and a large lake (Healey and Richardson 1996). European settlers arrived as early as 1850, and over the next one hundred years, the vast majority of the forest was harvested and cleared (Healey and Richardson 1996). Following this, the wetlands were drained to create farmland, and to protect developments from flooding, dikes were constructed. As the population grew on the floodplain so did the systems of dikes, cutting the river off from approximately 70% of the floodplain by the mid-20<sup>th</sup> century (Healey and Richardson 1996). Overall by the beginning of the 21<sup>st</sup> century, the forests and wetlands had been reduced to approximately one-tenth of the land base, with agricultural and urban land uses dominating the landscape (Healey and Richardson 1996).

The most recent assessment of the salmon resources of the Lower Fraser was conducted in 1997 as part of the Fraser River Action Plan, an initiative of the Habitat and Enhancement Branch of Fisheries and Oceans Canada. This review resulted in the Lower Fraser Valley Streams Strategic Review (PIBC 1997) and summary report, “Wild, Threatened, Endangered and Lost streams of the Lower Fraser Valley” and accompanying map (See Figure 2.1 below). Streams were evaluated based on whether they faced one or more of a number of stressors and classified as: wild (no stressors), threatened (one stressor), endangered (two or more stressors), or lost (culverted, paved over). Unsurprisingly, they found that very few streams can still be considered wild (<4%, no stressors), 20% were already lost (culverted or filled), 63% endangered (two or more stressors), and 13% threatened (one stressor) (Wild Streams Map, PIBC 1997).

Similar to much of the Lower Fraser watershed, the Fraser estuary has been considerably altered since the late nineteenth century. Dike construction, to permit agriculture and other developments and to prevent flooding, is estimated to be responsible for removing 70% of the estuary from use by fish, aquatic invertebrates and waterfowl (Hoos and Packman 1974). The mudflat and intertidal region of estuary delta is often the most ecologically important of these coastal habitats, yet protection of these areas in the Fraser estuary has been minimal (Elliott and Taylor 1989).

The various jetties and causeways constructed in the estuary have created significant barriers to fish migration and affected natural flow and sediment patterns (Harrison et al. 1999). This is particularly significant for certain species of juvenile salmon, which must now swim around these structures, exposing themselves to deep, saltier waters during a vulnerable juvenile stage of ocean entry when they would otherwise remain in the safer, nearshore areas. One such jetty, the Iona jetty, is also the source of an average of 557 million liters of partially treated sewage that is pumped directly into the estuary each day (Metro Vancouver 2013). Construction of the Roberts Bank coal port and container terminal removed significant amounts of habitat from the estuary, and coal dust is found in ever increasing concentrations in the surrounding mudflats (Johnson and Bustin 2006). Expansion of the coal port in 1980 was described by Fisheries and Oceans Scientist Dr. Levings (1985) as having “obliterated feeding areas, invertebrate communities, and possibly herring spawning areas from the local productions system”. Cumulatively, these human actions have likely severely reduced the ability of the estuary to support juvenile salmon and other species.

Climate change is already beginning to alter conditions in the Fraser estuary potentially placing further stressors on an ecosystem already suffering from an array of cumulative effects. Sea-level rise will likely lead to an increase in flood control structures and other infrastructure which contributes to coastal squeeze and the loss of coastal marsh habitats. Changes to the hydrology in the watershed are

predicted to result in spring freshets which arrive earlier each year, altering salinities in the estuary during the juvenile Chinook residence period. We are already seeing changes to flows and temperatures in the Fraser River. Data series collected since 1953 indicate that spring freshet is arriving earlier and reaching half of its annual cumulative flow an average of nine days earlier than a century ago (Fraser Basin Council 2010; Figure 3.1). Low flows may create barriers to spawning salmon, and tributary streams that support juvenile coho may run dry during late summer. Summer mean water temperatures have increased over the past 50 years, equivalent to 2.2°C per century, and are predicted to rise another 1.9°C by 2080 (Morrison et al. 2002; Figure 3.2).

### 1.3. Current status of the five species of salmon that rely on the Fraser River estuary as habitat.

Before the 1990's the Salish Sea supported a valuable recreational fishery for coho, and Chinook marine survival was strong. Over the past few decades Chinook, coho and steelhead have had consistently low returns in the Fraser and other parts of the Salish Sea. However, these trends have not been seen in other areas of Washington or B.C. This has led many to conclude that the problem is within the Salish Sea itself. In response, the Pacific Salmon Foundation together with Long Live the Kings in Washington launched an ambitious project, funding research across the Salish Sea investigating a variety of hypotheses into the decline in marine survival of Chinook and coho ([marinesurvivalproject.org](http://marinesurvivalproject.org)). Conversely, new research by Welch et al. (2018) points to a coastwide problem with marine survival for Chinook salmon related to poor ocean conditions. Regardless of the cause marine survival for Chinook salmon remains poor and shows no signs of improvement in the short term.

Various levels of government are responsible for protecting fish and their habitats but Fisheries and Oceans Canada (DFO) is the main authority responsible for managing Pacific salmon. In 2005, DFO published the Wild Salmon Policy to preserve and restore populations within the five commercially harvested species of wild Pacific salmon. While the majority of the policy has yet to be implemented, one initiative that has been carried out is establishment of individual Conservation Units (CU's), defined as "a group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to recolonize naturally within an acceptable time frame" (DFO 2005). This classification recognizes and aims to protect the irreplaceable genetic and ecological diversity that is contained within thousands of BC's local streams and spawning populations (Holtby and Ciruna 2007). The Fraser River has 56 unique CUs of commercially managed salmon, including 16 in the Lower Fraser. Chinook and sockeye salmon make up the majority of CUs in the Fraser and unfortunately recent assessments of Chinook in 2018 and Sockeye in 2017 have shown serious cause for concern with the majority of populations struggling.

The Fraser River system produces the greatest number of Chinook salmon in Canada (Parken et al. 2008) and these Chinook make up the vast majority of Southern Resident Killer whale diets in their critical habitat (Hanson et al. 2010). In 2016 a Canadian Science Advisory Secretariat review published by Fisheries and Oceans Canada concluded that the majority of Fraser River Chinook had declined over the past 12 to 15 years and that this was a significant cause for concern (DFO 2016, Attachment 1). In November 2018 COSEWIC published a new summary

of wildlife species assessments which included all Fraser River Chinook populations. They found that out of 16 CU's, half of them or 8 populations were listed as endangered, only 1 was listed as Not at Risk, and the remaining were listed as Threatened (3 populations), Special Concern (1 population) or Data Deficient (2 populations) (COSEWIC 2018, Attachment 2). Harrison River Fall ocean type Chinook salmon, which are the most reliant on the estuary of any Fraser Chinook population (DFO 1995; Raincoast unpublished genetics data), were listed as Threatened in this recent assessment, and have failed to reach their escapement target in six of the last seven spawning years (Figure 1; CTC 2017, DFO 2018 Attachment 4). In 2018 Fraser River Chinook spawner abundance was poor across all populations including stream and ocean types, prompting new restrictions for Chinook fisheries in 2019 (DFO 2019 Attachment 4)

## **2. Effects of the Project on salmon and salmon habitat**

### **2.1. Magnitude, geographic extent, temporal extent and reversibility of potential project effects on salmon.**

The project has the potential to result in negative impacts to juvenile salmon and their habitats as a result of terminal placement and activities associated with terminal operations. In my opinion the greatest potential impact of this project is the cumulative impact of the existing terminal placement and the additional new terminal placement on juvenile salmon migration pathways in the estuary. There is also the potential for impacts to juvenile salmon behaviour and predation risk associated with anthropogenic lighting and noise from terminal operations. Lastly, there is the potential for changes to the Roberts Bank ecosystem and prey availability for juvenile Chinook which can not be properly characterized by the Roberts Bank ecosystem model based on flaws in its application as described below. Although the geographic extent of this impact is localised at Roberts Bank, there is little information available which can allow the proponent or the public to quantify the magnitude of these impacts on juvenile salmon survival during the critical estuary rearing and ocean entry phase of their life cycle. Juvenile salmon migrating southward from the mouth of the Fraser River may be exposed to highly saline waters as a result of the migration interruption created by the terminal, with unknown effects on their physiology and survival. Temporally, the effects of terminal placement are ongoing, permanent and irreversible, the construction of the new terminal further disrupts the migration pathway of juvenile salmon currently impacted by the existing causeway and terminal. This effect could only be reversed by the decommissioning and removal of the causeway and terminal. Alternatively, the causeway could be breached and openings created which could restore ecosystem connectivity and juvenile salmon migration pathways, however the impact of this type of action on the Roberts Bank ecosystem as a whole would require a thorough study.

### **2.2. Opinion on the Proponent's conclusions with respect to potential effects of the Project on salmon and salmon habitat.**

It is my opinion that the information presented by the proponent in the EIS and supplementary information request responses is insufficient to justify their conclusions that the project will result in negligible adverse impacts to juvenile Chinook and chum VC's. The proponent's justification falls short due to four main issues; a) insufficient baseline data collection to

properly characterize juvenile salmon use of Roberts Bank, b) flaws in the application of the Robert Bank ecosystem model c) lack of quantitative analysis of potential impacts of migration disruption, lighting and noise, and d) demonstrated ongoing lack of success in past habitat compensation activities.

a) Insufficient baseline data collection to properly characterize current juvenile salmon use of Roberts Bank and conduct a historical comparison

### Current use of Roberts Bank

The field studies carried out by the proponent form the basis for their effect's assessment and the inputs for the ecosystem model; therefore, it is of the utmost importance that these data accurately represent use of Roberts Bank by juvenile Chinook salmon. In my professional opinion, for details discussed below, these studies fail to accurately characterize juvenile Chinook use of the Roberts Bank area. The proponent's field studies which relate to juvenile Chinook include the RBT2 Eelgrass Community Survey and the RBT2 Juvenile Salmon Surveys, which were conducted across 2012 and 2013. Due to their limited duration, lack of intensity, limited number of sites, and inefficient field methodology, the RBT2 Juvenile Salmon Surveys are wholly insufficient to accurately depict juvenile Chinook habitat preferences and abundance in the Roberts Bank ecosystem. Thus the parameters which have been used for the ecosystem model likely carry a high degree of uncertainty in their ability to make predictions about productivity.

The field studies conducted by the proponent had a very limited number of replicates, both spatially and temporally, that prevented them from detecting habitat preferences and likely lead to highly uncertain estimates of abundance for juvenile Chinook. The RBT2 Juvenile Salmon Survey (p. 40) states:

*“No consistent seasonal or annual trends were observed in juvenile chinook abundance at individual sites or habitats, as numbers were overall fairly low and extremely variable”.*

The assumption that juvenile Chinook do not exhibit habitat preferences between salt marsh, un-vegetated flats, and eelgrass is not supported by the literature, and instead seems to be an artifact of the limited field sampling conducted by the proponent. The RBT2 Eelgrass Fish Community Survey consisted of only 5 sites - 4 eelgrass sites and 1 reference site on the sandflat- and the RBT2 Juvenile Salmon Survey consisted mostly of shore tied sites and again appears to have had only one reference sandflat site. The likely reason they were unable to detect any habitat preferences is that their study had very limited replication both in the number of sites of each habitat and in the number of sampling occasions.

Along with being unable to detect habitat preferences the abundance estimates they have produced are unlikely to accurately represent juvenile Chinook use of Roberts Bank. Juvenile



Chinook abundance in the Fraser estuary is known to have a sharp peak in the spring and then drop off rapidly (Levy and Northcote 1982), however only one round of sampling was conducted during the spring season in each of the two sampling years. The results of their two years of spring sampling were highly variable:

*“Juvenile chinook salmon abundance in the survey area was significantly higher in 2012 ( $4.1 \pm 1.2$  SE) than 2013 ( $0.5 \pm 0.2$  SE)(RBT2 Juvenile Salmon Surveys p. 25).”*

Due to the limited replication of their sampling protocol, it is difficult to know whether this represents a true difference in abundance or in outmigration timing, or is an artifact of the sampling methods. Based on the lack of replication, there is little confidence in the abundance estimates generated, which represent a mere snapshot versus an accurate or relative representation of juvenile Chinook abundance at Roberts Bank across the spring outmigration period. As outmigration abundance is determined by the strength of the spawning class in the previous year, juvenile Chinook abundance in the Lower Fraser and estuary varies considerably from year to year. The limited repetition of their sampling protocol both within and across years is insufficient to represent the long term average of juvenile Chinook abundance at Roberts Bank.

Based on this information which was provided as part of my initial review of the technical merit of the information provided, the review panel sent numerous information requests regarding the juvenile salmon surveys including IR05-17 - Juvenile Chinook Salmon Baseline.

In their response, VFPA does not provide any additional information regarding the justification of their sampling intensity, duration or number of sampling events to determine baseline information on juvenile Chinook abundance at Roberts Bank. Juvenile Chinook salmon and chum salmon abundance in the Fraser estuary has been shown to change rapidly throughout the spring and summer outmigration season (Levy and Northcote 1982), therefore repeated sampling is necessary to create an accurate representation.

Their response states *“No mismatches are identified between the actual sampling timing in relation to the period of juvenile salmon habitat occupation in the Project’s local assessment area. Beach seines deployed for the Project using techniques and timing in a manner explained earlier in the response actually captured juvenile salmon. Therefore, field survey objectives (i.e., determination of seasonal abundance, distribution, and use by juvenile salmon of habitats, including eelgrass beds, in the local assessment area) were effectively achieved, and meet the overall need of informing the Project’s effects assessment.”*

Simply succeeding in capturing juvenile salmon does not give you any determination regarding the overall accuracy of your estimation. By sampling only once during the peak juvenile Chinook and chum outmigration period as VFPA indicated its sampling program was designed

to do, they are unable to provide any estimation of variability in abundance over time and provide very little confidence in their estimation of overall juvenile Chinook biomass at Roberts Bank. Research conducted at Roberts Bank by Archipelago and GL Williams (2016) repeated their sampling across March, April and May and over 3 years post construction, with results demonstrating month to month and yearly variability in juvenile Chinook and chum salmon abundance.

For example, the Juvenile Salmon Survey (Section 4.1.7 of TDR MF-7 in Appendix AIR10-C of CEAR Document #388) in reference to the same data states: *“In 2012, the abundance of juvenile chum salmon at Roberts Bank causeway south and the BC Ferries Terminal varied by month (Figure 47; Table 36), with abundance at both locations being low in early March, higher at the BC Ferries Terminal in early April, and higher at the Roberts Bank causeway south site in early May.”*

This variability is also demonstrated in the genetic data presented in the VFPA response to IR5-19 in table IR5-19-1 which demonstrates that not only does Chinook abundance vary from month to month within the summer season, the population of Chinook present in the estuary also varies over time. This table also demonstrates that in 2013 and 2014 juvenile Chinook abundance was highest in May, however VFPA field sampling as part of their Juvenile Salmon Surveys was conducted in June.

Therefore, the VFPA suggestion that their sampling did not mismatch peak abundance as they were successful in catching juvenile salmon is unsatisfactory, this data provides no estimation of error or indication of where on the curve of seasonal abundance there sampling occasion happened to occur. To properly estimate overall abundance in the study area, sampling intensity should be increased during peak outmigration timing and occur at regular intervals as demonstrated by Levy and Northcote (1982). Furthermore, as juvenile salmon abundance is variable across years with fluctuations in spawner abundance, sampling should be repeated across years in order to create an accurate representation of average juvenile Chinook and Chum salmon biomass at Roberts Bank.

The VFPA also further defend their choice of sampling technique by stating that *“These beach seining techniques continue to be used in the present by Raincoast Conservation Foundation to capture juvenile salmon as part of their Fraser River Estuary Juvenile Salmon project (Raincoast Conservation Foundation 2016)”* however Raincoast uses a small purse seine to sample habitats at Roberts Bank and only uses a beach seine in marsh channels where it can be deployed effectively.

#### Inability to conduct a historical comparison

The field studies also failed to make comparisons across years which could generate more accurate estimates of abundance and detect any changes in juvenile Chinook use of Roberts Bank over time. The Juvenile Salmon Surveys, although designed to complement the Eelgrass Community Survey, used a different methodology with a larger net and thus was not comparable across years. As juvenile chinook abundance varies significantly from year to year, a one-year study is unlikely to result in an accurate representation of long-term juvenile chinook use of the assessment area which could allow for an analysis of how the use of Roberts Bank by juvenile Chinook has changed over time. However, RBT2 Juvenile Salmon Survey Page 10 states:

*“While CPUE data were reported in studies occurring pre-1983 (Greer et al. 1980, Gordon and Levings 1984), CPUE data from studies completed after the year 2000 was not available for comparison”*

Research that has been conducted since 2000 (Triton 2004; Martel 2009; Thurninger 2013 a,b) has all been done on behalf of the proponent. Catch per unit effort (CPUE) could have been calculated to standardize effort across sampling regimes and allow for a longer-term comparison. Based on the available information, it would appear that use of the Roberts Bank area by juvenile Chinook has decreased since the studies conducted in the 1980’s;

*Page 10: “because studies conducted pre-1983 were carried out prior to the expansion of Roberts Bank Port facilities on Pods 3 and 4 (Hemmera 2004, Figure 3) and modifications to the BC Ferry Terminal, data from these studies are less relevant for inter-annual comparisons than data from more recent studies”*

By avoiding comparisons of recent studies with historical data, the proponent is excluding any examination of how previous Port expansions may have impacted juvenile salmon use of the Roberts Bank area. A review of the potential impacts of the proposed expansion and investigation into juvenile salmonid use Roberts Bank would have been highly pertinent information. However, the proponent has conducted their studies in a way that precludes such analysis. The idea that studies conducted prior to the previous expansion are no longer valid creates a shifting baseline where conditions after each impact are taken as the new normal, while the cumulative impact of prior and proposed expansions is never truly evaluated.

b) Flaws in the application of the Robert Bank ecosystem model.

The output of the Roberts Bank ecosystem model was clearly used as a line of evidence to support the conclusions in the EIS for juvenile Chinook; however, this application of the model is flawed for several reasons. The model fails to incorporate a number of factors which have the potential to impact juvenile Chinook, and the field data used to develop several key input parameters is insufficient. The ecosystem model is also inappropriate to predict effects on juvenile Chinook as they only spend a portion of the year in the assessment area. As noted previously, the proponent stated:



*“...the objective of the RB model was not to provide an assessment of Project impacts for each functional group at a fine temporal scale, but to estimate changes in productive potential, with and without the Project, at the ecosystem level” (CEAR doc. #547, p. 99, lines 1914-1917).*

The ecosystem productivity model is unable to incorporate several factors which have the potential to cause adverse effects on juvenile Chinook. The potential effects of the Project resulting from construction activities, noise, lighting and changes to migration pathways are only assessed qualitatively by the applicant, despite their potential to impact juvenile Chinook. EIS Section 13.6.3.6 p. 13-123 states:

*“Discrepancy between ecosystem model and other lines of evidence attributed to inability of model to incorporate construction, acoustic, lighting, and migration mechanisms.”*

The inability of the model to incorporate these factors cannot be interpreted as lack of risk to juvenile Chinook.

The proponent also states:

*“.....the objective of the RB model was not to provide an assessment of Project impacts for each functional group at a fine temporal scale, but to estimate changes in productive potential, with and without the Project, at the ecosystem level”*

(From the Vancouver Fraser Port Authority to the Review Panel re: Answers to preliminary technical questions submitted during the completeness phase from Fisheries and Oceans Canada, Natural Resources Canada, and Environment and Climate Change Canada, concerning the ecosystem modelling to support the Roberts Bank Terminal 2 Project environmental review (CEAR doc. #547, p. 99, lines 1914-1917).

Based on that statement, it would follow that the ecosystem productivity model should not be used as a line of evidence to conclude potential effects. However, based on EIS Section Table 13-12, it would appear that the ecosystem model *is* considered equal to other lines of evidence in the final conclusion.

The prediction of the ecosystem model is that juvenile Chinook will see an increase in productivity is based on the model’s prediction that there will be a large increase in the productivity of macrofauna as a result of abiotic changes associated with the Project. However, the ecosystem model does not provide enough temporal clarity to accurately predict changes in juvenile Chinook productivity.

The ecosystem model predicts an increase in juvenile Chinook biomass of 16%:

*“based on an increase in productivity on the tidal flats northwest of the Roberts Bank causeway” EIS Appendix 10-C Roberts Bank Ecosystem Model Development And Key Run Section 3.7.2 Chinook Salmon Juvenile (p. 74).*

However it is not known if the predicted 27% increase in macrofauna biomass (EIS Appendix 10-C Roberts Bank Ecosystem Model Development and Key Run Section 3.7.2 Chinook Salmon Juvenile p. 75) which drives this trend occurs at a time of year when it is relevant to juvenile Chinook. Juvenile Chinook peak in abundance at Roberts Bank in the spring and are completely absent from the area during the fall and winter, at least half of the year. The ecosystem model also describes several decreases in productivity associated with the project that have the potential to adversely impact juvenile Chinook at Roberts Bank. A decrease in Pacific herring productivity is predicted to occur (EIS Appendix 10-C Roberts Bank Ecosystem Model Development And Key Run Section 3.7.2 Chinook Salmon Juvenile P. 138).

Juvenile and immature Chinook are known to rely on larval and juvenile herring as prey. EIS Section 13.5.1.2 (p. 13-29) states:

*“At Roberts Bank, major food items (for juvenile Chinook) change from spring to summer (i.e., epibenthic crustaceans and other invertebrates are more prevalent in spring, whereas fish such as Pacific herring are prevalent in later months)”*

Does this decrease in herring productivity not have a negative effect on juvenile Chinook? Juvenile salmon rely on these two different types of prey items at different times during their estuarine residence, therefore an increase in macrofauna may not be suitable to compensate for the loss of herring and other prey items at different times of the year.

The ecosystem model and EIS also fail to incorporate the predicted effects of climate change on the Roberts Bank ecosystem, despite being directed to do so in the EIS guidelines, adding considerable uncertainty to the description of future conditions with the project. EIS guidelines Section 10.1.5 Effects of the Environment on the Project (p. 26):

*“Longer-term environmental effects of potential future sea level rise and other changes to the climate on the project and surrounding ecosystems will also be assessed. This assessment will include a description of methodological approaches and climate data used as well as the scenarios and the assumptions made.”*

EIS Section 13.5 (p. 13-20) states:

*“Such variability is likely to be further amplified by climate change, where sea level rise is anticipated to cause a reduction in the intertidal mudflat area and an increase in marsh erosion in the foreseeable future.”*

However, the EIS fails to capture these potential effects, as EIS Section 13.5 (p. 13-20) states:

*“As such, in the absence of concrete predictions around changes in physical processes, for the purposes of this assessment, expected conditions are assumed to be the same as existing conditions”*

Sea level rise is predicted to result in decreases to freshwater and salt intertidal marsh and a decrease in the total area of tidal marshes (Craft et al. 2009). As the ecosystem model fails to incorporate sea-level rise, it fails to accurately characterize future conditions with the project. As tidal marshes are an extremely productive component of the Roberts Bank ecosystem, sea-level rise has the potential to result in adverse effect on the productivity of Roberts Bank. This has the potential to interact with the Project to decrease juvenile chinook productivity.

Overall there are many sources of uncertainty and significant assumptions in the ecosystem model which limit its ability to adequately predict the effects of the project on juvenile Chinook salmon. Due to these significant uncertainties it is my conclusion that the results of the ecosystem model should not be used as a line of evidence when evaluating the potential adverse effects of the project on juvenile Chinook salmon.

c) Lack of quantitative analysis of potential impacts of migration disruption, lighting and noise.

The EIS states that the effects of the project on juvenile Chinook will be minor; however, there is little quantitative evidence to support this conclusion. The balance of this conclusion appears to be based on the ecosystem productivity model and a qualitative assessment of other effects of the Project on juvenile Chinook, yet no explanation is provided regarding how these differing and opposing lines of evidence were weighed and incorporated into the final decision. It appears that in the absence of information, the effects of construction, acoustic disturbance, lighting and migration disruption are all assumed by the applicant to be minor. This is despite the fact that they were previously assumed to have an effect. Without quantitative evidence to analyze the potential effects there can be little confidence in the prediction that any effects will be minor.

#### Migration Disruption

The causeway and the terminal have the potential to impact juvenile Chinook migration, orientation and behaviour; however the magnitude of these effects is a question that has remained unresolved since the construction of the original terminal.

EIS Section 13.6.3.1 (p. 13-102) states:

*“terminal placement (expected to disrupt juvenile migration, especially given remaining uncertainties around juvenile salmon movement patterns and residency times in the LAA)”.*

The EIS Section 13.6.3.6 Summary of Marine Fish Productivity Changes Table 13-12 again states:

*“Long-term minor decreases [in juvenile Chinook productivity] during operation due to change in lighting and migration disruption...”* yet no information is provided on why these effects were concluded to be minor.

Small juvenile Chinook may avoid moving around the terminal, as this would push them into deeper more saline waters, potentially exposing them to a higher risk of predation. The proponent has failed to perform the necessary field studies to support the conclusion that the effects on migration will be minor. It is scientifically indefensible to conclude that juvenile Chinook will not be adversely affected when it is unknown how they rely on habitat that has the potential to be impacted. This conclusion cannot be supported.

EIS section 13.8.1 (p. 13-141) states:

*“quantification of this [disruption to juvenile salmon migration] effect is not available...”* with the footnote *“The Project would need to be in place in order to conduct studies evaluating potential changes in juvenile salmon migration”*.

However, a study of the existing effects from previous expansions could and should be undertaken. This issue has consistently been raised by panels that reviewed the previous expansions, and yet it still has failed to be quantified. In the Final Report of the Environmental Assessment Panel – Roberts Bank Expansion Project 1977 (80 pp.) states:

*“(10) The existing Roberts Bank Port and ferry terminal causeways **could represent a significant interruptive effect on the orientation of juvenile salmonids in their utilization of the intercauseway area, and this question warrants investigation.**”*

Furthermore, the RBT2 Juvenile Salmon Surveys (p. 39) found that:

*“juvenile Chinook salmon abundance was lower at locations in the Inter-causeway Area relative to other locations at Roberts Bank”*.

It seems very probable that the effect of the existing causeway and terminal is to inhibit or alter juvenile Chinook movement at and around Roberts Bank. This represents a significant concern regarding potential effects to juvenile Chinook salmon. Despite this recommendation of the review panel nearly 40 years ago, the Port has not followed up with any research to answer this question. The overall size and orientation of the proposed expansion would further the movement barrier that was created by the initial causeway construction and no information exists on how this will impact juvenile Chinook and other salmon. Without further research into how the significantly increased barrier to movement affects juvenile salmon use of Roberts Bank, it is hard to understand how the EIS can conclude that there will not be significant adverse residual effects to juvenile Chinook.

It is presumable that before the construction of the original causeway, juvenile salmon navigated along the marsh and eelgrass nearshore areas of Roberts Bank, and experienced a gradient of

salinity as they moved further out into the estuary. However, with the current footprint of Deltaport, juvenile Chinook must move from the brackish eelgrass habitats on the north side of the causeway into deeper saline waters if they hope to move into the intercauseway habitat. Expanding the footprint would only further this issue. While the intercauseway area may be a productive ecological zone, the proponent has not provided any evidence that juvenile Chinook will move into this area. What is the potential increase in predation associated with having to move through these deeper and illuminated waters? What incentive do juvenile Chinook have to move south around the Port to reach the intercauseway eelgrass? What is the incentive for juvenile Chinook to move into deeper waters if they are still in an estuary rearing phase? These questions need be resolved before further impacts to juvenile Chinook migration and behaviour can be properly assessed.

VFPA states *“Although a review of the literature yielded no evidence to suggest a causal link between causeway/terminal construction and fitness or predation consequences for juvenile salmon, because of the paucity of data on juvenile salmon movement patterns and residency in the LAA, the assessment conservatively concluded that migration disruption produced a minor adverse effect on productivity pre-mitigation.”*

In their response to IR05-18 VFPA provides some information on juvenile Chinook movement patterns however they fail to provide any new specific reasoning for assessing the impacts on migration pathways as minor, and again discuss the lack of prior information which would be necessary to create an informed examination.

It appears that their conclusion is based solely on the assumption that there is some negative impact of terminal placement, yet they provide little evidence of how they concluded this effect to be minor.

They state *“Based on this assumption, terminal placement may encumber migration by increasing linear distance travelled and time spent in deeper waters, thereby increasing exposure and susceptibility to predators (e.g., Nightingale and Simenstad 2001, Ono et al. 2010)”*

Here they fail to discuss how changes in salinity experienced by juvenile salmon as a result of terminal placement may also lead to cumulative effects, as juvenile Chinook are forced to migrate from brackish waters through highly saline waters to go around the terminal, potentially with negative physiological consequences. This could further increase their vulnerability to predation or cause salinity stress, yet the magnitude of this effect is unknown and has not been discussed.

### Light and Noise

The EIS lacks of a full evaluation of the potential effects of Project related noise and lighting on juvenile Chinook salmon behaviour. Underwater noise has the potential to effect juvenile Chinook salmon use of the Roberts Bank ecosystem by causing behavioural changes including avoidance behaviour. Changes to light and shading have the potential to increase susceptibility to predation and lower foraging success. Together these effects have the potential to adversely affect juvenile salmon productivity, and no information has been provided which would allow an accurate quantification of the magnitude of these effects.

While little research has been conducted on juvenile salmon sound sensitivity, Pacific herring have been shown to avoid noise produced by vessels (Schwarz and Greer 1984). A recent review by Robertis and Handegard (2012) looked at a number of reasons that vessels may elicit a behavioural response in fish and concluded:

*“simple models of behaviour, for example those based on sound pressure level alone, cannot explain the observations of fish avoidance”.*

However the EIS relies on a simple sound threshold which may not accurately predict juvenile Chinook avoidance behaviour and is not based on peer reviewed literature.

The conclusion that noise associated with shipping will not have an effect on juvenile Chinook is based on the threshold:

*“sound levels generated by ship movements are not predicted to reach the behavioural threshold for salmon (i.e., 90 dBht) (Nedwell et al. 2007)” (EIS Section 13.6.1.2 Changes in the Acoustic Environment p. 13-75).*

Nedwell et al. (2007) states:

*“On this basis, a method which is relatively simple to calculate and apply is proposed for estimating areas around a pile driving operation within which the two key auditory effects of noise will occur”.*

This method may be summarised as:

*“Provided animals are free to flee the noise, those within the area bounded by the 90 dBht level contour will strongly avoid the noise.”*

This standard which the proponent has chosen to use is inappropriate as it is based on a consultant’s report which looked at the effect of pile driving noise (associated with the construction of wind farms) which creates very different types of noise than container ship operations. Pile driving creates short duration high intensity sounds as opposed to long duration low frequency noises produced by ships, which occur in the audible range for salmon (Schwarz and Greer 1984). The other significant problem with this standard is it provides no information on the minimum level of noise at which effects begin to occur, but instead is the level at which all individuals exhibit a strong response. Further justification for the use of this standard should be provided, and if possible it should be replaced.



Interestingly, Perry et al. (2012) investigated the use of a noise and light barrier to prevent juvenile Chinook salmon in the Sacramento River from entering a slough where survival was thought to be poor. They found that up to 40% of juvenile Chinook altered their behaviour to avoid the artificial barrier that they had created, depending on influence by the environment (Perry et al. 2012). Although the noise and light barrier they used certainly differs from that produced by the project this study clearly demonstrates that there is the potential for juvenile Chinook to alter their behaviour in the presence of noise and light. In recent studies of other fish species, the impacts of noise on behaviour and predation risk has been well documented. Studies on coral reef fish have documented increased risk of predation in the presence of boat noise (Simpson et al. 2016) and shown that noise reduces their ability to learn to avoid predators (Ferrari et al. 2018). A study of two species of goby found that in the presence of noise they had reduced spawning success (de Jong et al. 2018) and a study of bass found that in the presence of boat noise they exhibited reduced parental care leading to reduced fitness (Maxwell et al. 2018). Overall, there is an emerging body of research in the past few years which is beginning to document a much greater impact of noise on fish behaviour than previously anticipated.

The role of artificial lights in facilitating excessive predation by seals on juvenile salmon has been documented in BC (Yurk and Trites 2000). Lighting and shading have the potential to negatively affect juvenile Chinook, but again the magnitude of this effect has not and cannot be quantified. EIS Section 13.6.3.1 (p. 13-97)

*“Changes in the light environment have the potential to influence Pacific salmon productivity in the LAA; however, since it was not possible to incorporate this mechanism into the ecosystem model, it is addressed qualitatively. Low light conditions, such as those brought about by structural shading, are not optimal for juvenile salmon, which depend upon light for prey capture and schooling (Nightingale and Simenstad 2001a). Increased predation on juvenile salmonids in low light (i.e., dawn or dusk) has been documented (Ginetz and Larkin 1976), and may be caused by a period of partial night blindness, since the process of dark adaptation takes as long as 50 minutes (Ali 1959), or by a loss of schooling ability (Ono et al. 2010).”*

Again, an effect on juvenile Chinook is predicted, and as there is no quantitative evidence provided on the potential magnitude of this affect, yet it is assumed in the EIS to be minor. Overall, little information is presented to support the conclusion that project related noise and light will not have an effect on juvenile Chinook, and more information should be provided and the uncertainty should be more directly acknowledged.

d) Demonstrated ongoing lack of success in past habitat compensation activities.

Habitat compensation has long been a tool used by proponents in the Lower Fraser and estuary to offset for habitat losses associated with development projects according to the no net less

principal. However, while proponents are typically required by law to construct these offsetting habitats, there has been very limited requirements for follow up monitoring to determine the effectiveness of these efforts. Recently, a review conducted by Lievesley et al. (2017) surveyed compensation sites throughout the Lower Fraser which had been constructed between 1983 and 2010. They assessed sites based on both the area of habitat established and the proportion of native species relative to nearby reference sites and found that only 65% of sites achieved their intended area, and only 50% of sites were scored “good” for the proportion of native species established. Overall, they found that combining these two metrics only one third of past compensation sites achieved their intended function, and importantly they found that time since construction did not have a significant influence on the proportion of native species demonstrating a lack of improvement in the ability of proponents to build successful projects over three decades (Lievesley et al. 2017).

As the Port plans to offset habitat losses with tidal marsh creation, a detailed evaluation of the effectiveness of past compensation works should be presented. In their response to IR7-28 Marine Fish – Mitigation, Habitat Compensation the VFPA uses two examples of past compensation projects to demonstrate their ability to successfully complete compensation works. Both of the projects are admittedly failures as initially designed, with follow up work conducted to improve function.

Project 1 - BC Ferries - Following failed plantings in 1993 the ecosystem was eventually established and following sampling in 2015 was deemed to have naturally reached acceptable functional levels and no remedial action was taken.

*Over time the constructed marsh had established successfully and transitioned (influenced by local patterns of inundation and oxygen availability) to closely resemble and function like salt marsh formed naturally nearby at the base of the BC Ferries causeway (Envirowest Consultants Inc. 2015)*

The productivity and functionality of the project over the intervening 22 years is not discussed, and was likely less than predicted. As this is a compensation works, the impact on net productivity during the period of time prior to successful establishment is important.

Project 2 – Inter-causeway South Marsh – This project represents the most recent and nearby compensation works the VFPA has constructed and included fish sampling over multiple years. Despite this being a recent project, which could build on decades of past experience, the project has mostly been a failure to date.

*In 2010, as part of the east causeway habitat compensation for DP3, the VFPA constructed four lagoon marshes (behind barrier islands) and five open marsh benches along the south shoreline of the Roberts Bank causeway (see Figure IR7-28-1) to satisfy the requirements of the project’s*



*DFO Fisheries Act Authorization (these compensation works are referenced in the context to this information request).*

*Establishment of marsh vegetation was poor in three of four lagoon marshes and in two of five open marsh benches; pickleweed was most frequently recorded (Archipelago and Williams 2016). Overall, constructed lagoon marshes and open marsh benches were determined to not function as intended (Archipelago and Williams 2016).*

Not surprisingly this also failed in terms of increasing juvenile salmon abundance, and VFPA states: *“Juvenile chum and Chinook salmon were caught during each year of postconstruction sampling (i.e., 2011, 2012, 2015) in every constructed habitat type (i.e., open marsh bench, sand/silt, gravel/sand), and fish presence was similar to references sites (Archipelago and Williams 2016). Based on these results, Archipelago and Williams (2016) “concluded that, as juvenile chum and Chinook salmon have consistently been present in the inter-causeway area since the late 1970s, the DP3 habitat compensation area continues to provide habitat for outmigrating juvenile salmon”*

Based on these results, Archipelago and Williams (2016) found no significant increase in juvenile salmon use of the restored areas post construction, demonstrating the ineffectiveness of their approach.

Following six growing seasons of failure, further remediation and planting was conducted:

*“Three months after planting in May 2017, the VFPA conducted a salt marsh assessment, which revealed that vegetation establishment was generally good. Plug survival exceeded 80% at five out of eight remedial locations, while at the remaining three locations, plug survival ranged from 50% to 70% (Golder Associates 2018).”*

*“Effectiveness of remedial habitat creation cannot be determined yet as long-term effectiveness monitoring is scheduled to begin in September 2018.”*

Thus, following seven years of underwhelming performance by their largest compensation to date, the VFPA has still yet to provide evidence that they are able to successfully complete compensation projects which meet their desired goals. This is critically important considering the currently declining status of Fraser Chinook populations, reduced productivity for any given period of time such as the 7 years which have elapsed here could lead to impacts on vulnerable populations.

Furthermore, lessons learned from these projects may not be informative for RBT2 compensation projects, as VFPA states in their response:

*“The south side of the Roberts Bank causeway is primarily exposed to southerly and southeasterly winds in winter that generate the largest offshore waves; in contrast, extreme wind and wave conditions on the north side of the Roberts Bank causeway, where intertidal marsh creation is proposed for RBT2, are less intense and much less frequent (see EIS Appendix 9.5-A).*

*These projects demonstrate the VFPA’s technical capability to undertake large-scale translocation projects as well as commitment to long-term monitoring that allows for adaptive management and early remedial action if required to ensure transplant success.*

In my opinion the Deltaport Third berth projects clearly demonstrate the limited success with which VFPAs habitat compensation projects have reached. Considering there is a significant difference between these habitats it seems likely that new challenges which will arise which will continue to limit the effectiveness of there habitat creation efforts.

In terms of compensating for time lags associated with habitat compensation VFPA states in their response to IR7-27:

*“As a fundamental principle used in the development of the final Offsetting Plan during permitting, the VFPA will make all reasonable efforts to avoid and minimise time tags between the potential impacts and the functioning of the offsetting measures. The quantification of any remaining losses of fisheries productivity will be performed as an inherent component of the Offsetting Plan with provision for offsetting these losses.”*

Considering the current importance of juvenile Chinook salmon as prey items later in life for the SRKW, lost productivity in one out-migration cohort can unlikely be compensated for by increased productivity in future years due to further compensation actions.

### 2.3. Potential for the Project to exacerbate existing problems in the estuary and result in any cumulative adverse effects on salmon or salmon habitat.

The project will further exacerbate existing problems in the estuary and will result in additional cumulative adverse effects to an ecosystem which already faces a high degree of cumulative effects on salmon habitat. The project combined with the existing Deltaport causeway and terminal will further reduce ecosystem connectivity in the estuary and further disrupt juvenile salmon migration pathways. Migration pathways for juvenile salmon are already highly altered by multiple structures including the current Deltaport causeway and terminal and BC Ferries causeway at Roberts Bank, as well as the Steveston North Jetty, Iona Jetty, North Arm Jetty and Iona Causeway on Sturgeon Bank and Sea Island.

As the project is likely to result in adverse effects on juvenile Chinook, an assessment of cumulative effects should be conducted. Even though the EIS fails to accurately describe

existing conditions experienced by juvenile Chinook in the assessment area, and fails to conduct a cumulative effects assessment, the EIS assumes the potential effects on juvenile Chinook to be negligible after mitigation. However, the EIS guidelines Section 12.1.1 Residual Environmental Effects (p. 31) states that:

*“The residual effects, even if very small or deemed insignificant, will be described.”*

Without an adequate assessment of project or cumulative effects, the effect of the project nor the potential effectiveness of mitigation cannot be quantified and are thus functionally unknown. The lack of a cumulative effect’s assessment fails to provide the panel with sufficient information to properly evaluate the potential project effects in the context of the many other activities which adversely affect juvenile Chinook in the assessment area.

The proponent was directed to address cumulative effects on juvenile Chinook in the Regional Assessment Area, which is outlined as Hope to the estuary, with attention to be paid to the Cohen Commission Final Report (EIS Guidelines 12.2.1 Cumulative Effects Assessment p. 32). EISG 12.2.1 Cumulative Effects Assessment states that:

- i) *This narrative discussion should include historical data, where available and applicable, to assist interested parties to understand the potential effects of the project and how they may be addressed.*
- ii) *The EIS will describe the analysis of the total cumulative effect on a VC over the life of the project, including the incremental contribution of all current and proposed physical activities, in addition to that of the project. The EIS will include different forms of effects (e.g. synergistic, additive, induced, spatial or temporal) and identify impact pathways and trends.*

Despite this, the proponent has failed to describe previous cumulative effects on salmon and their habitats in the Lower Fraser. Cumulative effects to the Lower Fraser and estuary include, but are not limited to, the loss/alienation of at least 70% of floodplain and 70% of estuarine habitats which are now diked or armoured and converted to human uses, an array of pollutants discharged from sewage treatment plants and industrial activities, drastic recession of marsh across Sturgeon Bank, and trifurcation schemes with numerous jetties in the estuary, including the existing Roberts Bank Terminal causeway, which have altered the flow of water and sediment in the estuary, changing salinity gradients and the ability of juvenile salmon and other fishes to move throughout the estuary. These are only some of the cumulative changes to the Regional Assessment Area which the proponent failed to adequately represent. A full evaluation should be requested for the panel to be able to accurately understand the potential for significant cumulative effects on juvenile Chinook in the RAA.

#### 2.4. Options for avoiding or mitigating the direct or cumulative effects of the Project on salmon or salmon habitat and the viability and the effectiveness of those options.

The options for avoiding the direct effect of the project on juvenile salmon and their habitats is limited due to the nature of the impacts. In my opinion the creation of habitat offsetting projects in other areas of the estuary, regardless of their success, will not directly compensate for the increased migration disruption at Roberts Bank. As previously discussed, the proponent has a dismal track record regarding the successful establishment of these compensation projects. Therefore, in my opinion the proposed mitigation works are limited both in their viability and effectiveness for compensating for direct and cumulative effects of the project on juvenile Chinook.

Viable options for avoiding the direct impact of migration disruption are limited but would involve allowing for the passage of juvenile salmon without the interruption created by the additional footprint of Terminal 2 and would ideally also compensate for the ongoing interruption created by the existing causeway and terminal. Passage for juvenile salmon could be allowed by creating openings in the causeway through the installation of a series of culverts or bridges to allow the movement of water and fish. In 2005, Northwest Hydraulic Consultants prepared a report analyzing the effectiveness of creating a 1m or 4m culvert opening in the causeway and found that they would have limited success (CEA Agency Registry Document #539). The choice to model such a small opening is perplexing as they undoubtedly would have little impact on a causeway which is over 3.5 km in length. Currently Fisheries and Oceans Canada has been working with Raincoast Conservation Foundation to address the presence of other barriers to juvenile salmon movement in the Fraser estuary through the Coastal Restoration Fund. Early in March 2019 three 50-meter-wide breaches were created in the Steveston North Jetty to allow for the passage of juvenile salmon following hydraulic modelling work which had demonstrated its potential effectiveness. In future years, projects being pursued include a breach of the McDonald Slough causeway with a minimum channel width of 9 meters for a causeway less than 1 km in length, and a 75-meter-wide breach of the North Arm jetty. These are the scale of breaches which should be investigated and which would have the potential to mitigate for the ongoing and cumulative impacts of the Deltaport causeway and terminal on juvenile chinook movement at Roberts Bank. The current investment by Fisheries and Oceans Canada in addressing barriers to juvenile salmon passage in the Fraser estuary demonstrates the importance of this issues and in the shared concern for the impacts of barriers such as these to juvenile salmon movement. Therefore, in my opinion the only viable option for mitigating these impacts is clearly the creation of significant breaches in the existing and expanded causeway.

### **3. Relationship with a party to this Hearing that might affect my duty to be objective and impartial.**

3.1. Relationship with the Proponent, or with any federal government department participating in the Hearing, such as Fisheries and Oceans Canada prior to agreeing to give an expert report in this regulatory proceeding.

Prior to agreeing to give an expert report in this proceeding I had no relationship with the proponent or Fisheries and Oceans Canada. However in the time since the review began I have developed a positive working relationship with the Proponent's Habitat Enhancement Program team in relation to Raincoast's own restoration activities in the Fraser estuary. I have also developed a collaborative working relationship with Fisheries and Oceans Canada through our Coastal Restoration Fund project.

3.2. Relationship with the Organization, or with David Suzuki Foundation, Wilderness Committee, or Georgia Strait Alliance prior to agreeing to give an expert report in this regulatory proceeding.

Prior to agreeing to give an expert report in this proceeding I had previously been retained on contract by the Raincoast Conservation Foundation to provide written evidence for the National Energy Board joint review of the Trans Mountain Expansion project with a focus on potential risk to juvenile salmon in the Lower Fraser River and estuary. In 2016, as a contract employee with Raincoast, I lead the beginning of a juvenile salmon research project in the Fraser estuary which is now in its fourth consecutive season. I continued to work with Raincoast on a full-time basis from 2016 until fall 2018 when I began my doctoral program in the Faculty of Forestry at the University of British Columbia. I continue to work with Raincoast on a part time basis helping to coordinate our Fraser estuary restoration project under the Fisheries and Oceans Canada Coastal Restoration Fund. My relationship with Raincoast in no way affects my ability to be impartial and objective in my review of the available scientific information in my opinion.

### **References**

Archipelago Marine Research Ltd. 2014. Technical Data Report, Roberts Bank Terminal 2 Project, Marine Fish, Juvenile Salmon Surveys. Prepared for: Hemmera. November 2014.

Carr-Harris, C., Gottesfeld, A. S., Moore, J. W. 2015. Juvenile salmon usage of the Skeena River estuary. PLoS One 10:e0118988

Craft, C., Clough, J., Ehman, J., Joye, S., Park, R., Pennings, S., ... and Machmuller, M. 2009. Forecasting the effects of accelerated sea-level rise on tidal marsh ecosystem services. *Frontiers in Ecology and the Environment*, 7(2): 73-78.

CTC (Chinook Technical Committee). 2017. Annual report of catch and escapement for 2017 Pacific Salmon Commission, Report TCCHINOOK (16)–3. Vancouver, BC.

De Robertis, A., and Handegard, N. O. 2012. Fish avoidance of research vessels and the efficacy of noise-reduced vessels: a review. *ICES Journal of Marine Science: Journal du Conseil*, p. fss155.

Department of Fisheries and Oceans. 1995. Fraser River chinook salmon Prep. By Fraser River Action Plan, Fishery Management Group. Vancouver, B.C. 24 p.

Department of Fisheries and Oceans. 1996. Fraser River coho salmon Prep. By Fraser River Action Plan, Fishery Management Group. Vancouver, B.C. 20 p.

Department of Fisheries and Oceans. 1999. Fraser River Chinook Salmon. DFO Science Stock Status Report D6-11 (1999).

Department of Fisheries and Oceans. 2013. Review and update of southern BC Chinook conservation unit assignments. DFO Can. Sci. Advis. Sec. Sci. Resp. 2013/022.

DFO. 2016. Integrated Biological Status of Southern British Columbia Chinook Salmon (*Oncorhynchus tshawytscha*) Under the Wild Salmon Policy. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/042.

Elliott, M. and Taylor, C. J. L. 1989. The production ecology of the subtidal benthos of the Forth Estuary, Scotland. *Scientia Marina* 53(2-3): 531-541.

Ferrari, M. C., McCormick, M. I., Meekan, M. G., Simpson, S. D., Nedelec, S. L., and Chivers, D. P. 2018. School is out on noisy reefs: the effect of boat noise on predator learning and survival of juvenile coral reef fishes. *Proceedings of the Royal Society B: Biological Sciences*, 285(1871), 20180033.

Fraser Basin Council. 2010. The Fraser: a Canadian heritage river. Prepared by The Fraser Basin Council with the British Columbia Ministry of Environment, Victoria, British Columbia, Canada. 84 pp.

FRAP (Fraser River Action Plan) 1999. Lower Fraser Valley streams strategic review. Lower Fraser Valley Stream Review 1. Habitat Enhancement Branch, Fisheries and Oceans Canada, Ottawa, ON.

Harrison, P. J., Yin, K., Ross, L., Arvai, J., Gordon, K., Bendell-Young, L., Thomas, C., Elner, R., Sewell, M., and Shepherd, P. 1999. The delta foreshore ecosystem: past and present status of geochemistry, benthic community production and shorebird utilization after sewage diversion. Chapter 3.10 in *Health of the Fraser River Aquatic Ecosystem, Volume 1: A Synthesis of Research Conducted Under the Fraser River Action Plan*. Gray, C. and Tuominen, T, eds. DOE-FRAP 1998. Environment Canada, Vancouver, BC.



Healey, M. C. and Richardson, J. S. 1996. Changes in the productivity base and fish populations of the lower Fraser River (Canada) associated with historical changes in human occupation. *Large Rivers* 10(1-4): 279-290.

Hoos, L.M. and Packman, G.A. 1974. The Fraser River estuary: status of environmental knowledge to 1974. Special Estuary Series No. 1. Estuary Working Group, Environment Canada, Vancouver: 518 p.

Holtby, L.B. and Ciruna, K.A. 2007. Conservation units for Pacific Salmon under the Wild Salmon Policy. *Can. Sci. Advis. Sec. Res. Doc.* 2007/070. viii + 350 pp.

Johnson, R., and Bustin, R. M. 2006. Coal dust dispersal around a marine coal terminal (1977–1999), British Columbia: The fate of coal dust in the marine environment. *International Journal of Coal Geology*, 68(1): 57-69.

de Jong, K., Amorim, M. C. P., Fonseca, P. J., Fox, C. J., & Heubel, K. U. 2018. Noise can affect acoustic communication and subsequent spawning success in fish. *Environmental Pollution*, 237, 814-823.

Junk, W. J., Bayley, P. B., and Sparks, R. E. 1989. The flood pulse concept in river-floodplain systems, In *Proceedings of the International Large River Symposium*. Canadian Special Publication of Fisheries and Aquatic Sciences 106. p. I10-I27.

Levings, C. D., Boyle, D. E., and Whitehouse, T. R. 1995. Distribution and feeding of juvenile Pacific salmon in freshwater tidal creeks of the lower Fraser River, British Columbia. *Fisheries Management and Ecology* 2(4): 299-308.

Levings, C.D. 2004. Knowledge of fish ecology and its application to habitat management. In: *Fraser River Delta, British Columbia: Issues of an Urban Estuary*, (ed.) B.J. Groulx, D. C. Mosher, J.L. Luternauer, and D.E. Bilderback. Geological Survey of Canada, Bulletin 567, p. 213-236.

Levy, D. A., and Northcote, T. G. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. *Can. J. Fish. Aquat. Sci.* 39(2): 270-276.

Lievesley, M., Stewart, D., Mason, B., & Knight, R. (2017). *Marsh and Riparian Habitat Compensation in the Fraser River Estuary: A Guide for Managers and Practitioners*. 42pp + vii

Martel, G. 2009. T2 Environmental Baseline Monitoring Report, Section 7: Fish Communities. Prepared for Vancouver Port Authority, Vancouver, B.C.

Maxwell, R. J., Zolderdo, A. J., de Bruijn, R., Brownscombe, J. W., Staaterman, E., Gallagher, A. J., and Cooke, S. J. 2018. Does motor noise from recreational boats alter parental care behaviour of a nesting freshwater fish?. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 28(4), 969-978.

- McLean, D. G., Church, M., and Tassone, B. 1999. Sediment transport along lower Fraser River: 1. Measurements and hydraulic computations. *Water Resources Research* 35(8): 2533-2548.
- McNatt, R. A., Bottom, D. L., & Hinton, S. A. 2016. Residency and movement of juvenile Chinook Salmon at multiple spatial scales in a tidal marsh of the Columbia River estuary. *Transactions of the American Fisheries Society*, 145(4), 774-785.
- Metro Vancouver 2013. Wastewater: The Greater Vancouver Sewerage & Drainage District Environmental Management and Quality Control Annual Report. ISSN 1496-9602
- Morrison, J., Quick, M. C., and Foreman, M. G. 2002. Climate change in the Fraser River watershed: flow and temperature projections. *Journal of Hydrology*, 263(1): 230-244.
- Milliman, J. D. 1980. Sedimentation in the Fraser River and its estuary, southwestern British Columbia (Canada). *Estuarine and Coastal Marine Science* 10(6): 609-633.
- Moore, J. W., Gordon, J., Carr-Harris, C., Gottesfeld, A. S., Wilson S. M., Russell J. H. 2016. Assessing estuaries as stopover habitats for juvenile Pacific salmon. *Mar Ecol Prog Ser* 559:201–215
- Nedwell, J. R., Parvin, S. J., Edwards, B., Workman, R., Brooker, A. G., and Kynoch, J. E. 2007. Measurement and Interpretation of Underwater Noise during Construction and Operation of Offshore Windfarms in U.K. Waters. Subacoustic Report 544R0738, Prepared for COWRIE Ltd.
- NHC (Northwest Hydraulic Consultants). 2008. Comprehensive review of Fraser River at Hope: Flood hydrology and flows—scoping study. British Columbia Ministry of Environment, Victoria, British Columbia, Canada.
- Northcote, T. G. and Atagi, D.Y. 1997. Pacific salmon abundance trends in the Fraser River watershed compared with other British Columbia systems. In: Stouder DJ, Bisson PA, Naiman RJ (eds) *Pacific Salmon & Their Ecosystems*. Springer US, Boston, MA, p 199–219.
- Parken, C. K., Candy, J. R., Irvine, J. R., and Beacham, T. D. (2008). Genetic and coded wire tag results combine to allow more-precise management of a complex Chinook salmon aggregate. *North American Journal of Fisheries Management*, 28(1), 328-340.
- Perry, R. W., Romine, J. G., Adams, N. S., Blake, A. R., Burau, J. R., Johnston, S. V., and Liedtke, T. L. 2014. Using a non-physical behavioural barrier to alter migration routing of juvenile chinook salmon in the Sacramento–San Joaquin river delta. *River Research and Applications*, 30(2), 192-203.
- PIBC (Precision Identification Biological Consultants). 1997. Lower Fraser Valley Stream Review (Vol. 3): Wild, Threatened, Endangered and Lost Streams of the Lower Fraser Valley.



Prepared for Fraser River Action Plan. Available from <http://www.dfo-mpo.gc.ca/library/229864.pdf>

Richardson, J. S., Lissimore, T. J., Healey, M. C. and Northcote, T. G. 2000. Fish communities of the lower Fraser River (Canada) and a 21-year contrast. *Environmental Biology of Fishes*, 59(2): 125-140.

Schwarz, A. L. and Greer, G. L. 1984. Responses of Pacific herring (*Clupea harengus pallasii*) to some underwater sounds. *Can. J. Fish. Aquat. Sci.* 41(8): 1183-1192.

Scott, D. C., Arbeider, M., Gordon, J., and Moore, J. W. 2016. Flood control structures in tidal creeks associated with reduction in nursery potential for native fishes and creation of hotspots for invasive species. *Canadian Journal of Fisheries and Aquatic Sciences*, 73(999): 1-11.

Shaepe, D. M. 2001a. The land and the people: glaciation to contact. In K. T. Carlson (Ed.), *A Stó:lō-Coast Salish historical atlas*. Vancouver and Chilliwack: Douglas and McIntyre and the Stó:lō Nation.

Simpson, S. D., Radford, A. N., Nedelec, S. L., Ferrari, M. C., Chivers, D. P., McCormick, M. I., and Meekan, M. G. 2016. Anthropogenic noise increases fish mortality by predation. *Nature communications*, 7, 10544.

Slaney, T. L., Hyatt, K. D., Northcote, T. G., and Fielden, R. J. 1996. Status of anadromous salmon and trout in British Columbia and Yukon. *Fisheries* 21(10): 20-35.

Talbot, G. B., and R. I. Jackson. 1950. (I) A biological study of the effectiveness of the Hell's Gate fishways. II. Variations in flow patterns at Hell's Gate and their relationships to the migration of sockeye salmon. *International Pacific Salmon Fisheries Commission Bulletin* 3.

Taylor, E. B. 1991. A review of local adaptation in Salmonidac, with particular reference to Pacific and Atlantic salmon. *Aquaculture* 98(1): 185-207.

Thomson, A.R. 2005. Flood box management in southwestern British Columbia. Consultant's report prepared for Ministry of Water Land and Air Protection, Surrey, BC.

Thuringer, P., H. Anderson, M. Morris, J. Tyler, and G. Williams. 2013a. Deltaport Third Berth Habitat Compensation Monitoring: East Causeway Year 1 Post-Construction Annual Report. Annual Report, Prepared by: Archipelago Marine Research Ltd., and GL Williams and Associated Ltd. Prepared for: Port Metro Vancouver, Vancouver, B.C.

Thuringer, P., J. Tyler, M. Morris, A. Park, S. Roais, and G. Williams. 2013b. Deltaport Third Berth Habitat Compensation Monitoring: East Causeway Year 2 Post-Construction Annual Report. Annual Report, Prepared by Archipelago Marine Research Ltd. and GL Williams and Associated Ltd., Prepared for Port Metro Vancouver, Vancouver, B.C.

Triton Environmental Consultants Ltd. (Triton) 2004. Deltaport Third Berth Project Marine Resources Impact Assessment. Prepared by Triton Environmental Consultants Ltd., Prepared for Vancouver Port Authority, Richmond, B.C.

Volk, E. C., Bottom, D. L., Jones, K. K., and Simenstad, C. A. 2010. Reconstructing juvenile Chinook salmon life history in the Salmon River estuary, Oregon, using otolith microchemistry and microstructure. *Trans Am Fish Soc* 139:535–549

Ward, J., Tockner, K. and Schiemer, F. 1999. Biodiversity of floodplain river ecosystems: ecotones and connectivity. *River Research and Applications* 15: 125 – 139.

Weitkamp, L. A., Goulette, G., Hawkes, J., O'Malley, M., Lipsky, C. 2014. Juvenile salmon in estuaries: Comparisons between North American Atlantic and Pacific salmon populations. *Rev Fish Biol Fish* 24:713–736.

Welch, D. W., Porter, A. D., and Rechisky, E. L. 2018. The coast-wide collapse in marine survival of west coast Chinook and steelhead: slow moving catastrophe or deeper failure?. *BioRxiv*, 476408.

Woodson, L. E., Wells, B. K., Weber, P. K., MacFarlane, R. B., Whitman, G. E., and Johnson, R. C. 2013. Size, growth, and origin-dependent mortality of juvenile Chinook salmon *Oncorhynchus tshawytscha* during early ocean residence. *Marine Ecology Progress Series*, 487, 163-175.

Yurk, H. and A. Trites. 2000. Experimental attempts to reduce predation by harbor seals on out-migrating juvenile salmonids. *Trans. Am. Fish. Soc.* 129:1360–1366.

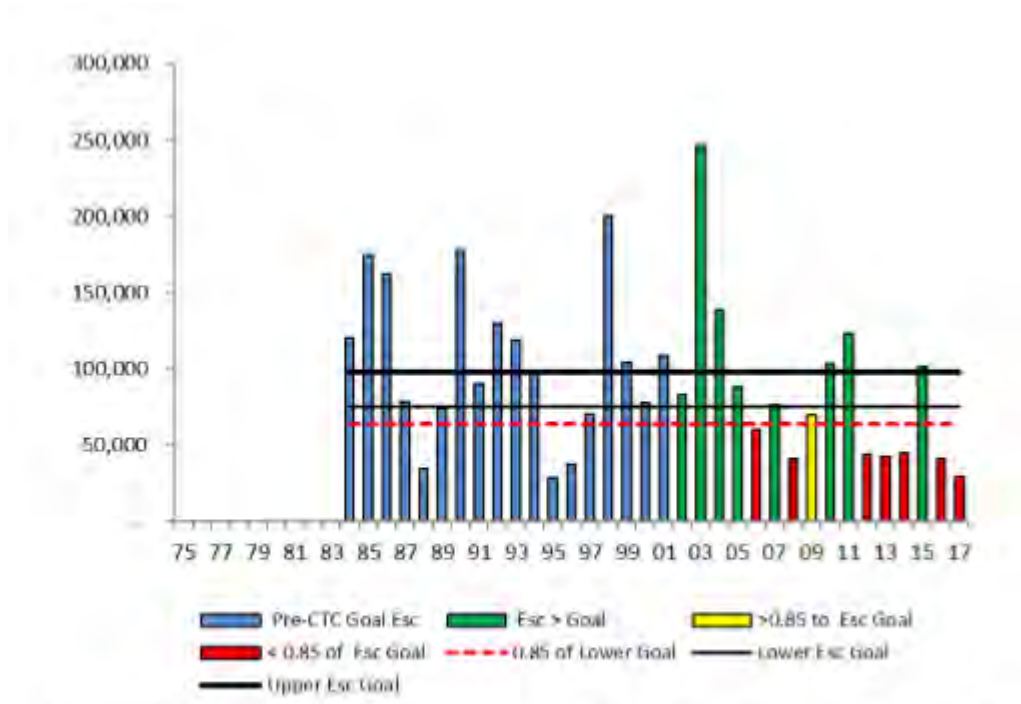


Figure 2.33.—Harrison River escapements of Chinook salmon, 1984–2017.

Figure 1. Harrison River escapements of Chinook salmon, 1984-2017, taken from the 2017 Pacific Salmon Commission Chinook Technical Committee report.

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## Academic Background

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### Doctor of Philosophy in Forestry

Sept 2018 - present

- Current student in the Pacific Salmon Ecology and Conservation Lab under Dr. Scott Hinch studying juvenile Chinook use of the Fraser estuary including outmigration timing, habitat preferences, physiological adaptation to saline water, and evaluating restoration effectiveness.

### Masters of Resource Management: Simon Fraser University, Burnaby, BC

Sept 2012 – Dec 2014

- Master's Research Project – Supervisor Dr. Jonathan W. Moore: *Flood mitigation structures transform tidal creeks from nurseries for native fish to non-native hotspots.* **GPA 3.97/4.33**

### Bachelor of Science Honours: University of Regina, Regina, SK

Sept 2006 – Oct 2010

- Honours Thesis – Supervisor Dr. Bjoern Wissel: *Quantifying Productivity and Respiration in a Urea Fertilization Experiment using O<sub>2</sub> and CO<sub>2</sub> Stable Isotopes.* **GPA 82.68/100**

## Publications

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Warkentin, L., Favaro, C., **Scott, D.**, Seifert, R., and Moore, J. W. 2018. Urban planning for fishes: untangling a new project's effects from old infrastructure and regional patterns. *Canadian Journal of Fisheries and Aquatic Sciences*, 999: 1-12.

**Scott, D. C.**, Harris, S. L., Hebert, A. S., and van Poorten, B. T. 2017. Nutrient dynamics in a highly managed reservoir system: considering anadromous sockeye salmon (*Oncorhynchus nerka*) and nutrient restoration. *Lake and Reservoir Management*, 33(1): 14-22.

**Scott, D. C.**, Arbeider, M., Gordon, J., and Moore, J. W. 2016. Flood control structures in tidal creeks associated with reduction in nursery potential for native fishes and creation of hotspots for invasive species. *Canadian Journal of Fisheries and Aquatic Sciences*, 73(7): 1138-1148.

Moore, J.W., Beakes, M.P., Nesbitt, H.K., Yeakel, J.D., Patterson, D.A., Thompson, L., Phillis, C.C., Braun, D., Favaro, C., **Scott, D.**, Carr-Harris, C., and Atlas, W. 2015. Emergent stability in a large free-flowing watershed. *Ecology*. 96: 340–347.

Gordon, J., Arbeider, M., **Scott, D.**, Wilson, S., and Moore, J. W. 2015. When the tides don't turn: Floodgates and hypoxic zones in the lower Fraser River, British Columbia, Canada. *Estuaries and Coasts*. 38 (6): 2337-2344

**Scott, D.**, Moore, J., Herborg, L.M., Clarke Murray, C., and Serrao N.R. 2013. A non-native snakehead fish in British Columbia, Canada: Capture, genetics, isotopes, and policy consequences. *Management of Biological Invasions* 4(4): 265-271.

## Work Experience

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Biologist: Raincoast Conservation Foundation

February 2015 – Present

- **Fraser Estuary Juvenile Salmon Research Project:** Raincoast has been conducting a field research program over the past two years in partnership with the Baum Lab from the University of Victoria to investigate juvenile Chinook salmon habitat preferences in the Fraser estuary. I have been responsible for leading or co-leading all aspects of the projects including our successful grant application to the Salish Sea Marine Survival Project in 2016, planning the field project including applying for permits, choosing and purchasing sampling equipment and determining field sites and methods. I have also been directly responsible for leading all data collection including organizing field crew and volunteers and conducting field research activities.

- **CEAA Review Roberts Bank Terminal 2:** Working on behalf of Raincoast, I am assisting Ecojustice in their participation in the CEAA review of this project. Working independently I produced a submission on the completeness of the Marine Shipping Addendum, a submission on the Sufficiency and Technical Merit of the Marine Shipping Addendum, and a submission on the Sufficiency and Technical Merit of the Environment Impact Statement, all as it pertains to potential effects on juvenile Chinook.
- **Lower Fraser River Salmon Habitat Outreach:** Over the past two years Raincoast has been working with conservation groups, First Nations, and other stakeholders towards creating a “Vision for Salmon Habitat” in the Lower Fraser. Working towards this goal I have been reaching out to and meeting with groups and individuals throughout the Lower Fraser Region; groups range from large and small ENGO’s to stream keepers groups to First Nations to local governments and to concerned citizens. I have also drafted a report on the current state of salmon habitat in the Lower Fraser to support this initiative. To date, we have held the first in a series of workshops which I helped organize and facilitate. This successfully brought together members of the Kwantlen and Kwikwetlm First Nations along with other streamkeeper groups and local government representatives to work towards a collective vision.
- **NEB Review Trans Mountain Pipeline Expansion:** I worked with Toxicologist Kate Logan to co-produce a report submitted to the National Energy Board on the potential effects of a Trans Mountain pipeline rupture or tanker spill on salmon in the Lower Fraser River.

Nutrient Restoration Technician: British Columbia Conservation Foundation

Sept – Oct 2014

- **Field Research:** Assisted B.C. Ministry of Environment staff with field work on nutrient restoration projects in Alouette and Wahleach Reservoirs. Duties included conducting stream spawner surveys of kokanee salmon including leading group of BCIT students, setting and retrieving gill nets, and identifying and processing freshwater fish including sexing and removing otoliths of salmonids.
- **Manuscript Preparation:** Lead collaboration with B.C. Ministry of Environment staff to produce a now published manuscript on the effect of their management efforts on nutrient dynamics in Alouette Lake. I lead all aspects of manuscript preparation including analysis, writing, submission and the review process.

## University Research Experience

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**Masters Research: Simon Fraser University, Burnaby, B.C.**

Sept 2012 – Dec 2014

- **Masters Project:** Led field research project – designed and managed research project and crew consisting of two research and volunteer assistants; captured fish at field sites, tidal creeks and sloughs located throughout the lower Fraser Valley; identified freshwater fish species and juvenile salmon. Analysis – gained experience working with R software package to present and analyze data using various techniques. Research – gained experience in compiling primary literature and scientific writing while completing thesis and drafting manuscript for publication.
- **Snakehead Fish Project:** Worked with a team of researchers including a government scientist and geneticist to investigate the occurrence of a non-native snakehead fish discovered in a local pond. My duties including stable isotope analysis, working with Dr. Jon Moore on applying stable isotope tissue turnover model, writing manuscript and incorporating collaborators efforts and reviewers comments into now published manuscript. Worked with SFU Information Officer to draft press release, lead to >10 newspaper articles including Vancouver Sun, and recent CBC TV interview.

**Research Assistant: Simon Fraser University, Burnaby, B.C.**

July 2012 – July 2014

- Lower Mainland Urban Stream Monitoring project: Assisted MSc Candidate Corinna Lichota in 2012 and 2013, and led research project in 2014. Collected physical data on streams and captured fish in small urban streams throughout the Lower Mainland using Backpack Electrofishing technique. Gained experience identifying freshwater fish and conducting stream research.

**Research Assistant: University of Regina, Regina, S.K.**

Mar 2008 – Apr 2010

- Conducted field sampling of lakes throughout southern Saskatchewan under supervision of Dr. Bjoern Wissel. Duties included identification, enumeration and preparation for stable isotope analysis of zooplankton samples, preparation of various other types of samples for water chemistry and stable isotope analysis, and preparation of equipment for field season. Collected water chemistry data and water samples from lakes throughout southern Saskatchewan. Interpreted results from isotope analysis including using model to determine productivity to respiration ratios from dissolved oxygen saturations and isotope values.

### Presentations

- Scott, D.,** Chalifour, L., MacDuffee, M., and Baum, J. 2019. Variation in out-migration timing and estuary reliance of “ocean-type” Chinook salmon in the Fraser River estuary, BC. Pacific Ecology and Evolution Conference. Bamfield, British Columbia, February 2019.
- Chalifour, L., **Scott, D.,** MacDuffee, M., and Baum, J. 2018. Juvenile Chinook salmon (*Oncorhynchus tshawytscha*) residency and early growth in the lower Fraser River estuary. Salish Sea Ecosystem Conference. Vancouver, B.C.
- Scott, D.,** Chalifour, L., MacDuffee, M., and Baum, J. 2018. Characterizing juvenile Chinook salmon outmigration timing, size and population origin in the Fraser River estuary. Salish Sea Ecosystem Conference. Vancouver, B.C.
- Scott, D.** 2016. Flood control structures in tidal creeks associated with reduction in nursery potential for native fishes and creation of hot-spots for invasive species. Salish Sea Ecosystem Conference. Vancouver, B.C.
- Scott, D.** 2014. Impacts of small scale flood proofing barriers on fish communities in tidal creeks. Eco Evo Retreat. Brackendale, B.C., November 2014.
- Hebert, A. S., **Scott, D.,** Harris, S., Weir, T. 2014. A Multi-Step approach To Restoring Anadromy in Alouette Reservoir (British Columbia): Understanding Nutrient Fluxes of Our Management Activities. Joint Aquatic Sciences Meeting. Portland, Oregon, May 2014.
- Scott, D.** 2014. Altering Connectivity in Tidal Creeks: Impacts of flood proofing on fish communities in Lower Fraser streams. Pacific Ecology and Evolution Conference. Bamfield, B.C., March 2014.
- Scott, D.** 2014. Altering Connectivity in Tidal Creeks: Impacts of flood proofing on fish communities in Lower Fraser streams. Inter-Departmental Ecology of Aquatic Systems. Simon Fraser University, Burnaby, British Columbia, January 2014.
- Scott, D.** 2013. Invasive Species CSI: The Case of the Snakehead. Pacific Ecology and Evolution Conference. Bamfield, British Columbia, March 2013.
- Scott, D.** 2013. Snakehead CSI. Inter-Departmental Ecology of Aquatic Systems. Simon Fraser University, Burnaby, British Columbia, January 2013.
- Scott, D.,** Quiñones-Rivera, Z., Bogard, M., Leavitt, P.R., Wissel, B. 2010 Quantifying Productivity and Respiration in a Urea Fertilization Experiment using O<sub>2</sub> and CO<sub>2</sub> Stable Isotopes. Canadian Conference For Fisheries Research. Winnipeg, Manitoba, January 2010.

### Awards

- national Science and Engineering Research Council CGS – D Award, **2018**
- University of British Columbia Graduate Fellowship (Doctorate), **2018**
- Best Talk Award – Ecology and Evolution retreat, Brackendale, B.C. **2014**
- Coastal Zone Canada (BC) Association Graduate Fellowship in Coastal Studies. **2013**
- Simon Fraser University Graduate Fellowship (Masters), **2012**
- University of Regina Academic Silver Scholarship, **2009, 2008**
- University of Regina Wildlife Awareness Prize in Biology, **2009**
- NSERC-Undergraduate Student Research Award, **2009**

### Teaching Experience

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**TA for Marine Invertebrate Zoology: Bamfield Marine Sciences Center, B.C.** Summer 2014

- Coordinated field trips and field gear, operated various boats in marine environments, and assisted students with independent research projects.

**TA for Ecology and Conservation of Coastal BC: SFU, Burnaby, B.C.** Spring 2014

- Led tutorials which included coordinating paper discussions, field outings and marking assignments.

**TA for REM 698: Simon Fraser University, Burnaby, B.C.** Summer 2013 / 2014

- Twice planned and led four-day field trip, around B.C. for 25 new graduate students in the Resource and Environmental Management Program.

**Supplemental Instructor: University of Regina, Regina, S.K.** Fall 2009 – Winter 2010

- Duties included attending class, preparing material for and running three weekly study sessions for students as well as midterm and final review sessions for Biology and Statistics 100 courses.

## Volunteer Experience

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**President – Still Creek Streamkeepers** 2017 – present

- Worked with a local stewardship group to start a streamkeepers group which carries out activities such as spawner surveys, water quality testing, and garbage cleanups, and meets monthly.

**Chair of the PEEC Organizing Committee: Bamfield Marine Sciences Center, B.C.** 2013 / 2014

- Gained experience working with a team to organize the Pacific Evolution and Ecology Conference.

**Lab Assistant: Simon Fraser University, Burnaby, B.C.** Jan. 2012 – Apr. 2012

- Volunteered with Dr. Anne Salomon's Coastal Marine Ecology and Conservation lab preparing various tissue samples for stable isotope analysis.

## Certifications

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- **Backpack Electrofishing Crew Supervisor – Vancouver Island University** July 2012
- **Marine Basic First Aid Certificate** April 2014
- **Boat Operation**
  - o Small Vessel Operator Proficiency – 2014
  - o Restricted Operator Certificate – Marine – DSC – 2014
  - o Med A3 – Small Non-Pleasure Vessel Basic Safety – 2011
  - o Pleasure Craft Operator Card – 2003
- **SCUBA**
  - o PADI Advanced Open Water Diver Certification – 2011



## INTEGRATED BIOLOGICAL STATUS OF SOUTHERN BRITISH COLUMBIA CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) UNDER THE WILD SALMON POLICY



Chinook Salmon adult spawning phase.  
(Photo credit: Fisheries and Oceans  
Canada.)

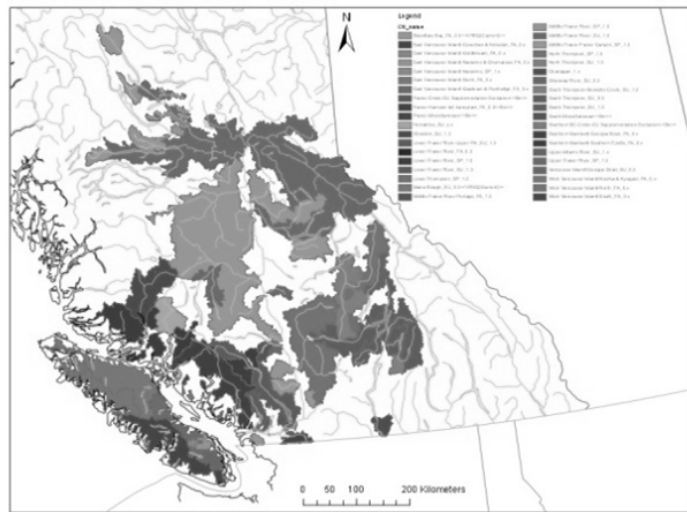


Figure 1. Map of southern BC showing the Chinook Conservation Units.

### Context:

Canada's Wild Salmon Policy's (WSP) identifies six strategies for implementation. Strategy 1 is "Standardized monitoring of wild salmon status" and requires biological status assessments for all Pacific salmon conservation units (CUs). To conduct WSP status assessments, a toolkit comprised of a number of classes of indicators and metrics for status evaluation was completed in 2009. However, since a number of metrics can be used to evaluate biological status, it is possible that each metric can indicate a different status (Red, Amber, or Green). Therefore, status integration, which includes synthesis of CU status information across metrics into one or more status zones, and the provision of expert commentaries on the information used to assess status, is a useful final step in the status designation process. This report presents the application of WSP status integration conducted in a CSAS workshop. This workshop builds upon a previous application of WSP status integration techniques conducted for Fraser Sockeye CUs.

This Science Advisory Report is from the February 4-6, 2014 Assessment of Southern British Columbia Chinook Salmon Conservation Units, Benchmarks and Status. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.



## SUMMARY

- A workshop entitled “Assessment of Southern British Columbia Chinook Salmon Conservation Units, Benchmarks and Status” was conducted to determine an integrated Wild Salmon Policy (WSP) status for each of the 35 southern BC Chinook Salmon Conservation Units (CU). The status integration method used was similar to that applied to Fraser Sockeye (Grant & Pestal 2013). A characteristic of southern BC Chinook Salmon CUs that is distinct from the Sockeye Salmon CUs assessed so far is the significant presence of hatchery-origin fish in addition to wild-origin fish in many of the CU area/watersheds.
- For this workshop, multi-page standardized data summaries were produced for each southern BC Chinook Salmon CU. The data used to generate these summaries had been previously reviewed through two Regional Peer Review processes.
- Participants were asked to determine a single WSP status zone from Red (poor status) to Amber (cautious status) to Green (healthy status) for the CU based on a combination of the information from the individual status metrics.
- Status evaluations were completed and consensus reached on an integrated WSP status designation for 15 of the 35 CUs. Of these, 11 were assigned a Red status, one was assigned a Red/Amber status, one was assigned an Amber status and two were assigned a Green status. For another nine of the 35 CUs, an integrated status evaluation was not possible based on the information presented at the workshop. For these CUs, the status designation is “data deficient” and this designation is not expected to change until more information becomes available. For the remaining 11 of the 35 CUs, status evaluations were not completed. Instead, the status of these CUs was classified as “to be determined”. These CUs are a component of units where the enhanced sites are predominant; consensus was not reached on how to derive a WSP status assessment for such units.
- In addition to providing final integrated status for each CU, the expert interpretation of the data summaries was documented in status commentaries. These commentaries provide the details underlying the final integrated status decisions. Status zones on their own do not provide an indication of which factors drive their designation, which would influence subsequent WSP strategies. The commentaries are an important source of information to inform management considerations.
- The designation of seven Fraser River CUs as Red and two others with a status of Amber is especially noteworthy. A review of all Chinook populations in BC carried out more than 30 years ago found compelling evidence of substantial declines in abundance in all geographic regions, except within the Fraser River watershed. The last 12 to 15 years have been a period during which most groups of Chinook within the Fraser River have declined in numbers, and the outlook for Chinook outside of the Fraser River has generally not shown sustained improvement since the earlier review.
- Integrated WSP status designations could not be developed for 20 of the 35 southern BC Chinook CUs based on the information and methods available to the workshop participants, which is very concerning. This highlights the need for additional work relating to information collection and assembly and for the development of a suitable method for status assessment when there is a significant contribution to recruitment and spawner abundance from enhanced sites.
- A proposal on the frequency of status re-assessments was agreed to: DFO staff should recalculate the individual status metrics annually, update the standardized data summaries,

and check for any substantial changes. If results from individual metrics indicate a change that could affect the overall status for the CU, a meeting would be convened to address the affected CUs only. A full re-assessment of all CUs would take place every four years.

## INTRODUCTION

The goal of the Wild Salmon Policy (WSP) is to “restore and maintain healthy salmon populations and their habitats for the benefit and enjoyment of the people of Canada in perpetuity” (DFO 2005). In order to achieve this goal, the WSP outlines a number of strategies, including Strategy 1 (Standardized Monitoring of Wild Salmon Status), which is the subject of this Science Advisory Report (SAR). Action Steps for Strategy 1 include:

1. identification of CUs;
2. development of criteria to assess CUs and identification of benchmarks to represent biological status; and,
3. monitoring and assessment of CU status.

Work on these action steps has progressed since the WSP was published in 2005, with the following peer-reviewed milestones:

- method for the identification of Pacific salmon CUs (Holtby & Ciruna 2007);
- method for the assessment of Pacific salmon biological status under the WSP (Holt *et al.* 2009);
- technical background for WSP status assessments (Holt 2009; Porszt 2009; Holt 2010; Holt & Bradford 2011; Porszt *et al.* 2012);
- integration techniques for WSP status assessments of salmon CUs (Grant & Pestal 2013);
- revision of southern BC Chinook Conservation Unit assignments (DFO 2013).

Four classes of indicators have been recommended to evaluate WSP status of wild Pacific salmon: abundance, trends in abundance, distribution, and fishing mortality (Holt *et al.* 2009). Within each class of indicator, one or more metrics can be used for status assessments, and, for each metric, a lower benchmark and upper benchmark delineate the Red to Amber and Amber to Green status zones, respectively (Table 1). These biological benchmarks are specifically used for status assessments, and are not prescriptive for specific management actions. They are also designed to be more conservative than the criteria established by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), as required by the WSP.

Table 1. The three zones of biological status defined in the WSP (Grant & Pestal 2013).

Status	Definition
<b>Red</b>	“... established at a level of abundance high enough to ensure there is a substantial buffer between it and any level of abundance that could lead to a CU being considered at risk of extinction by COSEWIC”
<b>Amber</b>	“While a CU in the Amber zone should be at low risk of loss, there will be a degree of lost production. Still, this situation may result when CUs share risk factors with other, more productive units”
<b>Green</b>	“identif[ies] whether harvests are greater than the level expected to provide on an average annual basis, the maximum annual catch for a CU, given existing conditions...there would not be a high probability of losing the CU”

Since CU status evaluations can include more than one metric, it is possible that different metrics could each indicate a different WSP status zone from Red (poor status) to Green (healthy status). For example, the WSP recent trend in abundance metric could suggest a CU's status is poor, while conversely, the long-term trend metric could indicate the same CU's status is healthy. In cases where metric information is contradictory, provision of this metric-specific status information alone does not provide complete scientific advice to fisheries management. Instead, a final step that synthesizes all metric and status-related information into an integrated status for each CU, and provides expert commentary on this information, is necessary as inputs into subsequent implementation of WSP Strategy 4 (Integrated Strategic Planning) to prioritize assessment activities and management actions (Table 2. Guidance in the WSP on assessment actions and management considerations for CUs in each of three status zones (Grant & Pestal 2013).Table 2).

Table 2. Guidance in the WSP on assessment actions and management considerations for CUs in each of three status zones (Grant & Pestal 2013).

Status	Assessment Actions	Management Considerations
<b>Red</b>	"... a detailed analytical assessment will normally be triggered to examine impacts on the CU of fishing, habitat degradation, and other human factors, and evaluate restoration potential", "... detailed stock assessments will identify the reasons for the change in status". "CUs in the Red zone ... will be identified as management priorities ... the protection and restoration of these CUs will be primary drivers for harvest, habitat, and enhancement planning."	"Biological considerations will be the primary driver for the management of CUs with Red status". "The presence of a CU in the Red zone will initiate immediate consideration of ways to protect the fish, increase their abundance, and reduce the potential risk of loss".
<b>Amber</b>	"... a detailed analytical assessment may be required to input into Strategies 2 & 3.."	"Decisions about the conservation of CUs in the Amber zone will involve broader considerations of biological, social, and economic issues"; "involves a comparison of the benefits from restoring production versus the costs arising from limitations imposed on the use of other CUs to achieve that restoration"; "implies caution in the management of the CU"
<b>Green</b>	"a detailed analytical assessment of its biological status will not usually be needed"	"Social and economic considerations will tend to be the primary drivers for the management of CUs in the green zone, though ecosystem or other non-consumptive values could also be considered".

For Pacific Salmon CUs, WSP biological status integration methods have previously been developed and applied to Sockeye Salmon assessments (Grant & Pestal 2013). However, a characteristic of southern BC Chinook Salmon CUs that is distinct from the Sockeye Salmon CUs assessed so far is that many areas support substantial numbers of hatchery-origin fish in addition to wild-origin fish. Therefore, the guidelines developed for Sockeye Salmon are only partially applicable to the southern BC Chinook Salmon situation. In order to explore the applicability of the status integration techniques developed previously, and to provide WSP

status assessments, a CSAS workshop entitled “Assessment of Southern British Columbia Chinook Salmon Conservation Units, Benchmarks and Status” was conducted to achieve these goals. This SAR summarizes the results from this CSAS workshop.

The objectives of the workshop were to:

1. Determine an integrated WSP status for each southern BC Chinook Salmon CU;
2. Indicate the effect on the status assessments of including, or excluding, enhanced Chinook Salmon contributions;
3. Provide advice on data and methods required for assessing the status of any CUs that are currently data deficient;
4. Include information specific to each CU on fishing mortality, where possible;
5. Provide advice on the appropriate frequency of status re-assessment, changes to monitoring variables that could invoke early re-assessment, and the appropriate timing for assessment relative to data availability; and
6. Identify and recommend data management approaches required to support recommended changes to re-assessment of CUs.

## ASSESSMENT

### Data

For this workshop, multi-page standardized data summaries were produced for each southern BC Chinook Salmon CU. The data used to generate these summaries had been previously reviewed through two CSAS Regional Peer Review processes<sup>1,2</sup>. These data summaries included the following:

- time series plots of spawner abundances (either relative indices or absolute abundances, where available);
- a table of absolute abundances relative to COSEWIC criteria D1 for small populations;
- a summary of overall data quality (as a percentage of spawner abundance);
- a summary of the categorization of enhancement activity level by census site<sup>3</sup>;

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<sup>1</sup>Brown, G.S., Baillie, S.J., Thiess, M.E., Bailey, R.E., Candy, J.R., Parken, C.K., and Willis, D.M. 2014. Pre-COSEWIC Review of Southern British Columbia Chinook Salmon (*Oncorhynchus tshawytscha*) Conservation Units: Part I, Background. CSAS Working Paper 2012/P62. In revision.

<sup>2</sup> Brown, G.S., Baillie, S.J., Bailey, R.E., Candy, J.R., Holt, C.A, Parken, C.K., Pestal, G.P., Thiess, M.E., and Willis, D.M. 2014. Pre-COSEWIC Review of Southern British Columbia Chinook Salmon (*Oncorhynchus tshawytscha*) Conservation Units, Part II: Data, Analysis and Synthesis. CSAS Working Paper 2012/13 P23. In revision.

<sup>3</sup> The concepts of a “Total Unit” (TU) and an Enhancement Unit (EU) were introduced at the workshop. A Total Unit can be comprised of two components: the CU and an associated EU. The CU includes only census sites with low or unknown enhancement level activity in an attempt to be consistent with the WSP focus on ‘wild salmon’. The EU contains only census sites with moderate or high enhancement level activity. Although these concepts were introduced at the workshop, they were not endorsed by the participants and therefore are not considered to form a viable conceptual approach to this issue.

- a stacked bar plot illustrating the distribution of spawner abundance across sites within the CU;
- a whisker plot illustrating short term trends by census site within the CU;
- a table of spawner abundance by census site within the CU;
- status information for up to three WSP metrics: one metric for abundance relative to biological benchmarks, one metric for extent of decline in abundance, and two related metrics for short-term trend in abundance;
- where available, supplementary time series plots of natural log-transformed spawner abundance, generational average of spawner abundance, CWT indicator spawner abundance, total return, productivity (recruits/spawner by brood year), hatchery releases from within and outside the CU, exploitation rates and marine survival;
- retrospective (historical) time series of status for each WSP metric relative to established benchmarks (Holt *et al.* 2009).

## Methods

Workshop participants were invited to attend based on their experience with different aspects of salmon assessment and included DFO staff from Science, Ecosystems Management and Fisheries Management sectors and external participants from First Nations organizations, the commercial and recreational fishing sectors, environmental non-governmental organizations, and academia. Participants were requested to join one of four pre-workshop seminars in order to review the data summary layout and to provide feedback to organizers on the workshop format. At the workshop, participants were assigned to one of six groups, each comprised of six or seven individuals. Their group assignment remained the same for the duration of the workshop. Individuals were assigned in order to provide a varied mix of views and expertise within each group.

Each of the 35 CUs (and their associated enhanced sites where applicable) was designated as an individual case study. The identity of the CU represented by a case study was not revealed to the participants during the initial assessment sessions. This “blind” approach was similar to that employed by Grant & Pestal (2013) during the Fraser Sockeye workshop. The 35 case studies were presented in seven sets over the first two days of the workshop. Participant groups were given 15 minutes, 30 minutes, one hour or 1.5 hours, depending on the set size and complexity, to discuss each set in a breakout session. At the end of each breakout session, back in a full participant plenary session, groups compared results and discussed their reasoning for their final integrated status designations. All of the 35 CUs were evaluated by at least some of the groups, and each group evaluated a representative number of CU types (different metrics and statuses). Late on the second day, the CU identity of each case study was revealed to the participants. The third day of the workshop was a full day of plenary discussion to reconcile group integrated status results allowing for use of knowledge of the identity of each CU.

## Results

### Final Integrated Status

By the end of the workshop, participants completed status evaluations and reached consensus on an integrated WSP status designation for 15 of the 35 CUs (Table 3 and Figure 2). The 15 southern BC Chinook CUs are ordered in Table 3 using their final integrated status, with CUs designated Red (poorest status) located at the top of the table to CUs designated Green (best

status) at the bottom. Thirteen out of the 15 CUs were reconciled between groups in the post-reveal plenary session to a single WSP status zone. There was one CU where final integrated statuses included two status zones. The Lower Fraser River\_FA\_0.3 (CK-03) CU's integrated Green status was flagged as provisional by participants. Following the example of the Fraser Sockeye WSP status assessments (Grant & Pestal 2013), when some participants held divergent views, the status assignment was classified as "provisional". In this case, the short-term decline observed in recent years, despite decreasing exploitation rate, resulted in a provisional status designation to highlight the need for monitoring the trend.

For another nine of the 35 CUs, an integrated status evaluation was not possible based on the information presented at the workshop. For these CUs, the status designation is "data deficient" (DD). When preparing the data summaries, the workshop organizers identified five CUs as obviously data deficient (Table 3, Cases 31 to 35). The workshop participants supported this initial assessment and also designated an additional four CUs as data deficient. For all nine of these CUs, the status designation is not expected to change until more information is available.

South Thompson-Bessette Creek\_SU\_1.2 (CK-16) and Okanagan\_1.x (CK-01) were designated as Red status. However, there was some concern expressed by the participants that the definition of these CUs might not be valid. The status of these CUs should be re-evaluated following a review of their CU definitions.

The remaining 11 of the 35 CUs (Table 4) presented a substantial challenge for the participants and ultimately, status evaluations could not be completed for them. Instead, the status of these CUs was classified as "to be determined" (TBD). These CUs are geographically proximate to predominantly enhanced sites, or data exist only for the enhanced sites geographically proximate to the CU (e.g. a CU may exist but no wild census sites have data of sufficient quality for assessment at this time). Consensus was not reached on how to derive a WSP status assessment for such combined wild and enhanced site units, or the CUs that spawn in the same area. A method to consider enhanced contribution by redefining the wild site versus enhanced site classification in the data summaries was proposed by the workshop organizers. However; there was consensus that a review of the proposed method was not within the scope of the workshop and should be the subject of a future review. Although there are no status evaluations provided for these 11 CUs, unlike the situation with the data deficient CUs, an integrated WSP status could be determined in some cases once a suitable method is developed to assess the status of enhanced sites and how they should be considered in status assessments of the CU.

### **Status Commentaries**

In addition to documenting a final integrated status designation for each CU, the expert interpretation of the data summaries was recorded as status commentaries (Appendix B of the Research Document resulting from the workshop). These commentaries provide the details underlying the final integrated status decisions, which varied even amongst CUs with identical status designations. These details will be important when the results from Strategy 1 (Standardized Monitoring of Wild Salmon Status) are linked to Strategy 4 (Integrated Strategic Planning). Status zones on their own do not provide an indication of which factors drive their designation, which would influence subsequent WSP strategies. The commentaries are an important source of information to inform management considerations.

Table 3. Summary of completed integrated status evaluations for Southern BC Chinook Salmon CUs.

**Integrated status evaluation completed at workshop**

Integrated Status	Case #	CU ID	CU Name	Area
RED	1	CK-10	Middle Fraser River_SP_1.3	Fraser
RED	4	CK-18	North Thompson_SP_1.3	Fraser
RED	6	CK-19	North Thompson_SU_1.3	Fraser
RED	11	CK-09	Middle Fraser River-Portage_FA_1.3	Fraser
RED	24	CK-17	Lower Thompson_SP_1.2	Fraser
RED	25	CK-31	West Vancouver Island-South_FA_0.x	WCVI
RED	26	CK-12	Upper Fraser River_SP_1.3	Fraser
RED	29	CK-29	East Vancouver Island-North_FA_0.x	Inner SC
RED	30	CK-32	West Vancouver Island-Nootka & Kyuquot_FA_0.x	WCVI
RED*	3	CK-16	South Thompson-Bessette Creek_SU_1.2	Fraser
RED*	5	CK-01	Okanagan_1.x	Columbia
RED / AMBER	27	CK-14	South Thompson_SU_1.3	Fraser
AMBER	12	CK-11	Middle Fraser River_SU_1.3	Fraser
GREEN(p)	9	CK-03	Lower Fraser River_FA_0.3	Fraser
GREEN	2	CK-13	South Thompson_SU_0.3	Fraser

**Integrated status evaluation not possible based on information presented at workshop**

Integrated Status	Case #	CU ID	CU Name	Area
DD	7	CK-82	Upper Adams River_SU_x.x	Fraser
DD	8	CK-06	Lower Fraser River_SU_1.3	Fraser
DD	10	CK-05	Lower Fraser River-Upper Pitt_SU_1.3	Fraser
DD	28	CK-28	Southern Mainland-Southern Fjords_FA_0.x	Inner SC
DD	31	CK-08	Middle Fraser-Fraser Canyon_SP_1.3	Fraser
DD	32	CK-20	Southern Mainland-Georgia Strait_FA_0.x	Inner SC
DD	33	CK-34	Homathko_SU_x.x	Inner SC
DD	34	CK-23	East Vancouver Island-Nanaimo_SP_1.x	Inner SC
DD	35	CK-35	Klinaklini_SU_1.3	Inner SC

“(p)” means provisional, and identifies cases where some participants held divergent views.

“\*” means that CU definition should be reviewed.

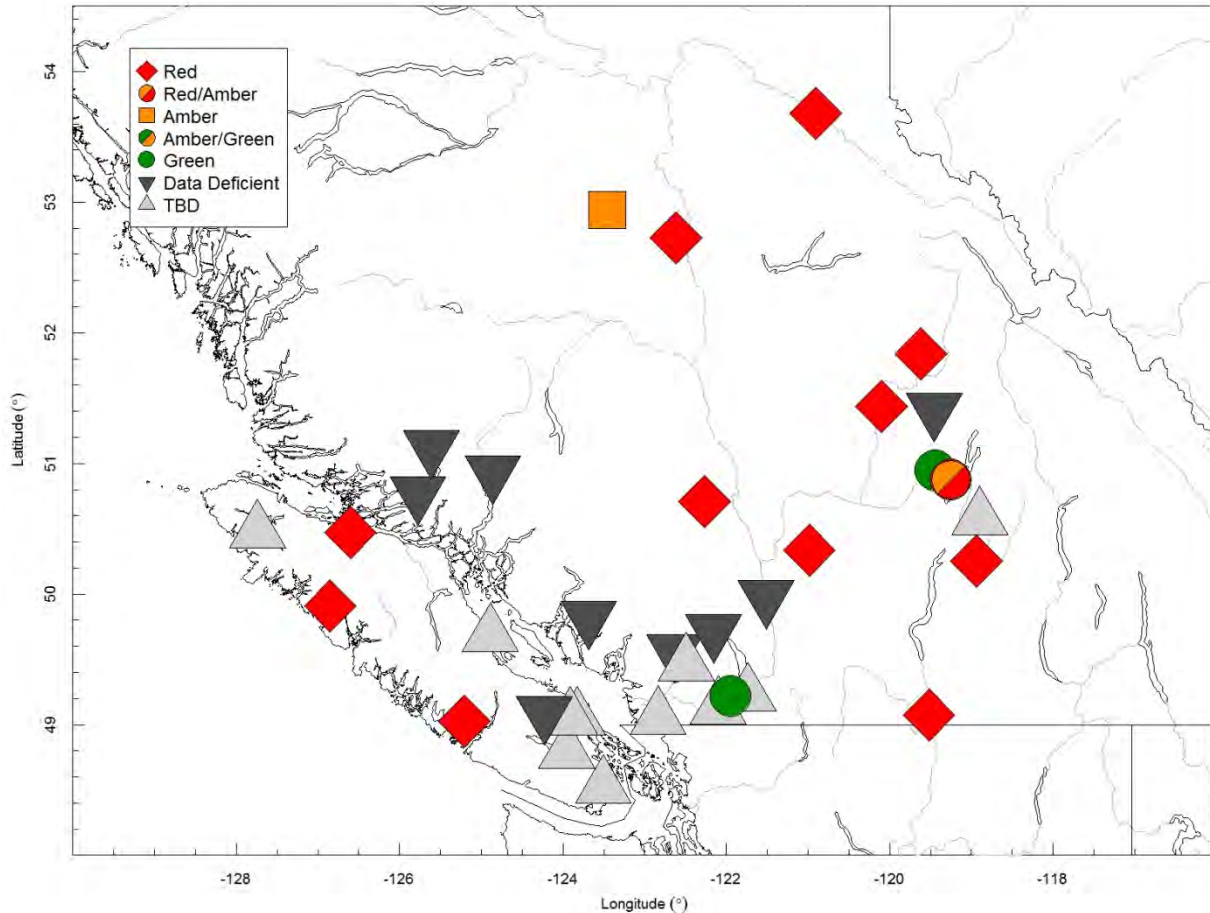


Figure 2. Map of southern BC summarizing workshop consensus on biological status of southern BC Chinook Salmon CUs.

### Status Integration Approaches

The workshop organizers had prepared an initial set of guidelines for status integration (see Appendix E of the Proceedings resulting from the workshop). These guidelines were largely based on the recommendations in Grant and Pestal (2013). After the groups had completed several evaluations they reported that they were adopting patterns in their approach to status integration. Based on the feedback from participants, the guidelines were revised and are reported in Section 3 of the Research Document resulting from the workshop. In addition, the status deliberation notes and plenary discussions exposed some common themes to status integration approaches that were not explicitly endorsed as guidelines by the participants. These are also documented in Section 3 of the Research Document resulting from the workshop.



Table 4. Summary of incomplete integrated status evaluations for Southern BC Chinook Salmon CUs.

**Integrated status evaluation not attempted at workshop due to unresolved methods**

Integrated Status	Case #	CU ID	CU Name	Area
TBD**	13	CK-04	Lower Fraser River_SP_1.3	Fraser
TBD	14	CK-21	East Vancouver Island-Goldstream_FA_0.x	Inner SC
TBD	15	CK-33	West Vancouver Island-North_FA_0.x	WCVI
TBD	16	CK-22	East Vancouver Island-Cowichan & Koksilah_FA_0.x	Inner SC
TBD	17	CK-02	Boundary Bay_FA_0.3	Inner SC
TBD	18	CK-07	Maria Slough_SU_0.3	Fraser
TBD	19	CK-25	East Vancouver Island-Nanaimo & Chemainus_FA_0.x	Inner SC
TBD	20	CK-15	Shuswap River_SU_0.3	Fraser
TBD	21	CK-83	East Vancouver Island-Georgia Strait_SU_0.3	Inner SC
TBD	22	CK-27	East Vancouver Island-Qualicum & Puntledge_FA_0.x	Inner SC
TBD	23	CK-9008	Fraser-Harrison fall transplant_FA_0.3	Fraser

“\*\*” means that CU status should be re-evaluated after review of enhancement level definition.

### Sources of Uncertainty

- The standardized data summaries were prepared based on data that had been previously reviewed<sup>1,2</sup>, however, these summaries are based largely on spawner data with a substantial but unquantified level of uncertainty.
- A period of apparent abundance increases occurred during the 1990s and early 2000s when major improvements were made in many BC escapement programs. These escapement estimation improvements typically resulted in immediate and noticeably higher annual estimates relative to earlier estimates. This suggests that apparent improvements in abundance could be related more to changes in survey and estimation methods than to genuine biological changes.
- Some of the abundance time series represent relative rather than absolute abundances. Relative abundances likely under-estimate true abundance (by unknown and variable amounts), so an indication of red zone status in relation to the WSP metric on absolute abundance may not be accurate.
- Some of the individual metrics display a pattern of changing status from one year to the next (e.g. red status one year followed by green status the next year and then returning to red). In this situation, the metric is not conveying meaningful results for determining integrated status and would typically be disregarded or given less weight in status deliberations.
- Information on the contribution of enhanced fish to the abundance of fish observed at “wild” sites is often limited; and as such, the actual wild contribution (which is key to the WSP CU definition) is often unknown. For the purposes of these status assessments, observations at wild sites are assumed to be comprised entirely of wild fish.
- The status evaluations developed at this workshop ultimately relied on the expert opinions of the participants and as such, are subject to the experience and opinions of the individuals involved. Because many of the evaluations are more subjective than objective, the

repeatability of these findings is uncertain. The status commentaries in Appendix B of the Research Document resulting from the workshop identify cases where participants were especially confident in their assessment, as well as cases where the status designations were particularly uncertain, which may be useful in developing approaches to quantifying this uncertainty in the future.

## CONCLUSIONS AND ADVICE

### Southern BC Chinook CUs Integrated Status

Integrated status designations were developed for 15 of the 35 southern BC Chinook CUs, and status commentaries were provided for all 35 CUs. In some cases, the commentaries provide more useful advice for management considerations than would be indicated by the mapping of the status zone to the management considerations in Table 2. These results address two of the six objectives for the workshop: “determine an integrated WSP status for each southern BC Chinook Salmon CU”, and “include information specific to each CU on fishing mortality, where possible”.

The majority of CUs for which an integrated status was developed occurred within the Fraser River watershed (11 of 15). This reflects the reduced prevalence of enhancement as a management intervention in that region. While seven of the Fraser River CUs were designated as Red, all four of the CUs that were assessed from other regions were also designated as Red. All adult and juvenile life history patterns known in southern BC Chinook are represented in the group of 11 Red status CUs. This suggests that declines in abundance shown by these CUs cover a broad geographic area and are not specific to any particular group of Chinook Salmon.

The designation of seven Fraser River CUs as Red and two others with a status of Amber is especially noteworthy. A review of all Chinook populations in BC carried out by Healey (1982) more than 30 years ago found compelling evidence of substantial declines in abundance in all geographic regions, except within the Fraser River watershed. Riddell *et al.* (2013) suggested that spawner abundances in most southern BC areas may have increased for a period in the 1990s and early 2000s. However, these apparent improvements in abundance could be related more to changes in survey and estimation methods than to genuine biological changes. Regardless of whether real abundance increases occurred in the 1990s, the last 12 to 15 years have been a period during which most groups of Chinook within the Fraser River have declined in numbers. The outlook for Chinook Salmon outside of the Fraser River has generally not shown sustained improvement since Healey’s (1982) review.

### Recommendations

- Integrated status designations could not be developed for 20 of the 35 southern BC Chinook CUs based on the information and methods available to the workshop participants. This represents the majority of the southern BC Chinook CUs, or approximately 21% of the surveyed aggregate abundance, which is a concern. This highlights the need for additional work and relates to the objectives: “provide advice on data and methods required for assessing the status of any Conservation Units that are currently data deficient”, and “identify and recommend data management approaches required to support recommended changes to re-assessment of CUs”.
- In some cases, additional information relating to the data deficient CUs is in the possession of the Department, but has not yet been incorporated into the regional escapement data holdings where it would be accessible to analysts. If this information were incorporated, it is possible that some of the CUs would no longer be data deficient and status designations could be developed. This information includes escapement survey records held by local

offices in paper and electronic formats that have not been a priority for further analysis to date. The work necessary to locate and incorporate this information into the regional escapement data holdings could provide significant benefits for future status assessments.

- The workshop participants identified an issue where a Chinook population is known anecdotally to exist, but there are no escapement surveys recorded in the regional escapement data holdings. Examples of this are information from local traditional knowledge, data from non-DFO programs such as fish habitat surveys initiated for forestry purposes, and data from juvenile salmon surveys. Since the regional adult escapement data holdings provided the source information for initial CU definition, the absence of survey records meant that these populations were not included in the CU definitions. Thus it is possible that there are additional Chinook CUs yet to be defined. These would likely form additional CUs for the data deficient category. This issue could be addressed by incorporating the information on un-surveyed but known Chinook populations into the regional escapement data holdings as placeholder records.
- The amount of data filtered out due to data quality concerns prior to status assessments raises questions regarding the utility of temporally extensive, low-quality surveys and their role in the stock assessment program should be reviewed. If such data are not useful for status assessment, then they are of little value other than indicating fish presence which has proved useful only in identifying spawning sites for potential grouping within a CU.
- Aside from the data deficiency issue, the other issue which prevented integrated status designations relates to the workshop objective: “indicate the effect on the status assessments of including and excluding enhanced Chinook Salmon, where applicable”. This was the only objective of the workshop that was not successfully addressed. The participants attempted to address this objective but the consensus was that given the methods and guidelines available to them, status designation was not possible for CUs that had a substantial contribution from enhanced sites. To resolve this issue for future assessments would require a specific project to develop a suitable method for status assessment for sites (or groups of sites) with significant enhancement contribution. In addition, guidance would need to be developed for considering the interaction between the CU and an associated enhanced contribution in the status assessment of the CU. The resulting proposed method and guidelines should then be subject to peer review. Once this work is complete, the southern BC Chinook CUs currently categorized with a status of To Be Determined should be re-assessed.

### **Status Integration Process**

Again, similar to the approach taken for Fraser Sockeye Salmon CUs (Grant & Pestal 2013), expert opinion on status integration and associated commentaries were elicited through a combination of smaller breakout groups and full participant plenary sessions. The advantage of this approach was that it permitted independent small-group evaluation of a range of integration approaches and integrated status designations, which could then be consolidated in a plenary session with all participants. Although not highlighted in the results presented here, more often than not, the individual group results showed a similar status designation for a CU and the status reconciliation during the plenary session was rapid and not controversial. This provides some confidence that the integration process is more objective than subjective, and is repeatable.

## Integration Guidelines

Now that two of these larger integration workshops have occurred, and a variety of CUs have been examined, it might be possible to prepare a more comprehensive set of integration guidelines for formal peer-review. Once accepted, these guidelines could allow for the completion of a preliminary status integration report for a collection of CUs by a small expert team. This report would then become the working paper to be reviewed via the more typical CSAS Regional Peer Review process. If this work were undertaken it would help to address the concern that the workshop format for WSP status assessment is onerous and is limiting the opportunity for status assessments.

## Frequency of Re-Assessment

A key workshop objective was to “provide advice on the appropriate frequency of status re-assessment, changes in monitoring variables that could invoke early re-assessment, and appropriate timing for assessment relative to data availability”. The following proposal on the frequency of status re-assessments was agreed on by participants in plenary session.

- DFO staff should recalculate the individual status metrics annually, update the standardized data summaries, and check for any substantial changes.
- A meeting would not be required to re-assess status of CUs unless results from individual metrics indicated a change that could affect the overall status for the CU.
- A shorter (and perhaps smaller) meeting would be convened to address the affected CUs only.
- A full re-assessment of all CUs would take place every four years (representing approximately once per generation for most Chinook CUs).
- Full re-assessment meetings would include representation from DFO and stakeholders, but could be shorter than the current workshop; the meeting could review a status assessment working paper, and could possibly be vetted through a CSAS Science Response process instead of a Regional Peer Review process.

## SOURCES OF INFORMATION

This Science Advisory Report is from the February 4-6, 2014 Assessment of Southern British Columbia Chinook Salmon Conservation Units, Benchmarks and Status. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada \(DFO\) Science Advisory Schedule](#) as they become available.

DFO. 2005. [Canada's Policy for Conservation of Wild Pacific Salmon](#). Fisheries and Oceans Canada, Vancouver, BC. 34 pp. (Accessed 12 January 2016)

DFO. 2013. [Review and Update of Southern BC Chinook Conservation Unit Assignments](#). DFO Can. Sci. Advis. Sec. Sci. Resp. 2013/022. 25 pp. (Accessed 06 July 2016)

Grant, S.C.H. & G. Pestal. 2013. [Integrated Biological Status Assessments Under the Wild Salmon Policy Using Standardized Metrics and Expert Judgement: Fraser River Sockeye Salmon \(\*Oncorhynchus nerka\*\) Case Studies](#). Can. Sci. Advis. Sec. Res. Doc. 2012/106. v + 132 p. (Accessed 06 July 2016)

Healey, M.C. 1982. [Catch, Escapement and Stock-Recruitment for British Columbia Chinook Salmon Since 1951](#). Can. Tech. Rep. Fish. Aquat. Sci. 1107: iv + 77 p. (Accessed 06 July 2016)

- Holt, C.A. 2009. [Evaluation of Benchmarks for Conservation Units in Canada's Wild Salmon Policy: Technical Documentation](#). Can. Sci. Advis. Sec. Res. Doc. 2009/059. xii + 50 pp. (Accessed 06 July 2016)
- Holt, C.A. and Bradford, M.J. 2011. [Evaluating Benchmarks of Population Status for Pacific Salmon](#). N. Am. J. Fish. Manage. 31:2, 363-378. (Accessed 06 July 2016)
- Holt, C.A., Cass, A., Holtby, B., & Riddell, B. 2009. [Indicators of Status and Benchmarks for Conservation Units in Canada's Wild Salmon Policy](#). Can. Sci. Advis. Sec. Res. Doc. 2009/058. vii + 74 pp. (Accessed 12 January 2016)
- Holt, C.A. 2010. [Will Depleted Populations of Pacific Salmon Recover Under Persistent Reductions in Survival and Catastrophic Mortality Events?](#) ICES J. Mar. Sci. 67 (9): 2018-2026. (Accessed 06 July 2016)
- Holtby, L.B. & Ciruna, K.A. 2007. [Conservation Units for Pacific Salmon Under the Wild Salmon Policy](#). Can. Sci. Advis. Sec. Res. Doc. 2007/070. viii + 350 pp. (Accessed 06 July 2016)
- Porszt, E.J. 2009. [An Evaluation of Criteria for Assessing Conservation Status of Fraser Sockeye Conservation Units](#). M.R.M. thesis, School of Resource and Environmental Management, Simon Fraser University, Burnaby, B.C. xiii + 104 pp. (Accessed 06 July 2016)
- Porszt, E.J., Peterman, R.M., Dulvy, N.K., Cooper, A.B. and Irvine, J.R. 2012. [Reliability of Indicators of Decline in Abundance](#). Conservation Biology. Doi:1111/j.1523-1739.2012.01882.x (Accessed 06 July 2016)
- Riddell, B., M. Bradford, R. Carmichael, D. Hankin, R. Peterman, and A. Wertheimer. 2013. [Assessment of Status and Factors for Decline of Southern BC Chinook Salmon: Independent Panel's Report](#). Prepared with the assistance of D.R. Marmorek and A.W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for Fisheries and Oceans Canada (Vancouver, BC) and Fraser River Aboriginal Fisheries Secretariat (Merritt, BC). xxix + 165 p. + Appendices. (Accessed 06 July 2016)

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*Aussi disponible en français :*

*MPO. 2016. État biologique intégré du saumon quinnat (oncorhynchus tshawytscha) du sud de la Colombie-Britannique en vertu de la politique concernant le saumon sauvage. Secr. can. de consult. sci. du MPO, Avis sci. 2016/042.*

# ATTACHMENT 2

## Summary of COSEWIC Wildlife Species Assessments, November 2018\*

Wildlife species are sorted according to current status and then by common name.

Status	Common name (population)	Scientific name	Range of occurrence
Extirpated	Pygmy Short-horned Lizard	<i>Phrynosoma douglasii</i>	BC
Endangered	Brook Spike-primrose	<i>Epilobium torreyi</i>	BC
Endangered	Chinook Salmon (East Vancouver Island, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Endangered	Chinook Salmon (Lower Fraser, Stream, Summer (Upper Pitt))	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Endangered	Chinook Salmon (Middle Fraser, Stream, Fall)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Endangered	Chinook Salmon (Middle Fraser, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Endangered	Chinook Salmon (North Thompson, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Endangered	Chinook Salmon (North Thompson, Stream, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Endangered	Chinook Salmon (South Thompson, Stream, Summer 1.2)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Endangered	Chinook Salmon (Upper Fraser, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Endangered	Hairy Valerian	<i>Valeriana edulis</i> ssp. <i>ciliata</i>	ON
Endangered	Nooksack Dace	<i>Rhinichthys cataractae</i>	BC
Endangered	Rainbow Smelt (Lake Utopia large-bodied population)	<i>Osmerus mordax</i>	NB
Endangered	Rainbow Smelt (Lake Utopia small-bodied population)	<i>Osmerus mordax</i>	NB
Endangered	Rapids Clubtail	<i>Phanogomphus quadricolor</i>	ON
Endangered	Ute Ladies'-tresses	<i>Spiranthes diluvialis</i>	BC
Threatened	Black Ash	<i>Fraxinus nigra</i>	MB ON QC NB PE NS NL
Threatened	Chinook Salmon (Lower Fraser, Ocean, Fall)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Threatened	Chinook Salmon (Lower Fraser, Stream, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Threatened	Chinook Salmon (Middle Fraser, Stream, Spring (MFR+GStr))	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Threatened	Chinook Salmon (Middle Fraser, Stream, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Threatened	Lake Chub (Atlin Warm Springs populations)	<i>Couesius plumbeus</i>	BC
Threatened	Lake Chub (Liard Hot Springs populations)	<i>Couesius plumbeus</i>	BC
Threatened	Wood Turtle	<i>Glyptemys insculpta</i>	ON QC NB NS
Special Concern	American Bumble Bee	<i>Bombus pennsylvanicus</i>	ON QC
Special Concern	Chinook Salmon (Lower Fraser, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean

**Summary of COSEWIC Wildlife Species Assessments, November 2018\***  
**Wildlife species are sorted according to current status and then by common name.**

<b>Status</b>	<b>Common name (population)</b>	<b>Scientific name</b>	<b>Range of occurrence</b>
Special Concern	Greater Short-horned Lizard	<i>Phrynosoma hernandesi</i>	AB SK
Special Concern	Pale Yellow Dune Moth	<i>Copablepharon grandis</i>	AB SK MB
Special Concern	Polar Bear	<i>Ursus maritimus</i>	YT NT NU MB ON QC NL Arctic_Ocean
Special Concern	Pygmy Snaketail	<i>Ophiogomphus howei</i>	ON NB
Special Concern	Yellow Scarab Hunter Wasp	<i>Dielis pilipes</i>	BC
Special Concern	Yukon Draba	<i>Draba yukonensis</i>	YT
Not at Risk	Chinook Salmon (South Thompson, Ocean, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Not at Risk	Roughhead Grenadier	<i>Macrourus berglax</i>	NU NB NS NL Arctic_Ocean Atlantic_Ocean
Data Deficient	Chinook Salmon (Southern Mainland, Ocean, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean
Data Deficient	Chinook Salmon (Southern Mainland, Stream, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific_Ocean

\*The assessments of Cryptic Paw Lichen (*Nephroma occultum*), White-rimmed Shingle Lichen (*Fuscopannaria leucosticta*), and Cobblestone Tiger Beetle (*Cicindela marginipennis*) were deferred. These wildlife species will be re-considered by COSEWIC at a later meeting.



# **ATTACHMENT 3**

**PACIFIC SALMON COMMISSION  
JOINT CHINOOK TECHNICAL COMMITTEE REPORT  
ANNUAL REPORT OF CATCH AND ESCAPEMENT FOR 2017  
REPORT TCCHINOOK (18)-02**

**July 19, 2018**

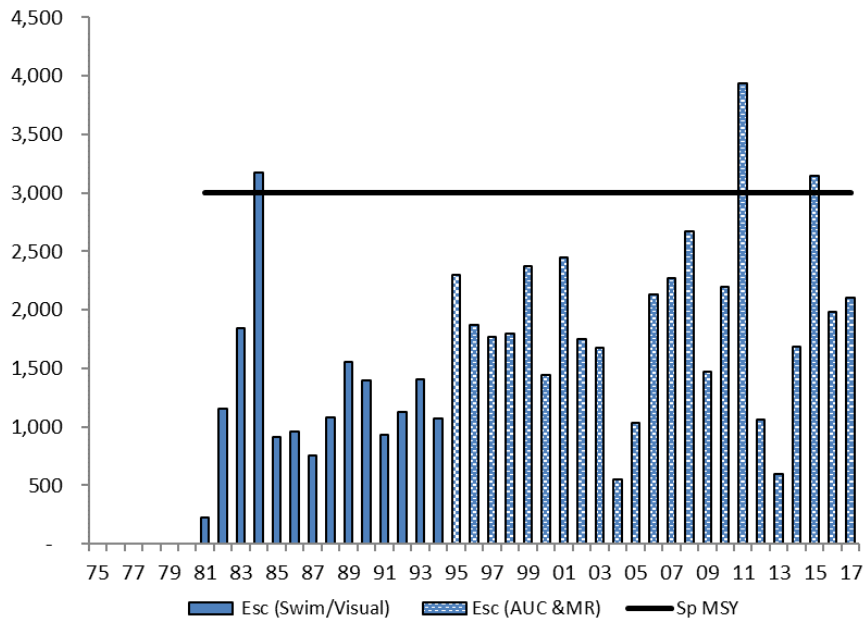


Figure 2.26.—Nanaimo River escapements of Chinook salmon, 1981–2017.

### 2.3.3.4 Fraser River Stocks

A large and diverse group of Chinook salmon spawning in Canada occurs in the Fraser River watershed, with many local populations (CTC 2002b; Candy et al. 2002).

Much of the knowledge about the status of Fraser Chinook salmon is based on spawner escapement data. Most of these data are from visual surveys, which are generally biased low, although many estimates are considered to be precise (Parken et al. 2003). Visual survey data are generated from aerial surveys and the escapement estimate is usually obtained by dividing the peak count by 0.65 (Farwell et al. 1999; Bailey et al. 2000). The CDFO continues to evaluate the accuracy and regularly updates estimates based on the peak count method through calibration studies on Middle Shuswap, Lower Chilcotin, Chilko and periodically Lower Shuswap. Escapement has also been estimated at several locations using MR methods; and direct counts at fences and using resistivity counters. Occasionally escapement estimates could not be determined for reasons including forest fires and extreme weather events that cause resistivity outages and cancellation of visual surveys. When this occurs, the missing estimate is infilled using the English method (English et al. 2007).

Currently, Fraser River Chinook are assessed as five stock groups for PSC management (Fraser Spring-Run 1.2, Fraser Spring-Run 1.3, Fraser Summer-Run 1.3, Fraser Summer-Run 0.3, and Fraser-Late), but are only represented by two stocks in the CTC Model (Fraser Early and Fraser Late). As part of the CTC Model Improvements program, the Fraser Early model stock is being separated into four model stocks to better represent population dynamics. The Fraser Late model stock is being separated into two stocks: natural (Harrison) and hatchery (Chilliwack).

The terminal run estimates in Appendix B6 include catch estimates derived from the Fraser run reconstruction model for CTC stocks only (English et al. 2007). Catches reported in Appendix A

includes reported catches for all stocks, not just those for CTC stocks.

Within the Fraser, there are five current CWT-indicator stocks; Nicola River (Fraser Spring-Run 1.2), Lower Shuswap (Fraser Summer-Run 0.3), Middle Shuswap (Fraser Summer-Run 0.3), and Harrison River and Chilliwack River (Fraser Late). The Dome Creek CWT-indicator stock (Fraser Spring-Run 1.3) was discontinued in 2005.

Only the Harrison River has a CTC-approved escapement goal. For the remaining four stock groups, habitat-based models have been developed to estimate spawning capacity and the spawner abundance required to produce maximum sustained yield,  $S_{MSY}$  (Parken et al. 2006). In 2014, a Canadian Centre for Science Advice Pacific meeting examined the status and benchmarks for Southern BC Chinook conservation units (CUs), including Fraser. Benchmarks and status were accepted for non-enhanced CUs, but further work on enhanced CUs was required to evaluate status.

Escapements to the three stock groups with yearling smolt life history declined steeply from 2003 to 2009, and yearling smolts that entered the ocean in 2005 and 2007 experienced especially low survival. Recently, escapements have remained low and escapements to many of the stock groups failed to attain brood year levels. In contrast, escapements to the Fraser Summer-Run 0.3 increased during the 1990s and remained abundant until 2012, 2016, and 2017; when escapements were very low compared to levels observed over the previous decade.

For the Fraser late stock group, the Harrison River had very low escapements from 2012–2017 (except 2015) with escapements more than 15% below the lower bound of the escapement goal (Figure 2.33). Escapement exceeded the upper bounds of the escapement goal in 2015 (101,516); however, was well below the lower bound of the escapement goal in 2014, 2016 and 2017 and the 2017 escapement estimate is the second lowest on record (Appendix Table B6).

#### **2.3.3.4.1 Fraser River Spring Run: Age 1.3**

The Fraser River spring run age-1.3 aggregate includes spring-run populations of the Mid- and Upper Fraser, North Thompson, and South Thompson, but excludes the Lower Thompson tributaries (CTC 2002b).

Escapements are typically estimated by expanded peak counts of spawners, holders and carcasses, surveyed from helicopters or on foot. Escapement decreased again in 2017 from levels observed in 2016 and was estimated at 8,154, which was lower than parental brood in 2012 and lower than base period values (Figure 2.27).

**Escapement Goal Basis:** There is currently no PSC-agreed escapement goal for this aggregate. Habitat-based estimates of  $S_{MSY}$  and other stock-recruitment reference points are available, but estimates of total escapement are needed to make them effective. Work is currently underway to estimate total escapements by developing factors that calibrate the visual survey indices to total escapements estimated by MR and electronic resistivity counter methods.

**Agency Comments:** The stock group has declined substantially over the last decade and is a stock of conservation concern.

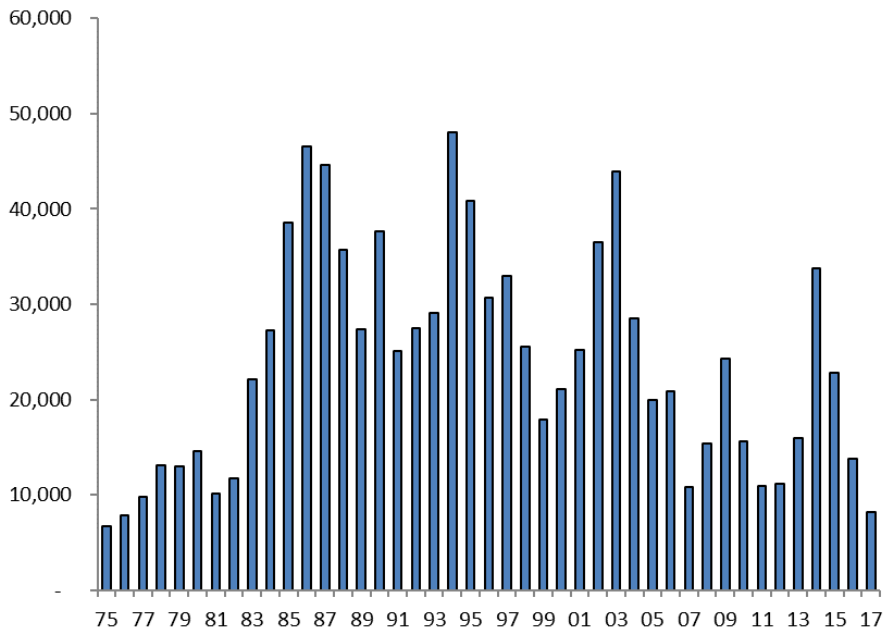


Figure 2.27.—Fraser River spring run age-1.3 stock group escapements of Chinook salmon, 1975–2017.

#### 2.3.3.4.2 Fraser River Spring Run: Age 1.2

The Fraser Spring-run Age 1.2 stock group includes six smaller body size populations that spawn in the Lower Thompson River tributaries, Louis Creek of the North Thompson and the spring-run fish of Bessette Creek in the South Thompson (CTC 2002b). This stock group has an early maturation schedule for a stream-type life history, with an average generation time of 4.1 years (brood years 1985–1986), which results in smaller body size and lower fecundity compared to other stock groups.

**Escapement Methodology:** For the CTC time series, escapements are estimated visually using expanded peak counts of spawners, holders and carcasses in Spius Creek, Coldwater River, Louis Creek and Bessette Creek. Escapements to the Deadman and Bonaparte rivers are estimated by resistivity counter. Mark-recapture and calibrated visual surveys are used to estimate escapement to the Nicola River. Escapement decreased again in 2017 from levels observed in 2016 and was estimated at 5,105, which was lower than parental brood escapement in 2013 (Figure 2.28).

The Nicola River is the exploitation rate indicator stock for the Fraser Spring-run Age 1.2 stock group. Since 1995, high precision escapement estimates (by age and sex) have been generated using an MR program where Petersen disk tags are applied by angling and post-spawned carcasses are examined for the presence of marks. Estimates of escapement have been generated using pooled Petersen and stratified Darroch methods. The expanded peak count time series for the Nicola River is generally less than the MR estimates (Parken et al. 2003); therefore, the Nicola peak count series has been calibrated to the mark-recapture data and is used prior to 1995 in the Fraser Spring-run Age 1.2 aggregate time series (Figure 2.28 and

Figure 2.29).

The MR estimated escapement of 1,702 in 2017 is lower than the 2016 escapement and represents 49% of the 2013 parental brood. Since 1995 hatchery origin fish have averaged 25% of the spawning escapement.

**Escapement Goal Basis:** There is currently no PSC-agreed escapement goal for this aggregate. Habitat-based estimates of  $S_{MSY}$  and other stock-recruitment reference points are available for this stock group (Parken et al. 2006), but estimates of total escapement are needed to make them effective. Work is currently underway to estimate total escapements by developing factors that calibrate the visual survey indices to total escapements estimated by MR and electronic resistivity counter methods. Since 2004, the Nicola River escapements have been less than the median estimate of  $S_{MSY}$  (9,300; CV 21%).

**Agency Comments:** The stock group has declined substantially over the last decade and is a stock of conservation concern.

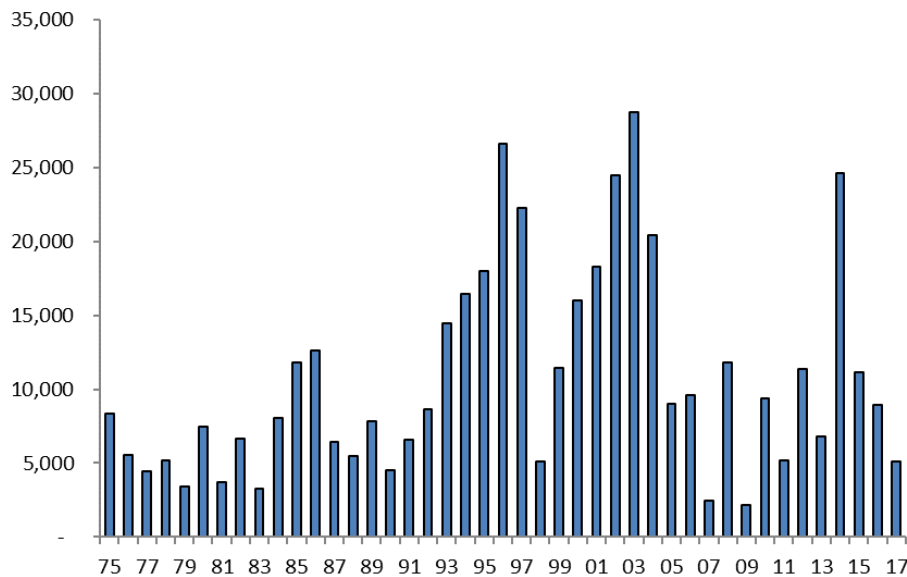


Figure 2.28.—Fraser River spring run age-1.2 stock group escapements of Chinook salmon, 1975–2017.

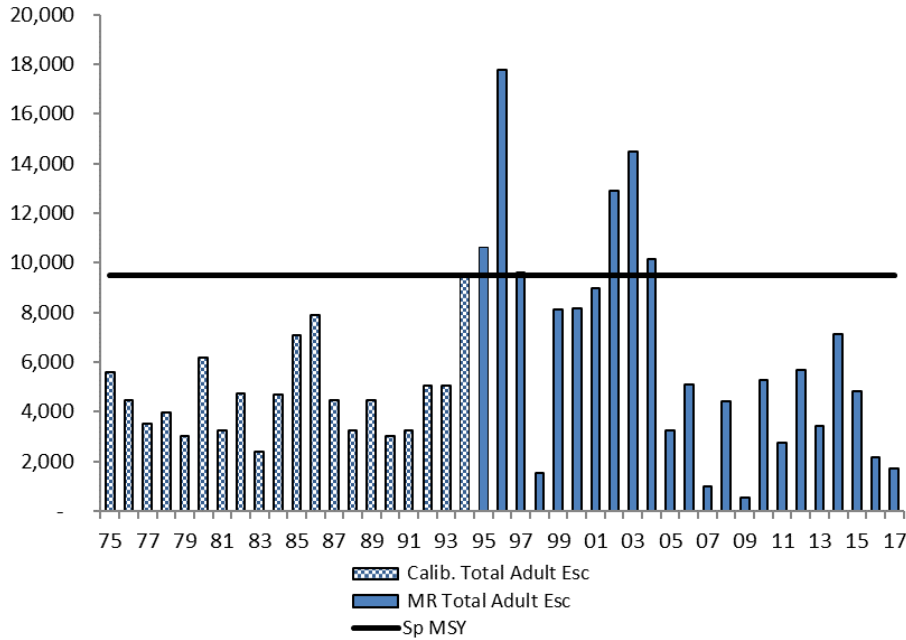


Figure 2.29.—Nicola River escapements of Chinook salmon, 1975–2017.

### 2.3.3.4.3 Fraser River Summer Run: Age 1.3

The Fraser River summer run age-1.3 aggregate includes 10 populations spawning in large rivers, mostly below the outlets of large lakes. These include the Nechako, Chilko, and Quesnel rivers in the Mid-Fraser and the Clearwater River in North Thompson watershed (CTC 2002b). The aggregate escapement was estimated at 6,459 in 2017, which is substantially lower from those observed in 2016 and in the parental brood in 2012. This is the lowest escapement on record for this aggregate (Figure 2.30).

**Escapement Methodology:** Escapements are estimated by expanded peak counts of spawners, holders and carcasses surveyed from helicopters. Surveys of the Stuart River and North Thompson River were discontinued in 2004 due to unreliable counting conditions and removed from the data series.

**Escapement Goal Basis:** There is currently no PSC-agreed escapement goal for the aggregate. Habitat-based estimates of  $S_{MSY}$  and other stock–recruitment reference points are available for this stock group, but estimates of total escapement are needed to make them effective. Work is currently underway to estimate total escapements by developing factors that calibrate the visual survey indices to total escapements estimated by MR and AUC methods.

**Agency Comments:** The stock group declined over the last decade and has been a conservation concern for several years. In 2017 it declined to the lowest level observed in 42 years.

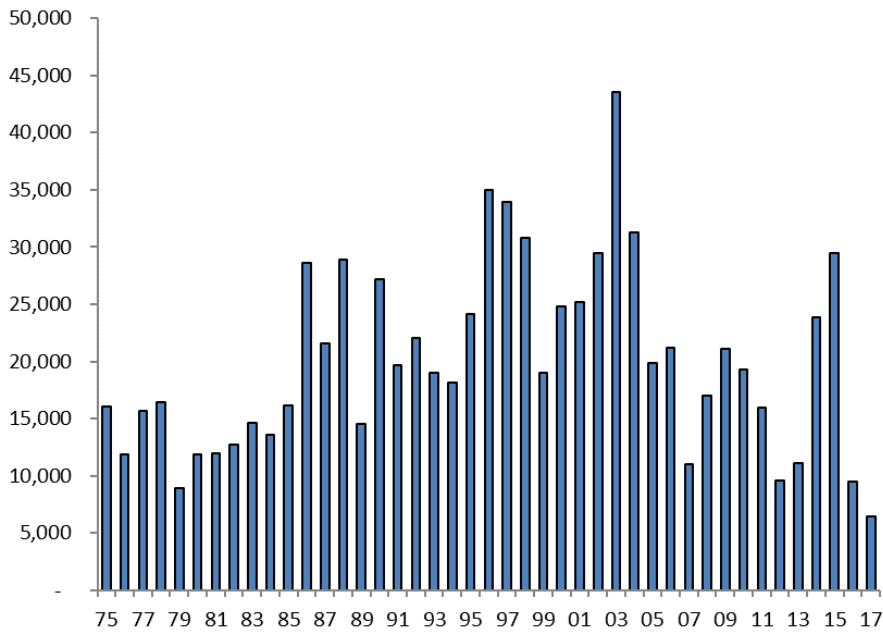


Figure 2.30.—Fraser River summer run age-1.3 stock group escapements of Chinook salmon, 1975–2017.

#### 2.3.3.4.4 Fraser River Summer Run: Age 0.3

The Fraser Summer-Run Age 0.3 aggregate includes six populations spawning in the South Thompson watershed and one in the lower Fraser. These include the Middle Shuswap, Lower Shuswap, Lower Adams, Little River and the South Thompson River mainstem, in the BC interior, and Maria Slough in the lower Fraser (CTC 2002b). Escapements to this stock group were low in 2017, although there was some variation within the stocks in the aggregate. Escapements were estimated at 84,470 in 2017 (Figure 2.31).

**Escapement Methodology:** Escapements are estimated using peak count visual survey and mark-recapture methods. Since 2000 (with the exception of 2003), the Lower Shuswap River has been an exploitation rate indicator stock for the Fraser Summer-run Age 0.3 stock group, and an MR program provides high precision estimates of escapement by age and sex. Tags have been applied to live fish by seining and salmon carcasses were examined later for the presence of marks. In addition, there are multiple years of MR and CWT data for the Middle Shuswap River. The estimated escapement for Lower Shuswap in 2017 was 13,430 which is less than half of the parental brood (Appendix Table B6). Since 2000, hatchery-origin fish averaged 11% of the escapement (range: 4%-22%; Figure 2.32), and were estimated to be 12% of the escapement in 2017.

**Escapement Goal Basis:** There is currently no PSC-agreed escapement goal for the aggregate. Habitat-based estimates of  $S_{MSY}$  and other stock-recruitment reference points are available for this stock group (Parken et al. 2006), but estimates of total escapement are needed to make them effective. Work is currently underway to estimate total escapements by developing factors that calibrate the visual survey indices to total escapements estimated by MR methods and novel methods developed during the Sentinel Stocks Program. Peak count estimates for the Lower Shuswap River from 1975 to 1999, and for 2003 have been calibrated to mark-recapture

equivalents. In the past two decades, with the exception of 2012 and 2016, Lower Shuswap River escapements have exceeded the median estimate of  $S_{MSY}$  (12,300; CV=17%).

**Agency Comments:** Escapements had been increasing for this stock group over the last decade and the stock group has been healthy and abundant, with the exception of the 2012 and 2016 escapement (the progeny of the 2012 brood year escapement).

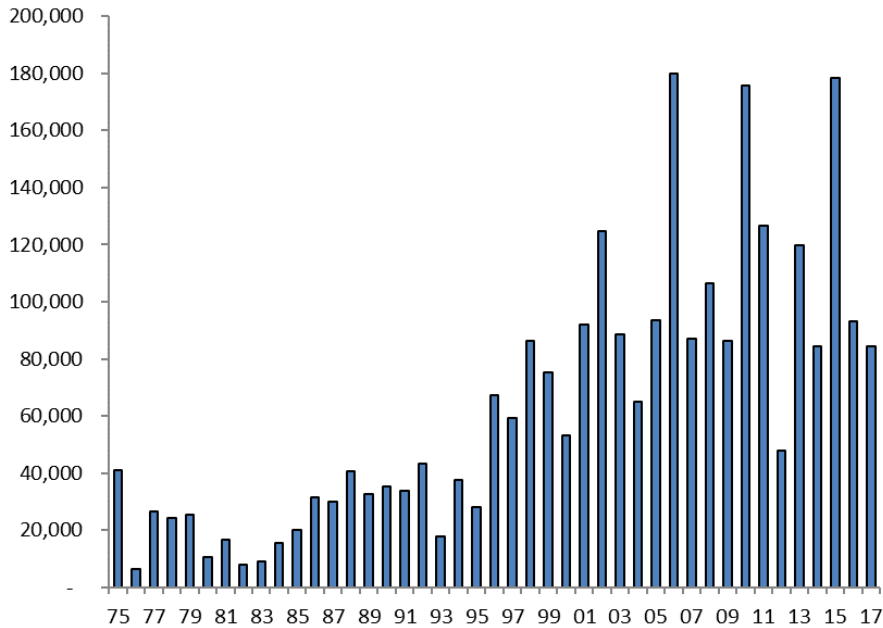


Figure 2.31.—Fraser River summer run age-0.3 stock group escapements of Chinook salmon, 1975–2017.

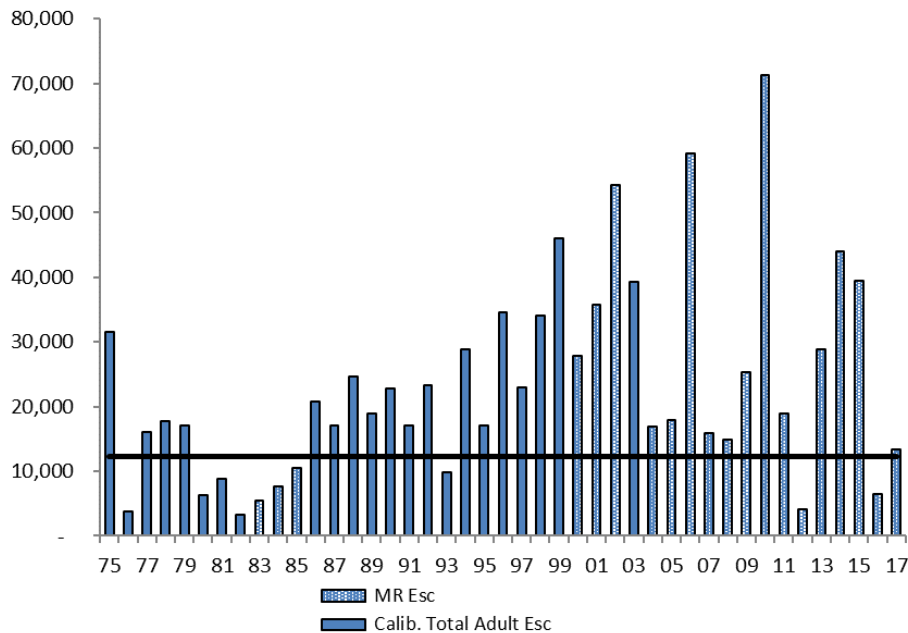


Figure 2.32.—Lower Shuswap River escapements of Chinook salmon, 1975–2017. The visual escapement estimates have been calibrated with the mark–recapture estimates.



#### **2.3.3.4.5 Fraser River Late Run (Harrison River)**

Harrison River Chinook salmon are white-fleshed fish that return to spawn during the fall. They are unusual in that the fry migrate into the lower Fraser River and estuary shortly after emergence. This stock spends 2-4 years in the coastal marine environment before returning to spawn. When healthy, the Harrison River stock is one of the largest naturally spawning Chinook salmon populations in the world and makes important contributions to fisheries in southern BC, and Washington State. Spawning escapements to the Harrison River have varied widely from a low of 28,616 adults in 1995 to a high of 246,984 adults in 2003 (Figure 2.31). Escapements were more than 15% below the lower bound of the escapement goal from 2012–2017 (excluding 2015), the estimated escapement in 2017 was only 27,799 adult Chinook salmon (Figure 2.33).

**Escapement Methodology:** Since 1984, MR studies have been conducted annually on the Harrison River to obtain reliable estimates of spawning escapements.

**Escapement Goal Basis:** Due to their natural abundance and importance in numerous British Columbia and Washington State fisheries, Harrison River Chinook salmon were designated as an escapement indicator stock (i.e., 'key stream' indicator) to aid in fulfilling commitments under the 1985 Pacific Salmon Treaty. In 1986, an interim escapement goal for Harrison River Chinook salmon was established at 241,700 fish, based on doubling of the escapement estimate obtained from a MR program in 1984. In 2001, an escapement goal range was developed for Harrison Chinook salmon using a Ricker stock-recruit approach (CTC 2002b). The escapement goal range that was proposed was 75,100–98,500 (CV=15%) with the upper bound equal to the upper 75% confidence limit derived from a bootstrap procedure. This range was reviewed and accepted by the CTC. Escapements have fluctuated substantially with no apparent trend in the time series, until the recent period of poor returns. Average contribution of enhanced fish is 4%.

**Agency Comments:** The stock was identified as a conservation concern in 2016 due its low escapement in five of the past six years relative to the escapement goal.

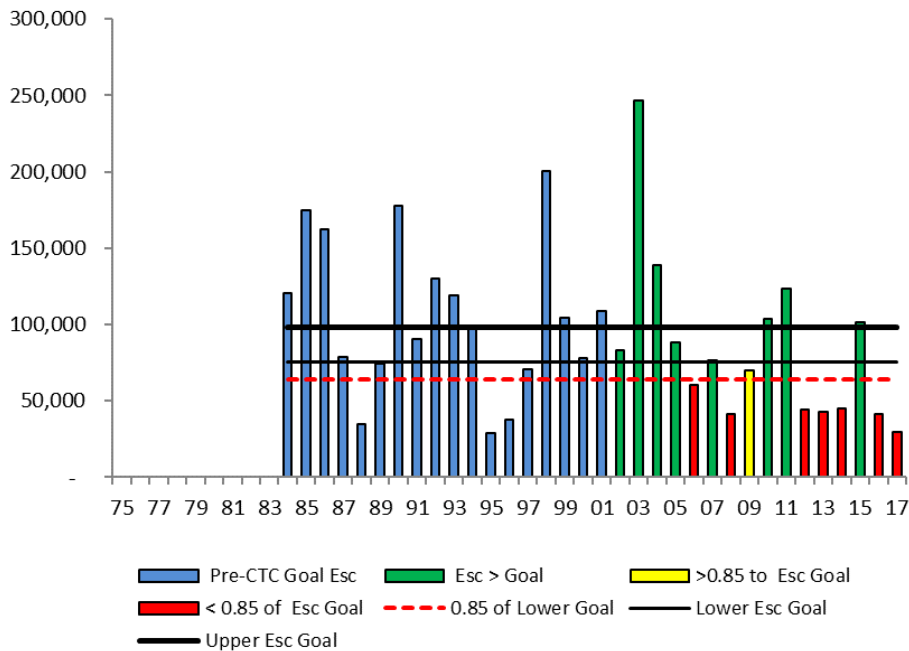


Figure 2.33.—Harrison River escapements of Chinook salmon, 1984–2017.

### 2.3.4 Puget Sound, Coastal Washington, Columbia River, and Coastal Oregon Stocks

The PSC escapement indicator stocks in Washington and Oregon are currently separated into four regional groups: Puget Sound, Washington Coastal, Columbia River, and North Oregon Coastal. Far north migrating Chinook salmon from the mid-Oregon Coast are currently being incorporated in the PSC Chinook model in this year’s base period recalibration. There are currently no CTC-agreed escapement indicator stocks for the Mid-Oregon Coastal group, although there have been two proposed (the South Umpqua and Coquille). The indicator stocks include a variety of run timings and ocean distributions.

Biologically based escapement goals have been reviewed and accepted by the CTC for four fall stocks (Queets, Quillayute, Hoh, and Grays Harbor) and two spring/summer stocks (Queets and Hoh) in coastal Washington, four Columbia River stocks (Lewis, Upriver Brights, Deschutes, and Mid-Columbia Summers), and three far north migrating Oregon coastal stocks (Nehalem, Siletz, and Siuslaw).

#### 2.3.4.1 Puget Sound

Puget Sound escapement indicator stocks include spring, summer/fall and fall Chinook salmon stocks from the Nooksack, Skagit, Stillaguamish, Snohomish, Lake Washington, and Green river systems. They tend to have a more local distribution than most coastal and Columbia River stocks and are caught primarily in WCVI AABM fisheries, and Canadian and US ISBM fisheries. Escapement for these stocks is defined as the total number of natural- and hatchery-origin fish spawning naturally on the spawning grounds.



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February 5, 2019

To First Nations and Stakeholders,

**Re: 2019 Fraser River Chinook Conservation Measures**

This letter is intended to communicate the Department’s approach for developing fisheries management actions to address conservation concerns for Fraser River Chinook in 2019. Additional information is outlined below on the conservation concerns for these stocks, proposed management approaches for consideration, and timelines for decision making. The Department will be seeking feedback on the proposed management approaches in February to inform possible adjustments to early season fisheries beginning in **April 2019**.

*Conservation concerns*

In November 2018, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) released the results for an assessment of 16 southern BC Chinook designatable units (DUs). Of these units, 13 DUs originate in the Fraser River with 7 DUs assessed as *endangered*, 4 *threatened* and 1 *special concern*; Southern Thompson Ocean Summer Chinook were deemed *not at risk*. For the other 3 DUs outside the Fraser River, 1 DU (East Vancouver Island Stream Spring; Nanaimo River) was assessed as *endangered* and 2 Southern Mainland DUs were data deficient. Status information is summarized in **Appendix 1** and at (<https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife/assessments/wildlife-species-assessment-summary-nov-2018.html>). COSEWIC is expected to submit these assessments to the Government of Canada via the annual report which is anticipated in the Fall 2019. This annual report will initiate the formal process to consider whether or not to these DUs will be listed under the *Species at Risk Act* (SARA). COSEWIC assessment of the remaining southern BC Chinook populations is also planned for 2019 with an expected report on the status of these DUs in Fall 2020.

In 2018, spawner abundances of Fraser Chinook salmon declined substantially compared with the parental brood year abundance for 4 of 5 management units (**Table 1**). In addition, productivity of many of these populations was likely further impacted by observations of smaller size at age, reduced fecundity, and lower proportions of females in spawner surveys. These observations are consistent with broad coast-wide declines in Chinook survival, size at age, and fecundity that have been documented for many populations (see [http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ScR-RS/2018/2018\\_035-eng.html](http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ScR-RS/2018/2018_035-eng.html)).

**Table 1: 2018 Spawner Abundance Relative to the Parental Brood Year and Recent Recruits per Spawner (R/S).**

Management Unit	2018 Spawners	Brood Year (2013 or 2014) Spawners	% Change	Projected Recruits per Spawner (R/S) <sub>c</sub>
Spring 4 <sub>2</sub>	2,100	24,867	-92%	0.04-0.08 <sup>A</sup>
Spring 5 <sub>2</sub>	8,399	15,947	-47%	0.6-0.9 <sup>A</sup>
Summer 5 <sub>2</sub>	5,443	12,604	-57%	0.5-0.8 <sup>A</sup>
Summer 4 <sub>1</sub>	46,543	84,700	-45%	0.85-0.93 <sup>A</sup>
Fall 4 <sub>1</sub> (Harrison)	46,094	44,686	3%	0.98 <sup>B</sup>

<sup>A</sup>Several assumptions were used to project recruits to account for missing age data, missing age-specific exploitation rates, infilling for incomplete escapements, and missing information to determine total hatchery-origin escapement.

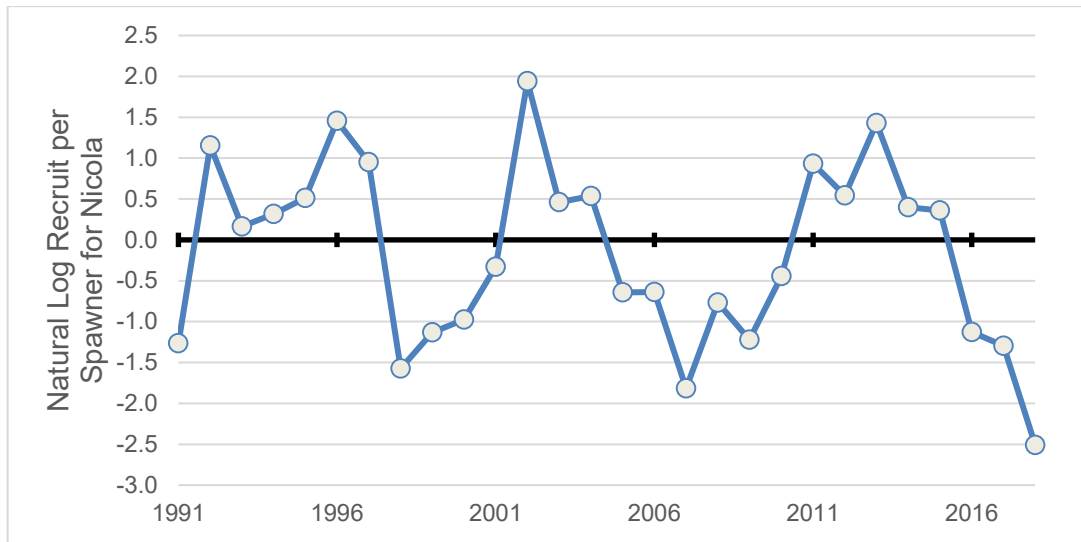
<sup>B</sup>Recruits and spawners reconstructed by cohort (brood year) using escapement goal methodology (Brown et al. 2001)

<sup>C</sup>Recruits represent the total number of adult offspring surviving to enter the fishery (i.e. pre-fishery abundance). Recruits are determined as catch plus spawners for the current year.

These declines in spawner abundance occurred even with additional fishery management actions implemented beginning in June of 2018 with the aim of reducing fishery mortality rates on Fraser Chinook salmon by 25-35%. An assessment of Coded-Wire Tag (CWT) data to determine fishery mortalities by fishery and location will be required to assess whether the target fishery reductions were achieved. This will take place when CWT data becomes available (March 2019).

The most serious declines in productivity have occurred for Spring 4<sub>2</sub> Chinook where projected R/S has declined to 0.04 to 0.08 R/S and the lowest on record since 1991. For every 100 parental spawners, between 4 and 8 adult recruits are projected to have returned before fishery removals (**Table 1; Figure 1**). When R/S is less than 1, populations will not replace themselves even in the absence of fishing mortality and spawner abundance will continue to decline; additional fishing mortality will increase declines in spawner abundance.

Figure 1: Time series of pre-fishery recruits per spawner for Spring 4<sub>2</sub> Chinook (Information for the Nicola River CWT indicator population).



Index values use a natural log scale where 0 equates to 1 recruit per spawner. Points below the x-axis (values less than 0) represent R/S less than 1 and will result in declining spawner abundance.

Recruits per spawner have also declined below 1 R/S for the Spring 5<sub>2</sub>, Summer 5<sub>2</sub>, Summer 4<sub>1</sub> and Fall 4<sub>1</sub> indicator populations; (see **Appendix 2**).

Southern Resident Killer Whales (SRKW) also continue to face threats to their survival and recovery and the Government is planning additional measures to strengthen protection of the species in 2019, these measures may have further implications for salmon fisheries. The seasonal distribution and movement patterns of SRKW are strongly associated with the availability of their preferred prey, Chinook salmon. The Department is working with a Technical Working Group to identify recommended approaches to support increased Chinook prey availability for SRKW.

#### *Proposed Management Approaches*

To address conservation concerns for Fraser River Chinook, the Department is proposing additional precautionary reductions in Canadian fishery mortalities. Proposed management objectives for each management unit are identified below

Table 2: Summary of Proposed Management Objectives

Management Unit	Management Objective	Considerations	Proposed CDN Fishery Mortality Range
<p><b>Spring 4<sub>2</sub></b></p> <p><b>Spring 5<sub>2</sub></b></p> <p><b>Summer 5<sub>2</sub></b></p>	<p>Maximize the number of returning Chinook reaching spawning grounds by reducing Canadian fishery mortalities to the greatest extent possible.</p>	<p>Substantial reductions in fishery mortalities are required for Spring 4<sub>2</sub>, Spring 5<sub>2</sub> and Summer 5<sub>2</sub> Chinook given their poor stock status, extremely poor productivity and expectations for continued declines in spawner abundance. Any fishery mortalities will worsen spawner declines unless productivity improves. New measures are anticipated to affect commercial, recreational and FSC fisheries.</p>	<p>The magnitude of reductions in CDN fishery mortalities will depend on the management measures implemented. Two scenarios are proposed that would aim to reduce total CDN fishery mortalities to less than 5% (see Scenario A below) or less than 10% (see Scenario B below).</p> <p>Recent CDN fishery mortalities averaged 14.5% (2013-2016) based on Spring 4<sub>2</sub> (Nicola) CWT indicator. Reducing fishery mortalities below 5% would require an overall 65% reduction.</p>
<p><b>Summer 4<sub>1</sub></b></p>	<p>Precautionary reduction in fishery mortalities similar to 2018 to protect co-migrating Fraser Chinook stocks of concern.</p>	<p>South Thompson Chinook were designated by COSEWIC as <i>Not At Risk</i>; however, productivity (R/S &lt;1) and fecundity has declined for this group since 2015 and there are concerns for the Maria Slough conservation unit given that fewer than 20 spawners returned in 2018. In addition, the migration of Summer 4<sub>1</sub> Chinook overlaps with other Fraser Chinook stocks of conservation concern, particularly Summer 5<sub>2</sub> chinook.</p> <p>Additional reductions in commercial and recreational fishery harvest opportunities will also need to be considered to support priority access for FN FSC fisheries in the Fraser River given expectations for very limited FSC fishery opportunities in 2019.</p>	<p>Reducing CDN fishery mortalities to 20% or less is proposed.</p> <p>Recent fishery mortalities average 27.5% (2013-2016) based on the Lower Shuswap CWT indicator. Reducing fishery mortalities to 20% or less would require a 25% or greater reduction.</p>

<p><b>Fall 4<sub>1</sub></b></p>	<p>Fraser Fall 4<sub>1</sub> (Harrison) Chinook is the only Fraser management unit with an approved management objective.</p> <p>The management objective is to achieve the spawning escapement goal range of 75,100 to 98,500 spawners.</p> <p>A precautionary reduction in CDN fishery mortalities is proposed, similar to 2018.</p>	<p>Since 2012, the escapement goal has not been achieved, with the exception of 2015, and the COSEWIC stock status is <i>threatened</i>. Given declines in productivity (<math>R/S &lt; 1</math>) and recent average fishery mortalities, spawner abundance may not reach the lower bound of the escapement goal range in 2019.</p> <p>Additional reductions in commercial and recreational impacts will need to be considered.</p>	<p>Reducing CDN fishery mortalities to 13% or less is proposed.</p> <p>Current fishery mortalities average 17% (2013-2016) based on the Harrison CWT indicator. Reducing fishery mortalities to 13% or less would require a 25% or greater reduction.</p>
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Note: Projected Canadian fishery mortalities used in **Table 2** are based on the average fishery mortalities for all Canadian fisheries from 2013 to 2016. **Appendix 3** shows where Fraser Chinook CWT indicator stocks have been encountered in BC fisheries and the corresponding average fishery mortalities (%) for the 2013-16 period.

## *Potential Fishery Scenarios*

Achieving the proposed management objectives will require additional reductions in fisheries impacts in times and areas where Fraser Chinook are encountered in Northern and Southern BC, including commercial, recreational and First Nations fisheries. Fraser Spring 4<sub>2</sub> and Spring 5<sub>2</sub> Chinook return to spawn from early March through late July, with migration peaks in June through the lower Fraser River. Summer 5<sub>2</sub> Chinook have later timing and return to the Fraser River to spawn from late June to August with a peak in late July.

Two potential fishery scenarios are outlined below that provide examples of potential management actions that would be required for Fraser Spring 4<sub>2</sub>, Spring 5<sub>2</sub> and Summer 5<sub>2</sub> Chinook to achieve less than 5% Canadian fishery mortalities (Scenario A) or less than 10% Canadian fishery mortalities (Scenario B).

**These are initial scenarios for discussion purposes; alternative fishery scenarios and/or management actions contained within a scenario may be considered based on feedback received.**

**Scenario A** – This approach would target a high degree of protection for Fraser Spring 4<sub>2</sub>, Spring 5<sub>2</sub> and Summer 5<sub>2</sub> Chinook, to permit as many fish as possible to pass through fisheries to spawning areas. This approach would aim to reduce total Canadian fishery mortalities to less than 5%. This would require commercial troll fisheries in Northern BC (Area F) and the West Coast of Vancouver Island (Area G) to remain closed through July (Area G) and to July 17 (Area F). Marine recreational Chinook fisheries along migration corridors in southern BC would be Chinook non-retention. Recreational fisheries in the Fraser River would remain closed to fishing for salmon into August, followed by no fishing for Chinook if there are openings for other species. First Nations FSC fisheries opportunities would be restricted to unplanned events or very limited communal fisheries. For fisheries following the Summer 5<sub>2</sub> migration, fishery measures would target reductions similar to 2018 for Summer 4<sub>1</sub> and Fall 4<sub>1</sub> Chinook with possible measures including:

- Measures to reduce removals in marine recreational fisheries (e.g. reduced daily/possession limit, hatchery-marked Chinook retention, size limit adjustments).
- Closures to salmon fishing or non-retention of Chinook salmon in Fraser River recreational fisheries.
- Possible reduction in harvest allocations in commercial troll fisheries.
- Consideration of retention of Chinook by-catch and/or limited Chinook-directed opportunities for FSC fisheries.

**Scenario B** – This approach would aim to reduce Canadian fishery mortalities to 10% or less for Fraser Spring 4<sub>2</sub>, Spring 5<sub>2</sub> and Summer 5<sub>2</sub> Chinook. This would require commercial troll fisheries in Northern BC (Area F) and the West Coast of Vancouver Island (Area G) to remain closed through July (Area G) and to July 10 (Area F). Southern BC marine recreational Chinook fisheries would have reduced daily limits and/or hatchery-marked retention depending on time/location. Recreational fisheries in the Fraser River would remain closed to fishing for salmon through July until August 23. First Nations FSC fisheries would have management actions similar to 2018. For fisheries following the Summer 5<sub>2</sub> migration, fishery measures would target reductions similar to 2018 for Summer 4<sub>1</sub> and Fall 4<sub>1</sub>.



Table 3: Summary Table of proposed management actions for Scenario A and B

Fishery	Scenario A	Scenario B
<b>Commercial</b>		
NBC AABM (Area F) Troll	Closed to July 17	Closed to July 10
WCVI AABM (Area G) Troll	Closed to August 1	Closed to August 1
Kamloops Lake Chinook Demonstration Fishery	Closed	Closed
<b>Recreational</b>		
NBC AABM	<i>No measures proposed for Fraser chinook</i>	<i>No measures proposed for Fraser chinook</i>
NBC ISBM	<i>No measures proposed for Fraser chinook</i>	<i>No measures proposed for Fraser chinook</i>
WCVI AABM (Areas 121 to 127)	a) Apr 1 to July 31, Chinook non-retention; b) Aug 1 to Dec 31, 2 Chinook/day.	<i>No measures proposed for Fraser chinook</i>
WCVI ISBM	<i>No measures proposed for Fraser chinook</i>	<i>No measures proposed for Fraser chinook</i>
Johnstone Strait (Area 12)	c) Apr 1 to July 31, Chinook non-retention; d) Aug 1 to Aug 29, 1 Chinook/day (with option for terminal fisheries); e) Aug 30 to Dec 31, 2 Chinook/day.	a) Apr 1 to August 29, 1 Chinook/day (with option for terminal fisheries). b) Aug 30 to Dec 31, 2 Chinook/day.
Strait of Georgia – North Areas 13 to 17, 28, portion of 29 (29-1 and 29-2)	a) Apr 1 to July 31, Chinook non-retention; b) Aug 1 to Aug 29, 1 Chinook/day (with option for terminal fisheries); c) Aug 30 to Dec 31, 2 Chinook/day.	d) Apr 1 to August 29, 1 Chinook/day (with option for terminal fisheries). e) Aug 30 to Dec 31, 2 Chinook/day.
Strait of Georgia – South and Juan de Fuca Areas 18 to 20, portions of Area 29 (29-3 to 29-5)	a) Apr 1 to July 31, Chinook non-retention; b) Aug 1 to Aug 29, 1 Chinook/day (with option for terminal fisheries); c) Aug 30 to Dec 31, 2 Chinook/day.	a) Apr 1 to July 31, 1 chinook/day; <u>hatchery marked only</u> b) Aug 1 to Aug 29, 1 Chinook/day (with option for terminal fisheries) c) Aug 30 to Dec 31, 2 Chinook/day.
Fraser River Tidal and Non Tidal and Sub area 29-6 to 29-10	a) Jan. 1 to August 23 , No fishing for salmon. Aug. 23 to Dec. 31, Chinook non-retention	a) Jan. 1 to August 23 , No fishing for salmon. b) Aug. Aug 23 to December 31, 1 Chinook/day
Freshwater Regions 3,5,7 &8	b) closed to fishing for salmon except in some areas where fisheries on other stocks or species may take place.	c) closed to fishing for salmon except in some areas where fisheries on other stocks or species may take place.

First Nations		
South Coast	a) Fishing to FSC communal allocations as in previous years; marine FSC Chinook fisheries are largely terminal and directed at local Chinook stocks. No measures proposed for SCA First Nations chinook fisheries.	A) Fishing to FSC communal allocations as in previous years; marine FSC Chinook fisheries are largely terminal and directed at local Chinook stocks. No measures proposed for SCA First Nations chinook fisheries.
Lower Fraser	a) Jan. 1 to Aug 10, very limited impacts on chinook in FSC fisheries b) After Aug. 10, targeted chinook fishing or bycatch during sockeye-directed opportunities.	a) Jan. 1 to Aug 10, limited chinook directed FSC fisheries with effort limitations extended to Aug. 10 or bycatch during sockeye-directed opportunities b) After Aug. 10, targeted chinook fishing or bycatch during sockeye-directed opportunities.
BC Interior - d/s of Thompson Confluence	a) Jan 1 to Aug 10, very limited impacts on chinook in communal FSC fisheries. Time or gear restrictions. b) After Aug. 10 limited selective chinook fishing or bycatch during sockeye-directed opportunities until. Later in August, targeted chinook fishing or by-catch during sockeye directed fishing. Low impact terminal harvests.	a) Jan 1 to Aug 10 limited communal FSC fisheries. Time or gear restrictions. b) After Aug 10, Directed chinook fishing or bycatch during sockeye-directed opportunities.
BC Interior - u/s of Thompson Confluence Note: the only chinook in the area are Spring 5 <sub>2</sub> and Summer 5 <sub>2</sub> chinook.	Fisheries in the area constrained by preferred gear type or fishing times. Discussion required to reduce overall catch.	Fisheries in the area constrained by preferred gear type or fishing times.

**Appendix 4** outlines the specific fishery management measures that were implemented in 2018.

*Process*

The Department is seeking feedback from First Nations and stakeholders on the proposed fishery scenarios, or effective alternatives, and on the associated fishery management actions that best achieve the management objectives. The Department will consider feedback and evaluate expected outcomes for consistency with proposed management objectives, conservation and allocation priorities, support for effective implementation and fostering compliance, and consider potential impacts on fishery monitoring and stock assessment programs (e.g. CWT data). Any proposed measures will also be evaluated for compliance with new fishery reductions identified for Canadian and US Chinook indicator populations under the renewed provisions of the Pacific Salmon Treaty. The revised versions of Annex IV, Chapters 1, 2, 3, 5, and 6 (plus current text for Chapters 4, 7, and 8) have been posted at

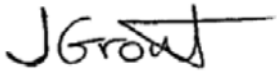
<https://www.psc.org/publications/pacific-salmon-treaty/>. Please note that Chapters 1, 2, 3, 5, and 6 are not yet formally in force, but the Parties have agreed to provisionally apply them as of January 1, 2019.

Given the early run timing of Fraser Chinook and potential importance of these stocks to SRKW in the early spring, the Department is considering adjustments to early season fisheries that occur between April and June 2019. Department staff will meet with First Nations and stakeholders through the **end of February** to discuss potential management scenarios and supporting information on consequences of potential early season actions to support decision making.

Fishery management measures later in the season (i.e. July 2019 and onward) will be considered as part of the process to develop the 2019/2020 Salmon Integrated Fisheries Management Plans. Further discussion with First Nations and advisory groups will take place during the consultation process to develop the 2019/20 salmon IFMPs.

If you wish to provide feedback, please do so in writing, by **March 1, 2019** to the DFO Pacific Salmon Management Team at [DFO.PacificSalmonRMT-EGRSaumonduDpacifique.MPO@dfo-mpo.gc.ca](mailto:DFO.PacificSalmonRMT-EGRSaumonduDpacifique.MPO@dfo-mpo.gc.ca). Feedback received will be summarized by the Department and any recommendations on harvest planning will be provided to First Nations and the Departments advisory committees, including the Sport Fishing Advisory Board (SFAB), Commercial Salmon Advisory Board (SFAB), Marine Conservation Caucus (MCC) and Integrated Harvest Planning Committee (IHPC) for further consideration.

Yours sincerely,



Jeff Grout  
Regional Resource Manager, Salmon

Appendices (4):

1. Summary of Stock Status of Fraser River BC Chinook Designatable Units.
2. Trends in productivity (R/S) for Fraser Chinook management units.
3. Graphical representation of average Canadian total fishing mortalities for Fraser River Chinook CWT indicator populations for the 2013-2016 period.
4. Summary of 2018 fishery management measures.

Appendix 1: Stock Status of Fraser River BC Chinook Designatable Units.

Fishery Management Unit	Designatable Unit	COSEWIC Assessment	CU and WSP Status no colour = TBD gray = Data Deficient orange = red/amber	Spawning Locations
Spring 4 <sub>2</sub> Chinook	DU14 BC South Thompson Stream Summer	<i>Endangered</i>	CK-16 STh Bessette Creek	Bessette Creek, Creighton Creek; Duteau Creek; Harris Creek
	DU15 BC Lower Thompson Stream Spring	<i>Not assessed</i>	CK-17 Lower Thompson Spring	Bonaparte River; Coldwater River; Deadman River; Louis Creek; Nicola River; Spius Creek
Spring 5 <sub>2</sub> Chinook	DU3 BC Lower Fraser River Stream Spring	<i>Special Concern</i>	CK-04 LFR Spring	Birkenhead
	DU4 BC Lower Fraser River Stream Summer (Upper Pitt)	<i>Endangered</i>	CK-05 LFR Upper Pitt	Pitt River-Upper
	DU7 BC Middle Fraser River Stream Spring	<i>Endangered</i>	CK-08 FR Canyon-Nahatlatch	Anderson, Nahatlatch
	DU9 BC Middle Fraser River Stream Spring	<i>Threatened</i>	CK-10 MFR Spring	Cariboo River-upper; Chilako River; Chilcotin River upper; Chilcotin River-lower; Cottonwood River; Horsefly River; Narcosli Creek; Naver Creek; West Road River and others
	DU11 BC Upper Fraser River Stream Spring	<i>Endangered</i>	CK-12 UFR Spring	Bowron River; Dome Creek; East Twin Creek; Fraser River-above Tete Jaune; Forgetmenot Creek; Goat River; Holliday Creek; Holmes River; Horsey Creek; Humbug Creek; Kenneth Creek; McGregor River; McKale River; Morkill River; Nevin Creek; Ptarmigan Creek; Slim Creek; Small Creek; Snowshoe Creek; Swift Creek; Torpy River; Walker Creek; Wansa Creek; West Twin Creek; Willow River; and others
	DU16 BC North Thompson Stream Spring	<i>Endangered</i>	CK-18 NTHOM Spring	Albreda River; Blue River; Finn Creek; Lyon Creek; Mad River

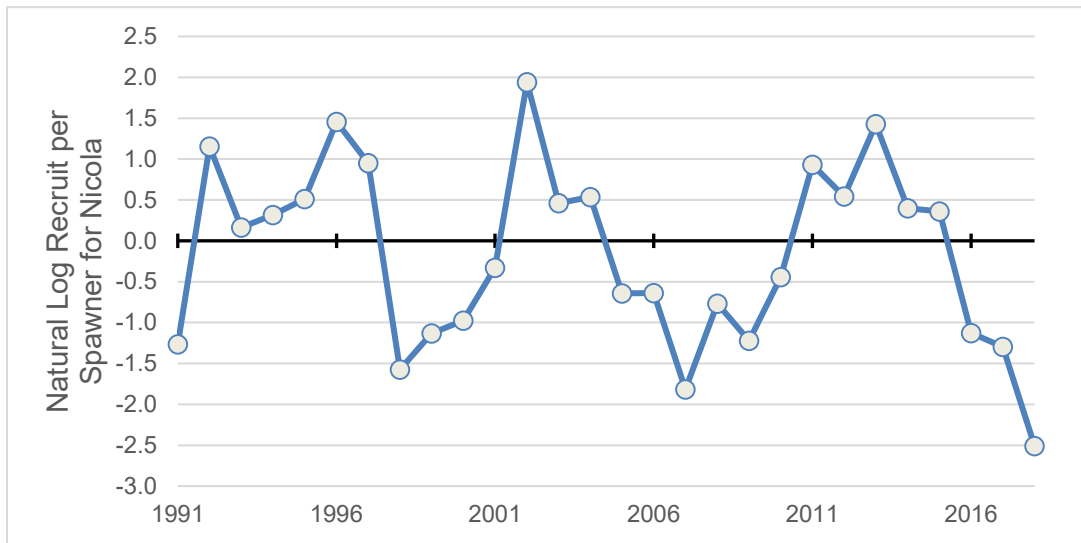
<b>Summer 5<sub>2</sub> Chinook</b>	DU5 BC Lower Fraser River Stream Summer	<i>Threatened</i>	<b>CK-06 LFR Summer</b>	Big Silver Creek; Chilliwack/Vedder River; Cogburn Creek; Douglas Creek; Green River; Lillooet River; Sloquet Creek; Tipella Cr.
	DU8BC Middle Fraser River Stream Fall	<i>Endangered</i>	<b>CK-09 MFR Portage</b>	Portage
	DU10 BC Middle Fraser River Stream Summer	<i>Threatened</i>	<b>CK-11 MFR Summer</b>	Bridge River; Cariboo River lower; Chilko River; Endako River; Kazchek Creek; Kuzkwa River; Nechako River; Quesnel River; Seton River; Stellako River; Stuart River; and others
	DU13 BC South Thompson Stream Summer	<i>Not assessed</i>	<b>CK-14 STh Summer age 5<sub>2</sub></b>	Eagle River; Salmon River
	DU17 BC North Thompson Stream Summer	<i>Endangered</i>	<b>CK-19 NTHOM Summer</b>	Barriere River; Clearwater River; Lemieux Creek; Mahood River; Mann Creek; North Thompson River; Raft River
<b>Summer 41 Chinook</b>	DU6 BC Lower Fraser River Ocean Summer	<i>Not assessed</i>	<b>CK-07 Maria Slough Summer</b>	Maria Slough
	DU12 BC South Thompson Ocean Summer	<i>Not At Risk</i>	<b>CK-13 STh Summer age 4<sub>1</sub></b> <b>CK-15 Shuswap River Summer</b>	Adams River; Little River; South Thompson River; Lower Thompson River; Lower Shuswap, Middle Shuswap
<b>Fraser Fall 4<sub>1</sub> Chinook</b>	DU2 BC Lower Fraser River Ocean Fall	<i>Threatened</i>	<b>CK-03 LFR Fall</b>	Harrison
<b>ECVI and Mainland Chinook</b>	DU19 BC East Vancouver Island Stream Spring	<i>Endangered</i>	<b>CK-23 East Vancouver Island – Nanaimo Spring</b>	Nanaimo River - Upper

**Appendix 2:** Trends in productivity (R/S) for Fraser Chinook management units.

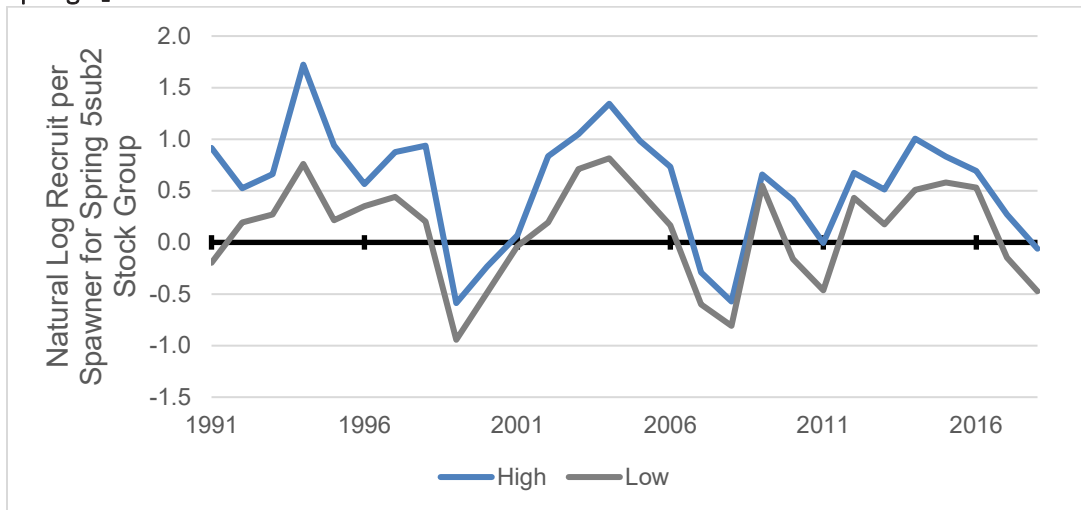
Notes:

1. For the Spring 4<sub>2</sub> and Summer 4<sub>1</sub> stocks, R/S estimates are shown for the CWT indicator stock, Nicola and Lower Shuswap, respectively.
2. For the Spring 5<sub>2</sub> and Summer 5<sub>2</sub> stocks, R/S series were generated using the CWT CYER data from Nicola and from Lower Shuswap to provide a range of R/S. This provides an index of recruitment but not a direct measure given assumptions (e.g. missing age data, missing age-specific exploitation rates, infilling for escapement, inability to measure total hatchery-origin escapement).
3. For the Fall 4<sub>1</sub>, the R/S series was based on recruits and spawners reconstructed by cohort (brood year) using the established escapement goal methodology (Brown et al. 2001)

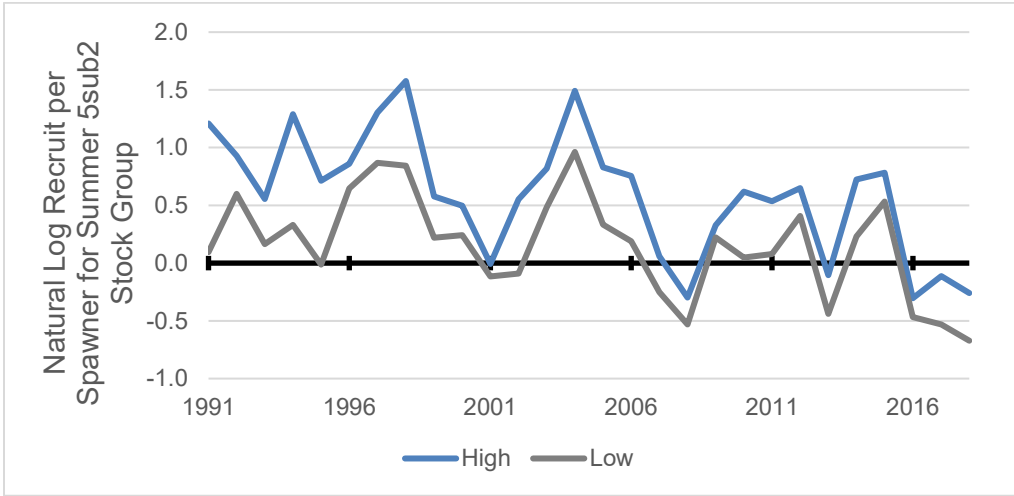
**Spring 4<sub>2</sub> (Nicola Indicator)**



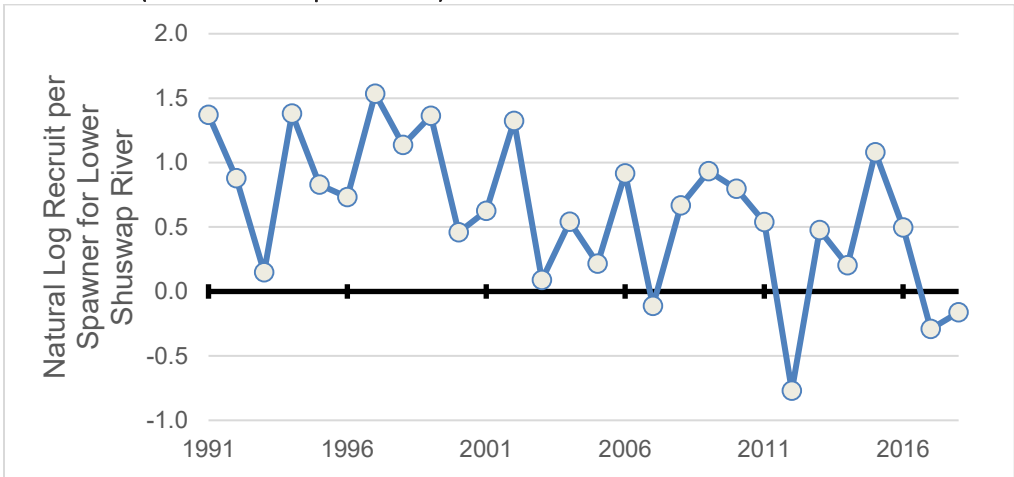
**Spring 5<sub>2</sub>**



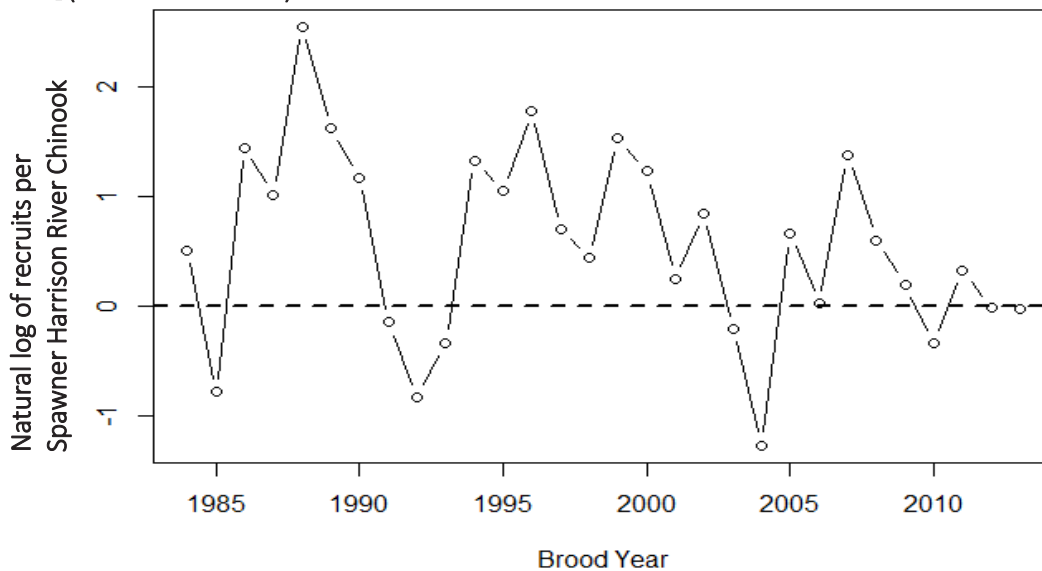
Summer 5<sub>2</sub>



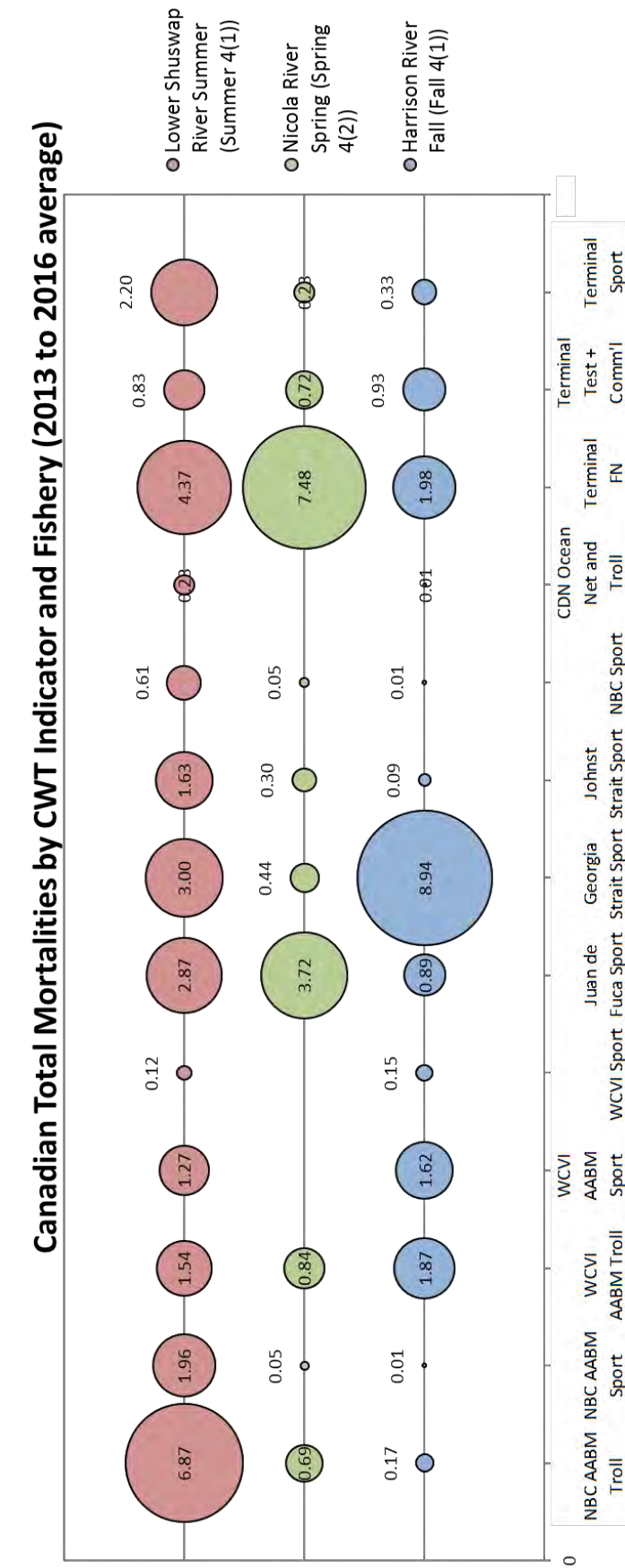
Summer 4<sub>1</sub> (Lower Shuswap indicator)



Fall 4<sub>1</sub> (Harrison indicator)



**Appendix 3:** Graphical representation of average Canadian total fishing mortalities for Fraser River Chinook CWT indicator populations for the 2013-2016 period.



Numbers in bubbles represent average number of Chinook fishery mortalities per 100 Chinook in the total run based on the hatchery CWT indicator stock. For example, CDN fishery mortalities for Nicola Chinook total 14.5% (sum of grey bubbles/100) and with US removals of 2.3% (not shown in figure); total fishery mortalities are 16.9% with remaining 83.1% of run going to spawning grounds



**Appendix 4:** Summary of 2018 fishery management measures.

**FN0428-Conservation Measures for Northern and Southern BC Chinook Salmon and Southern Resident Killer Whales**

[https://notices.dfo-mpo.gc.ca/fns-sap/index-eng.cfm?pg=view\\_notice&DOC\\_ID=208486&ID=all](https://notices.dfo-mpo.gc.ca/fns-sap/index-eng.cfm?pg=view_notice&DOC_ID=208486&ID=all)

This notice provides information on planned conservation measures for Northern and Southern BC Chinook Salmon and Southern Resident Killer Whales that will be implemented beginning June 1, 2018.

**Chinook Conservation Measures**

To address Chinook conservation concerns, DFO is implementing a precautionary 25-35% reduction in exploitation rates for Chinook stocks of concern to support conservation and promote rebuilding. These additional reductions are planned to address conservation concerns for Nass River, Skeena River and many small wild Chinook populations in Northern BC; and, all Fraser River Chinook populations (including Spring 4(2), Spring 5(2), Summer 5(2), Summer 4(1) and Fall 4(1) populations) in Southern BC.

Additional Northern BC Chinook management measures are outlined below, followed by additional Southern BC Chinook management measures.

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**Northern Commercial Fisheries**  
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Area F Troll - opening of AABM Chinook fishery delay to July 10 in addition to boundary changes. Refer to the subsequent Fishery Notice for details.

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**Northern Recreational Fisheries**  
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Please note that possession limits for Chinook Salmon are twice the daily limit.

The recreational daily limits of Chinook Salmon are being reduced in North Coast tidal waters as follows:

**Haida Gwaii:**

Effective June 1, 2018 to July 9, 2018, the daily limit is one (1) Chinook per day in Areas 1, 2, 142, and that portion of Area 101 west of 131 degrees 40.0 minutes West longitude

**North Coast:**

Effective June 1, 2018 to June 15, 2018, the daily limit is one (1) Chinook per day in Areas 3 to 5, 103 to 105, Subarea 102-1, and that portion of Area 101 east of 131 degrees 40.0 minutes West longitude

Effective June 16, 2018 to July 9, 2018, there is zero (0) retention of Chinook Salmon in Areas 3 to 5, 103 to 105, Subarea 102-1, and that portion of Area 101 east of 131 degrees 40.0 minutes West longitude

Effective July 10, 2018 to July 31, 2018, the daily limit is one (1) Chinook per day in Areas 3 to 5, 103 to 105, Subarea 102-1, and that portion of Area 101 east of 131 degrees 40.0 minutes West longitude

Effective June 1, 2018 to July 31, 2018 the daily limit is one (1) Chinook per day in Areas 6 and 106

Variation Order Number: 2018-RFQ-0307

Management measures for northern BC non-tidal waters were previously announced in FN0372 issued May 8, 2018.

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Southern BC Commercial Fisheries  
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Area G Troll:

There is no commercial fishery for AABM Chinook in June or July.

Area B Seine and Area H Troll:

Effective June 1 to September 30, 2018, there is no commercial salmon fishing in Subareas 20-3, 20-4 and that portion of Subarea 20-5 that lies west of 123 degrees 49.30 minutes west longitude (Otter Point).

Area B Seine and Area H Troll:

Effective June 1 to September 30, 2018 there is no commercial salmon fishing in Subareas 18-2, 18-4, 18-5 and 18-9.

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Southern BC Recreational Fisheries:  
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Southern BC Inside Waters

Areas 13 to 18, 28 and 29 and Subareas 19-1 to 19-6 (except those portions listed below):

Effective June 1, 2018 until September 30, 2018, the daily limit for Chinook Salmon is one (1) per day in in Areas 13 to 17, 28 and 29 with the exception of those four areas listed below under the headings Strait of Georgia, Pender Island, Juan de Fuca and Fraser River mouth. Terminal fishing opportunities at full limits for Chinook may be considered in-season if abundance permits.

Effective October 1, 2018 until further notice, the daily limit for Chinook Salmon is two (2) per day in in Areas 13 to 19, 28 and 29.

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Exceptions:  
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Strait of Georgia:

Note: this measure came into effect on May 7, 2018 as previously announced in FN0370 issued May 7, 2018.

Effective immediately until June 28, 2018 the daily limit for Chinook salmon is two (2) per day, of which only one may be greater than 67 cm in Subareas 18-1, 18-3, 18-6, 18-11, and 19-5.

Effective June 29, 2018 to July 31, 2018 the daily limit is two (2) Chinook salmon per day between both of which must be less than 85 cm in Subareas 18-1, 18-3, 18-6, 18-11, and 19-5.

Chinook salmon retained in these waters must have a fork length of at least 62cm.

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Pender Island:

Effective June 1 to September 30, 2018 there is no fishing for finfish in Subareas 18-2, 18-4, 18-5 and 18-9.

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Juan de Fuca (Subareas 19-1 to 19-4 and Area 20):

Effective June 1, 2018 to September 30, 2018 there is no fishing for finfish in Subareas 20-3, 20-4 and that portion of Subarea 20-5 that lies west of 123 degrees 49.30 minutes west longitude (Otter Point)

Effective June 1, 2018 until June 28, 2018 the daily limit for Chinook salmon is two (2) per day which may be wild or hatchery marked between 45 and 67 cm fork length or hatchery marked greater than 67 cm in Subareas 19-1 to 19-4 and 20-6 and 20-7 and that portion of Subarea 20-5 that lies east of 123 degrees 49.30 minutes west longitude (Otter Point).

Effective June 29, 2018 until July 31, 2018, the daily limit for Chinook salmon is two (2) Chinook per day which may be wild or hatchery marked between 45 and 85 cm or hatchery marked greater than 85 cm in Subareas 19-1 to 19-4 and 20-6 and 20-7 and that portion of Subarea 20-5 that lies east of 123 degrees 49.30 minutes west longitude (Otter Point).

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Fraser River Mouth (Subareas 29-6, 29-7, 29-9 and 29-10):

Effective June 1, 2018 to September 30, 2018, there is no fishing for salmon in Subareas 29-7, 29-9 and 29-10.

Effective June 1, 2018 to July 31, 2018, there is no fishing for salmon in Subarea 29-6.

Effective August 1, 2018 to September 30, 2018, there is no retention of Chinook Salmon in Subarea 29-6.

Variation Order Number: 2018-RFQ-0307; 2018-RCT-0321

# TAB C

**Roberts Bank Terminal 2 Project**  
**Environmental Impact Statement Marine Shipping Addendum – Comments on Completeness**  
 November 12 – December 16, 2015

I am Dr. Chris Kennedy, an aquatic toxicologist and professor at the Simon Fraser University in British Columbia. I have been retained on behalf of Georgia Strait Alliance, Western Canada Wilderness Committee, David Suzuki Foundation and Raincoast Conservation foundation to assist them in the Terminal 2 review.

**Comments on Completeness of Information in the EIS**

<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>
Indicators (EIS Guidelines; 10.1, Environmental Effects and 17.2.2 Description of Activity)	<i>Addendum, Section 8.2.2 Indicators p. 8.2-3, Table 8.2-1</i>	Include or provide justification for absence of water and sediment quality as an indicator in Table 8.2-1.	The description of indicators in Section 8.2.2 of the Addendum states that the indicators selected for this assessment are the same as those used in the RBT2 EIS. However those in the RBT2 EIS include 'Water and Sediment Quality' (p. 14-4)
Indicators EIS Guidelines; 10.1, Environmental Effects and 17.2.2 Description of Activity	<i>Addendum, Section 8.2.2 Indicators</i>	Provide a description of ballast water release as a source of contamination in the LAA and rationale for it absence as a potential to cause adverse health effects in SRKW.  Provide a detailed description of ballast water treatment and release activities.	Ships outlined for use in the completed project use large amounts of ballast water, which is often taken on in the coastal waters in one region after ships discharge wastewater or unload cargo, and discharged at the next port of call, wherever more cargo is loaded. Ballast water discharge typically contains a variety of biological materials which may affect SRKW.
Indicators (EIS Guidelines; 10.1, Environmental Effects and 17.2.2	<i>Addendum, Section 8.2.2 Indicators</i>	Provide a description of bilge water release as a source of contamination in the LAA and rationale for it absence as a potential to cause adverse health effects in SRKW.	Leaks and engine maintenance activities release oil and gasoline and along with the degradation products of petroleum, will contaminate water in the bilge. Bilge water also may contain solid wastes and other contaminants, as well as high biological oxygen demand which may affect SRKW.

**Roberts Bank Terminal 2 Project**  
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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>
Description of Activity)		Provide a detailed description of bilge water treatment and release activities.	
Indicators (EIS Guidelines; 10.1, Environmental Effects and 17.2.2 Description of Activity)	<i>Addendum, Section 8.2.2 Indicators</i>	Provide a description of sewage (grey or blackwater) release as a source of contamination in the LAA and rationale for it absence as a potential to cause adverse health effects in SRKW.  Provide a detailed description of grey and blackwater treatment and release activities.	Ships can release large amounts of greywater into the oceans. Sewage can contain bacteria, pathogens, viruses, parasites, nutrients, detergents, oil and grease, organic compounds, metals and other contaminants which may affect SRKW.
Indicators (EIS Guidelines; 10.1, Environmental Effects and 17.2.2 Description of Activity)	<i>Addendum, Section 8.2.2 indicators</i>	Provide a list of chemicals of potential concern (COPCs) in each of grey/blackwater, bilge water, and ballast water as potential contaminants released into the LAA and rationale for their absence as a potential to cause adverse health effects in SRKW.	The EIS Guidelines in Section 17 state that the proponent is expected to employ the standard ecological risk assessment framework as presented in section 10 of the EIS Guidelines. A risk assessment framework includes a description of COPCs entering the environment with the potential for causing adverse effects on the receiving environment. This begins the assessment for predicting/evaluating the likely effects on identified valued components outlined in Section 10 under 'Impact Matrix'.
Baseline Conditions (EIS Guidelines; 17.3.1, Existing Marine Environment)	<i>Addendum, Section 8.2.5.2 Species of Conservation Concern, Table 8.2-3, p. 8.2-8</i>	For SRKW, provide more detailed information on the yearly time spent in the LAA.	Table 8.2-3 lists all 33 species of marine mammals found in BC with time spent in the LAA as Predicted Occurrence and Use in LAA. This terminology and 'quantification' does not allow for any determination of total time (and when) spent in the LAA which is necessary for determining exposure risk to COPCs.

**Roberts Bank Terminal 2 Project**  
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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>
Baseline Conditions (EIS Guidelines; 17.3.1, Existing Marine Environment)	<i>Addendum, Section 8.2.5.2 Species of Conservation Concern, Table 8.2-3, p. 8.2-8</i>	For SRKW, provide more detailed information on the overlap between the LAA and the critical habitat of the SRKW.	Table 8.2-3 lists all 33 species of marine mammals found in BC with time spent in the LAA as Predicted Occurrence and Use in LAA. For data for the SRKW, it is stated that the LAA overlaps the majority of the identified critical habitat. A map or percentage overlap would be useful in determining exposure risk to SRKW and/or critical habitat.
Baseline Conditions (EIS Guidelines; 17.3.1, Existing Marine Environment)	<i>EIS, p. 14-32</i>	Provide existing data for concentrations of COPCs identified from ballast water, bilge water, grey/black water, and petroleum-derived hydrocarbons in the LAA.	In the current threats list for DFOs Recovery Strategies for SRKW, 'Environmental contaminants (i.e. persistent bioaccumulating toxins, oil spills and other toxic spills)' are noted. In order to determine exposure risks and potential effects to SRKW, background on these COPCs are needed. Some information on PCBs is outlined in the EIS (p. 14-32), however, PCBs have not been identified as a COPC in the EIA, and no others have been listed or discussed.
Baseline Conditions (EIS Guidelines; 17.3.1, Existing Marine Environment)	<i>Addendum, Section 8.2.5.3 Southern Resident Killer Whale, p. 8.2-15</i>	Provide as of 2015, age demographics of SRKWs.	SRKW age demographics can aid in determining risk from exposure to some contaminants. For example, it has been shown that young lactating whales (being at the apex of the food chain) may be more susceptible to biomagnification of contaminants than non-lactating whales resulting in higher accumulations of contaminant body burdens and potential effects.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-17</i>	<i>Provide justification for excluding water and sediment quality (i.e. contaminants other than oil spill related) from the list of potential interactions and effects.</i>	The interactions and potential effects of marine shipping on marine mammals is limited to acoustic and physical interactions with vessels. Contaminants may also play a role in affecting marine mammals, but have not been addresses at all, nor given a negligible rating.

**Roberts Bank Terminal 2 Project**  
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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-17	Provide a rationale (qualitative or quantitative method) for determining when an interaction is negligible.	The interactions and potential effects of marine shipping on marine mammals have been rated and some have been given a ‘classification’ of negligible. It is unclear how this categorization (qualitative or quantitative) was achieved.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-18, Table 8.2-5	Provide a rationale (qualitative or quantitative method) for determining the rating (low to high) for a potential effect.	The interactions and potential effects of marine shipping on marine mammals have been rated low to high. It is unclear how this rating (qualitative or quantitative) was achieved.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-21	Provide established ambient air quality objectives or standards for humans for comparison to marine mammal data. Provide literature data to support a negligible potential effect of direct fume inhalation from shipping or similar exhaust.	The lack of ambient air quality objectives or standards for marine mammals does not preclude negative impacts on marine mammal health. In order to be fully informed on the potential impacts of air pollution from shipping on SRKW, data from other mammalian species may be useful as direct fume inhalation from bunker oil and diesel fuelled ships are likely to cause some adverse effects.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-21	Provide information on the implementation in 2015 of the North American Emission Control Area.	The lack of effects on marine mammals with respect to increased shipping is based on an actual reduction in marine vessel emissions (even with increases in shipping) due to implementation of the ECA in 2015. If this has not been implemented, the proponents modelling exercise should be revisited.



**Roberts Bank Terminal 2 Project**  
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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	Addendum, Section 10.3.3.1 Plausible Accident or Malfunction #1: Hard Grounding Resulting in a Spill, p. 10-10	Provide a hypothetical spill scenario with light fuel oil.	The rationale behind choosing heavy fuel oil as an example for effects occurring from an oil spill accident are understood, however, the potential effects to SRKW exposed to petroleum under this scenario does not model risk for all fuel types as noted. Light fuel oil, while being less persistent and likely to spread less than a more persistent heavy oil is much more acutely toxic. The components of light oil can contain much higher proportions of compounds such as benzene, toluene, xylene and ethyl benzene and lower molecular weight polycyclic aromatic hydrocarbons such as the naphthalenes. Exposure scenarios and toxicity from this oil mixture are vastly different, but could potentially cause more impact through short-term effects.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	Addendum, Section 10.3.3.1 Plausible Accident or Malfunction #1: Hard Grounding Resulting in a Spill, p. 10-12	Modelling efforts towards spill scenario should use worst case parameters to determine the maximum spread and impact of oil on critical SRKW habitat. This should include a modelling of lighter fuel oils.	The modelling for the heavy fuel oil spill does not necessarily use all worst case scenario parameters. These should be outlined (e.g. during winter conditions of low ambient temperature and maximum wind/wave) and used to determine the maximum spread of oil.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	Addendum, Section 10.3.3.1 Plausible Accident or Malfunction #1: Hard Grounding Resulting in a Spill, p. 10-14	Provide evidence that the majority of spilled heavy oil that reached the shore would be recovered.	The duration of exposure of SRKW to contaminated food and a contaminated environment (water and sediments) is based on the environmental persistence and the recovery efforts for spilled oil. The Exxon Valdez example indicates that oil may last for decades following a spill, even following recovery and cleanup efforts.

**Roberts Bank Terminal 2 Project**  
**Environmental Impact Statement Marine Shipping Addendum – Comments on Completeness**  
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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.3.3.1 Plausible Accident or Malfunction #1: Hard Grounding Resulting in a Spill, p. 10-14</i>	<i>Provide information that assesses the use of chemical dispersants for spilled oil (e.g. COREXIT) and its potential effects on SRKW.</i>	Oil spill cleanup efforts often utilize chemical dispersants such as COREXIT (e.g. Deep Water Horizon). These dispersants are known to have toxicity to a wide variety of marine organisms. The proponents mitigation proposal should address the potential for its use and subsequent exposure and potential toxicity to SRKW.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.5.7.2 Potential Interactions and Effects, p. 10-60</i>	<i>Provide Potential Effects for Exposure to Light Fuel Oil due to an Accident or Malfunction.</i>	The list of effects of oil spills on marine mammals exposed to a heavy fuel oil spill include a number of health effects that can include those that would occur with short term exposure to petroleum hydrocarbons found more commonly and in higher concentrations in light fuel oil. However, compounds found in higher concentrations in light fuel oils (e.g. BTEX) may cause other effects not listed here.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.5.7.2 Potential Interactions and Effects, p. 10-60</i>	<i>Provide Potential Effects for Exposure to Heavy Fuel Oil due to an Accident or Malfunction that are more chronic in nature.</i>	Many chemicals in fuel oils have other effects in animals that are not listed such as carcinogenicity, teratogenicity, and potential endocrine disruption and reproductive effects found with chronic exposure. These should be assessed and listed as well.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.5.7.2 Potential Interactions and Effects, p. 10-62</i>	<i>Provide an assessment of the routes of exposure of chemicals that are contained in fuel oils.</i>	The routes of exposure to SRKW are well known and include the lungs, skin, gastrointestinal tract. Compounds in fuel oil can be absorbed from the air, food, and water.

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**Environmental Impact Statement Marine Shipping Addendum – Comments on Completeness**  
 November 12 – December 16, 2015

<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	Addendum, Section 10.5.7.2 Potential Interactions and Effects, p. 10-63	<i>Provide information showing that all oil impacted salmon populations will rebound after an oil spill and that reductions in SRKW salmon food supply during recovery years will not affect the health of SRKW.</i>	The conclusions that salmon populations will rebound due to natural recruitment and immigration processes and will return salmon populations to pre-spill numbers without any adverse effects on SRKW during low abundance must be supported with scientific evidence.
Effects Assessment (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	Addendum, Section 10.5.7.2 Potential Interactions and Effects, p. 10-63	<i>Provide evidence that contamination endpoints or biological communities can return to pre-spill conditions.</i>	It is unlikely that contamination endpoints in areas of significant oil spills have returned to baseline values. Additionally, ecological data suggest that impacted ecologies by oil spills do not return to pre-spill conditions, but are altered permanently.
<i>Please use as many pages as necessary.</i>			

# TAB D

# Roberts Bank Terminal 2 Project Environmental Impact Statement Marine Shipping Addendum – Comments on technical aspects

October 27, 2016

**Participant:** Dr. Chris Kennedy

**Organization (if applicable):** Georgia Strait Alliance

## **General comments:**

This report is divided into two major sections. Section I discusses completeness issues that were identified in the Marine Shipping Addendum and whether these issues were addressed by Port Metro Vancouver.

### **Highlights**

- Port Metro Vancouver responded to only 1 of 23 completeness issues identified. Their response highlighted the lack of science-based decision making for the selection of factors which may cause environmental impacts from marine shipping activities

In Section II, analysis and opinion are provided regarding the technical strengths and weaknesses of the relevant sections of the marine shipping addendum. In this section, italics are used to denote text from the shipping addendum, and regular font is used for analysis and opinion.

### **Highlights**

- The selection process used by the proponent in determining factors which may impact Southern Resident Killer Whales (SRKW) or the magnitude of their impacts did not rely on modern science-based methodology
- Environmental contaminants have been highlighted by both Fisheries and Oceans Canada and the Species at Risk Act as potential threats for SRKW. The proponent did not consider increases in contaminant input as a potential impact on SRKW due to regular shipping activities
- The proponent determined the potential impacts on SRKW only from a spill of heavy oil due to an accident or malfunction. The spill of light fuel oil may be more impactful under some circumstances due to physical properties and different toxicity
- The existing evidence that an oil spill can cause population-level impacts to killer whales is addressed in the shipping addendum; however, the strong evidence in this regard is downplayed and marginalized in the conclusions. The ‘Summary of Assessment’ in the shipping addendum for effects of a potential oil spill on SRKW is therefore, not supported by the scientific evidence

## **Section I:**

**Comments on completeness issues addressed by the Port of Vancouver:**

**Roberts Bank Terminal 2 Project**

**Environmental Impact Statement Marine Shipping Addendum – Comments on technical aspects**

October 27, 2016

<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>	<b>Did the Vancouver Fraser Port Authority address this completion issue?</b>
Indicators  (EIS Guidelines; 10.1, Environmental Effects and 17.2.2 Description of Activity)	<i>Addendum, Section 8.2.2 Indicators</i>  <i>p. 8.2-3, Table 8.2-1</i>	Include or provide justification for absence of water and sediment quality as an indicator in Table 8.2-1.	The description of indicators in Section 8.2.2 of the Addendum states that the indicators selected for this assessment are the same as those used in the RBT2 EIS. However those in the RBT2 EIS include ‘Water and Sediment Quality’ (p. 14-4)	<b>Issue addressed.</b> The assessment of marine mammals provided in the Marine Shipping Addendum did not include changes to water and sediment quality as an indicator because routine marine shipping associated with the Project is not anticipated to adversely affect water and sediment quality. <b>The response was not sufficient in its explanation as described at end of table.</b>
Indicators  EIS Guidelines; 10.1, Environmental Effects and 17.2.2 Description of Activity	<i>Addendum, Section 8.2.2 Indicators</i>	Provide a description of ballast water release as a source of contamination in the LAA and rationale for its absence as a potential to cause adverse health effects in SRKW.  Provide a detailed description of	Ships outlined for use in the completed project use large amounts of ballast water, which is often taken on in the coastal waters in one region after ships discharge wastewater or unload cargo, and discharged at the next port of call, wherever more cargo is loaded. Ballast water discharge typically contains a variety of biological materials that may affect SRKW.	<b>Not addressed.</b>

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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>	<b>Did the Vancouver Fraser Port Authority address this completion issue?</b>
		ballast water treatment and release activities.		
Indicators  (EIS Guidelines; 10.1, Environmental Effects and 17.2.2 Description of Activity)	<i>Addendum, Section 8.2.2 Indicators</i>	Provide a description of bilge water release as a source of contamination in the LAA and rationale for it absence as a potential to cause adverse health effects in SRKW.  Provide a detailed description of bilge water treatment and release activities.	Leaks and engine maintenance activities release oil and gasoline and along with the degradation products of petroleum, will contaminate water in the bilge. Bilge water also may contain solid wastes and other contaminants, as well as high biological oxygen demand that may affect SRKW.	<b>Not addressed.</b>
Indicators  (EIS Guidelines; 10.1, Environmental Effects and 17.2.2 Description of Activity)	<i>Addendum, Section 8.2.2 Indicators</i>	Provide a description of sewage (grey or blackwater) release as a source of contamination in the LAA and rationale for it absence as a potential to cause adverse health effects in SRKW.	Ships can release large amounts of greywater into the oceans. Sewage can contain bacteria, pathogens, viruses, parasites, nutrients, detergents, oil and grease, organic compounds, metals and other contaminants that may affect SRKW.	<b>Not addressed.</b>

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**Environmental Impact Statement Marine Shipping Addendum – Comments on technical aspects**

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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>	<b>Did the Vancouver Fraser Port Authority address this completion issue?</b>
		Provide a detailed description of grey and blackwater treatment and release activities.		
Indicators  (EIS Guidelines; 10.1, Environmental Effects and 17.2.2 Description of Activity)	<i>Addendum, Section 8.2.2 indicators</i>	Provide a list of chemicals of potential concern (COPCs) in each of grey/blackwater, bilge water, and ballast water as potential contaminants released into the LAA and rationale for their absence as a potential to cause adverse health effects in SRKW.	The EIS Guidelines in Section 17 state that the proponent is expected to employ the standard ecological risk assessment framework as presented in section 10 of the EIS Guidelines. A risk assessment framework includes a description of COPCs entering the environment with the potential for causing adverse effects on the receiving environment. This begins the assessment for predicting/evaluating the likely effects on identified valued components outlined in Section 10 under 'Impact Matrix'.	<b>Not addressed.</b>
Baseline Conditions  (EIS Guidelines; 17.3.1,	<i>Addendum, Section 8.2.5.2 Species of Conservation Concern, Table 8.2-3,</i>	For SRKW, provide more detailed information on the yearly time spent in the LAA.	Table 8.2-3 lists all 33 species of marine mammals found in BC with time spent in the LAA as Predicted Occurrence and Use in LAA. This terminology and 'quantification' does not	<b>Not addressed.</b>



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Issue (if possible, please include reference to the relevant section of the EIS Guidelines)	Reference to EIS Addendum	Requested Completeness Information	Rationale	Did the Vancouver Fraser Port Authority address this completion issue?
Existing Marine Environment)	<i>p. 8.2-8</i>		allow for any determination of total time (and when) spent in the LAA that is necessary for determining exposure risk to COPCs.	
Baseline Conditions  (EIS Guidelines; 17.3.1, Existing Marine Environment)	<i>Addendum, Section 8.2.5.2 Species of Conservation Concern, Table 8.2-3, p. 8.2-8</i>	For SRKW, provide more detailed information on the overlap between the LAA and the critical habitat of the SRKW.	Table 8.2-3 lists all 33 species of marine mammals found in BC with time spent in the LAA as Predicted Occurrence and Use in LAA. For data for the SRKW, it is stated that the LAA overlaps the majority of the identified critical habitat. A map or percentage overlap would be useful in determining exposure risk to SRKW and/or critical habitat.	<b>Not addressed.</b>
Baseline Conditions  (EIS Guidelines; 17.3.1, Existing Marine Environment)	<i>EIS, p. 14-32</i>	Provide existing data for concentrations of COPCs identified from ballast water, bilge water, grey/black water, and petroleum-derived hydrocarbons in the LAA.	In the current threats list for DFOs Recovery Strategies for SRKW, ‘Environmental contaminants (i.e. persistent bioaccumulating toxins, oil spills and other toxic spills)’ are noted. In order to determine exposure risks and potential effects to SRKW, background on these COPCs are needed. Some information on PCBs is outlined in the EIS (p. 14-32), however, PCBs have not been identified as a COPC in the	<b>Not addressed.</b>

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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>	<b>Did the Vancouver Fraser Port Authority address this completion issue?</b>
			EIA, and no others have been listed or discussed.	
Baseline Conditions  (EIS Guidelines; 17.3.1, Existing Marine Environment)	<i>Addendum, Section 8.2.5.3 Southern Resident Killer Whale, p. 8.2-15</i>	Provide as of 2015, age demographics of SRKW's.	SRKW age demographics can aid in determining risk from exposure to some contaminants. For example, it has been shown that young lactating whales (being at the apex of the food chain) may be more susceptible to biomagnification of contaminants than non-lactating whales resulting in higher accumulations of contaminant body burdens and potential effects.	<b>Not addressed.</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-17</i>	<i>Provide justification for excluding water and sediment quality (i.e. contaminants other than oil spill related) from the list of potential interactions and effects.</i>	The interactions and potential effects of marine shipping on marine mammals are limited to acoustic and physical interactions with vessels. Contaminants may also play a role in affecting marine mammals, but have not been addresses at all, or given a negligible rating.	<b>Not addressed.</b>

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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>	<b>Did the Vancouver Fraser Port Authority address this completion issue?</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-17</i>	<i>Provide a rationale (qualitative or quantitative method) for determining when an interaction is negligible.</i>	The interactions and potential effects of marine shipping on marine mammals have been rated and some have been given a ‘classification’ of negligible. It is unclear how this categorization (qualitative or quantitative) was achieved.	
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-18, Table 8.2-5</i>	<i>Provide a rationale (qualitative or quantitative method) for determining the rating (low to high) for a potential effect.</i>	The interactions and potential effects of marine shipping on marine mammals have been rated low to high. It is unclear how this rating (qualitative or quantitative) was achieved.	<b>Not addressed.</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-21</i>	<i>Provide established ambient air quality objectives or standards for humans for comparison to marine mammal data. Provide literature data to support a negligible potential effect of direct fume inhalation from shipping or similar exhaust.</i>	The lack of ambient air quality objectives or standards for marine mammals does not preclude negative impacts on marine mammal health. In order to be fully informed on the potential impacts of air pollution from shipping on SRKW, data from other mammalian species may be useful as direct fume inhalation from bunker oil and diesel fuelled ships are likely to cause some adverse effects.	<b>Not addressed.</b>

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Issue <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	Reference to EIS Addendum	Requested Completeness Information	Rationale	Did the Vancouver Fraser Port Authority address this completion issue?
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 8.2.6 Potential Interactions and Effects, p. 8.2-21</i>	<i>Provide information on the implementation in 2015 of the North American Emission Control Area.</i>	The lack of effects on marine mammals with respect to increased shipping is based on an actual reduction in marine vessel emissions (even with increases in shipping) due to implementation of the ECA in 2015. If this has not been implemented, the proponents modelling exercise should be revisited.	<b>Not addressed.</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.3.3.1 Plausible Accident or Malfunction #1: Hard Grounding Resulting in a Spill, p. 10-10</i>	<i>Provide a hypothetical spill scenario with light fuel oil.</i>	The rationale behind choosing heavy fuel oil as an example for effects occurring from an oil spill accident are understood, however, the potential effects to SRKW exposed to petroleum under this scenario does not model risk for all fuel types as noted. Light fuel oil, while being less persistent and likely to spread less than more persistent heavy oil is much more acutely toxic. The components of light oil can contain much higher proportions of compounds such as benzene, toluene, xylene and ethyl benzene and lower molecular weight polycyclic aromatic hydrocarbons such as the naphthalenes. Exposure	

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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>	<b>Did the Vancouver Fraser Port Authority address this completion issue?</b>
			scenarios and toxicity from this oil mixture are vastly different, but could potentially cause more impact through short-term effects.	
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.3.3.1 Plausible Accident or Malfunction #1: Hard Grounding Resulting in a Spill, p. 10-12</i>	<i>Modelling efforts towards spill scenario should use worst-case parameters to determine the maximum spread and impact of oil on critical SRKW habitat. This should include a modelling of lighter fuel oils.</i>	The modelling for the heavy fuel oil spill does not necessarily use all worst-case scenario parameters. These should be outlined (e.g. during winter conditions of low ambient temperature and maximum wind/wave) and used to determine the maximum spread of oil.	<b>Not addressed.</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.3.3.1 Plausible Accident or Malfunction #1: Hard Grounding Resulting in a Spill, p. 10-14</i>	<i>Provide evidence that the majority of spilled heavy oil that reached the shore would be recovered.</i>	The duration of exposure of SRKW to contaminated food and a contaminated environment (water and sediments) is based on the environmental persistence and the recovery efforts for spilled oil. The Exxon Valdez example indicates that oil may last for decades following a spill, even following recovery and clean-up efforts.	<b>Not addressed.</b>

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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>	<b>Did the Vancouver Fraser Port Authority address this completion issue?</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.3.3.1 Plausible Accident or Malfunction #1: Hard Grounding Resulting in a Spill, p. 10-14</i>	<i>Provide information that assesses the use of chemical dispersants for spilled oil (e.g. COREXIT) and its potential effects on SRKW.</i>	Oil spill clean-up efforts often utilize chemical dispersants such as COREXIT (e.g. Deep Water Horizon). These dispersants are known to have toxicity to a wide variety of marine organisms. The proponent's mitigation proposal should address the potential for its use and subsequent exposure and potential toxicity to SRKW.	<b>Not addressed.</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.5.7.2 Potential Interactions and Effects, p. 10-60</i>	<i>Provide Potential Effects for Exposure to Light Fuel Oil due to an Accident or Malfunction.</i>	The list of effects of oil spills on marine mammals exposed to a heavy fuel oil spill include a number of health effects that can include those that would occur with short term exposure to petroleum hydrocarbons found more commonly and in higher concentrations in light fuel oil. However, compounds found in higher concentrations in light fuel oils (e.g. BTEX) may cause other effects not listed here.	<b>Not addressed.</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.5.7.2 Potential Interactions and Effects, p. 10-60</i>	<i>Provide Potential Effects for Exposure to Heavy Fuel Oil due to an Accident or Malfunction that</i>	Many chemicals in fuel oils have other effects in animals that are not listed such as carcinogenicity, teratogenicity, and potential endocrine disruption and reproductive effects found	<b>Not addressed.</b>

**Roberts Bank Terminal 2 Project**

**Environmental Impact Statement Marine Shipping Addendum – Comments on technical aspects**

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Issue (if possible, please include reference to the relevant section of the EIS Guidelines)	Reference to EIS Addendum	Requested Completeness Information	Rationale	Did the Vancouver Fraser Port Authority address this completion issue?
Environment)		<i>are more chronic in nature.</i>	with chronic exposure. These should be assessed and listed as well.	
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.5.7.2 Potential Interactions and Effects, p. 10-62</i>	<i>Provide an assessment of the routes of exposure of chemicals that are contained in fuel oils.</i>	The routes of exposure to SRKW are well known and include the lungs, skin, and gastrointestinal tract. Compounds in fuel oil can be absorbed from the air, food, and water.	<b>Not addressed.</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects on the Marine Environment)	<i>Addendum, Section 10.5.7.2 Potential Interactions and Effects, p. 10-63</i>	<i>Provide information showing that all oil impacted salmon populations will rebound after an oil spill and that reductions in SRKW salmon food supply during recovery years will not affect the health of SRKW.</i>	The conclusions that salmon populations will rebound due to natural recruitment and immigration processes and will return salmon populations to pre-spill numbers without any adverse effects on SRKW during low abundance must be supported with scientific evidence.	<b>Not addressed.</b>
Effects Assessment  (EIS Guidelines; 17.4.1, Effects	<i>Addendum, Section 10.5.7.2 Potential Interactions and Effects,</i>	<i>Provide evidence that contamination endpoints or biological communities can</i>	It is unlikely that contamination endpoints in areas of significant oil spills have returned to baseline values. Additionally, ecological data suggest that	<b>Not addressed.</b>

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<b>Issue</b> <i>(if possible, please include reference to the relevant section of the EIS Guidelines)</i>	<b>Reference to EIS Addendum</b>	<b>Requested Completeness Information</b>	<b>Rationale</b>	<b>Did the Vancouver Fraser Port Authority address this completion issue?</b>
on the Marine Environment)	<i>p. 10-63</i>	<i>return to pre-spill conditions.</i>	impacted ecologies by oil spills do not return to pre-spill conditions, but are altered permanently.	
<i>Please use as many pages as necessary.</i>				

**Only one issue was addressed in the requests for completeness issues:**

Include or provide justification for absence of water and sediment quality as an indicator in Table 8.2-1.

Vancouver Fraser Port Authority response:

*The assessment of marine mammals provided in the Marine Shipping Addendum did not include changes to water and sediment quality as an indicator because routine marine shipping associated with the Project is not anticipated to adversely affect water and sediment quality.*

Response to VFPA:

Although the VFPA stated that no effects due to other contaminants from routine shipping associated with the Project are anticipated to adversely affect water and sediment quality, no information is given on how this decision was made. As described below in the section on technical aspects, consultation is not a generally accepted ‘scientific’ means of determining whether an effect will occur. Usually in circumstances such as this, a weight of evidence approach is used, or thresholds or criteria established, so that at the very least a semi-qualitative means of assessing the available data is performed. It is unclear what data was used (if any) in the determination, what guidelines, or other means to come to the conclusion that contaminant inputs would be insignificant and not result in adverse effects. In this regard, other requests for completion highlighted potential sources of contamination, however, these issues were not addressed.



# Roberts Bank Terminal 2 Project Environmental Impact Statement Marine Shipping Addendum – Comments on technical aspects

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## Section II:

### **Comments on the technical aspects in the EIS Marine Shipping Addendum:**

PORT METRO VANCOUVER / Roberts Bank Terminal 2 Marine Shipping Supplemental Report

#### **Section 8.2 Marine Mammals Effects Assessment p. 8.2-1**

*This section describes the assessment for SRKW through which potential effects of the Project and Project shipping on critical habitat features were examined. These included the acoustic environment, the availability of prey, and water and sediment quality. In particular, its goal was to determine how changes in critical habitat features could potentially affect SRKW life functions including foraging, mating, resting, and socialising.*

With regard to the potential effects of contaminants on SRKW related to the project shipping activities, the Port Metro Vancouver (PMV) did not address water and sediment quality in the addendum. It was identified and addressed in previous comments on completeness of information in the EIS. PMV has responded to this omission in the EIS. The merits of their response have been discussed above.

In addition, the statement that ‘life functions’ of SRKW will be examined (in particular foraging, mating, resting and socializing) is misleading; several of these ‘life functions’ are only investigated, and to a very limited extent either from the peer-reviewed literature or other sources. There is some information given regarding mortality data from the Exxon Valdez oil spill (discussed specifically later), however, no real attempt to determine critical effects on the other parameters are mentioned. Also, there are critical ‘life functions’ other than those mentioned which should have been addressed; any alteration in the biology of SRKW due to petroleum related, or other potential contaminants from shipping activities, should have been mentioned here to broaden the search for evidence of potential impacts on SRKW. For example, reproduction (and not mating) is an endpoint that has some information in the literature related to oil contamination and whales in particular (Matkin et al. 2008). Related information regarding other marine mammals (or mammals in general) on other endpoints such as growth, locomotion, physiology, biochemistry, teratogenicity, mutagenicity, carcinogenicity etc. should have been included in a more comprehensive search. Focussing on 4 parameters only limits the utility of the assessment.

#### **Section 8.2.2 Indicators p. 8.2-2, 3**

*The proponent describes ‘Indicators’ as measureable parameters and provides a means of determining change to a valued component (VC).*

Table 8.2-1 ‘Indicators for Marine Mammals’ lists indicators and the rationale for selection as an indicator. In regard to contaminants, particularly in light of critical habitat features (including water and sediment quality), there is no information regarding the non-selection of this parameter. A response to the omission of

# Roberts Bank Terminal 2 Project Environmental Impact Statement Marine Shipping Addendum – Comments on technical aspects

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this feature has been addressed by PMV and has been discussed above. Of note is that in Table 8.2-3, PMV highlights threats in DFO recovery strategies that list ‘environmental contaminants (i.e. persistent bioaccumulating toxins, oil spills, and other toxic spills)’ but the addendum only addresses accidental oil releases in the assessment. No justification is given for the decision process to omit other contaminants that may arise from shipping activities (e.g. contaminants in bilge water, ballast water, grey or blackwater).

## **Section 8.2.4 Information Sources p. 8.2-5**

*A summary of SRKW studies undertaken for the RBT2 environmental assessment that support this assessment are provided in RBT2 EIS Section 14.0 (Tables 14-6 and 14-7).*

While this section refers to studies that were done to support this assessment and in this case, the shipping addendum, it is unclear as to the utility of the contaminant-related study this section refers to. The comment refers to a PCB food web model that was developed, however, its utility in this regard is unclear. How the data on PCBs (a complex mixture, and not likely a contaminant of potential concern [COPC]) is useful in the assessment is not clear in the shipping addendum. Bioaccumulation models such as this are chemical-specific and are currently only useful in modelling unmetabolizable chemicals and those of a similar log Kow value (Arnot and Gobas 2004). It is unclear if the data were to be used for other contaminants that may have been identified as COPCs (as a priority outlined by DFO recovery strategies for SRKW).

## **Section 8.2.5.3 Southern Resident Killer Whale p. 8.2-15**

*The proponent describes SRKW and their classification as endangered under SARA that includes ‘potential anthropogenic threats’ as well as DFO recovery strategies that also highlight ‘environmental contaminants’.*

It is unclear how this information has been translated into assessment, or used to prioritize air, water, sediment, or prey contamination and exposure risk. Contaminants (except an accidental oil spill) are not prioritized or listed as factors that may impact SRKW, and no reason or lack of exposure pathway is given for this omission.

## **Section 8.2.6 Potential Interactions and Effects p. 8.2-17; Section 8.2.6.1, Negligible Effects p. 8.2-18**

*In this section the proponent considers the interactions and potential effects of marine shipping associated with the project on marine mammals.*

In this section, the proponent describes the potential interactions determined to be important and highlight these in Table 8.2-5. Selection of the listed potential effects is unclear. It appears that factors such as contamination (from sources other than an accidental oil spill) from any activity associated with shipping would be categorized as negligible and therefore not listed as a potential effect. The descriptor of a negligible potential effect is one that ‘is so small as to not detectable or measureable and not anticipated to affect the VC.’ The determination of this is given in the EIS p. 8-16 as being through ‘discussions with

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*regulators, Aboriginal groups, stakeholders, and the professional judgement of the project team*'. This process is summarized for the project and used for the shipping addendum process as: *'Project-VC interactions were considered with reference to a master list of Project construction and operation activities presented in Appendix 8-B. In cases in which no interaction is expected, no further consideration was given to the effect of the activity on the particular IC or VC.'* It can be concluded that there was no scientific method or data analysis used to determine if contaminants should be examined as a significant potential effect. No consideration of potential COPCs, fate models, exposure assessments, or potential effects of COPCs (other than accidental oil spill) are given as determining factors in the decision-making process of inclusion/exclusion of contaminants as indicators. The decisions appear completely subjective without detailed information on data used or process in making decisions. This appears to be a completely subjective decision for water and sediment contamination. There is mention of environmental contamination from air pollution as negligible potential health effects, however the inclusion of air contamination here (and not water) and its negligible status are unclear. Consideration of a modelling exercise with shipping air (or water) contamination with vessel traffic data, exposure risk, and potential effects on marine mammals (or other surrogates from the primary literature) would be appropriate for a decision of negligible.

In the above, a weight of evidence (WOE) approach could have been used to make the determination of important interactions (Linkov et al. 2009). Assessments of ecological risk draw upon multiple types and sources of information, requiring the integration of multiple lines of evidence before conclusions may be reached. Risk assessors often make use of WOE approaches to perform the integration, integrating evidence concerning potential toxicity and exposure from chemicals at a contaminated site. Historically, assessors have relied upon qualitative WOE approaches, such as professional judgment, or limited quantitative methods, such as direct scoring, to develop conclusions from multiple lines of evidence. The WOE approach uses a combination of information from several independent sources to give sufficient evidence to fulfill a requirement (such as inclusion/exclusion as an interaction). This approach is beneficial when the information from a single piece of evidence alone is not sufficient to fulfill a requirement. This could be, for example, due to clear deficiencies in one of the existing studies, or when individual studies provide different or conflicting conclusions. The weight given to the available evidence depends on factors such as the quality of the data, consistency of results, nature and severity of effects, and relevance of the information. A WOE approach requires the use of scientific judgment and, therefore, it is essential to provide adequate and reliable documentation. As a general principle, the more information provided, the stronger the WOE. The information must be presented in a structured and organized way and take into account the robustness and reliability of the different data sources to support justifications. The practice used to select interaction here by PMV lacks transparency in this regard.

### **Section 10.2.1 Potential Project-related Accidents or Malfunctions, Probabilities, and Consequences p. 10-2**

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*In this section the proponent discusses the potential for environmental risk associated with a particular accident or malfunction arising from marine shipping associated with the Project and are based on findings and information in Appendices 10-A and 10-B.*

Appendix 10-A gives a good general description of various petroleum mixtures and their properties which may be released during an accident or malfunction. It describes various fuel types and general properties of constituents and fate in the environment. This information is general, and can't be used to be predictive in any sense, and may have limited utility in risk assessment due to the variability of the environmental conditions, spill conditions, petroleum constituents, biological exposures, and biological effects.

## **Section 10.2.3 Identification and Assessment of Potential Interactions and Changes or Effects p. 10-2**

*In this section the proponent discusses the potential for an interaction between a worst-case accident or malfunction scenario and each VC as per the screening approach outlined in Section 8.1.5.*

This has been discussed above and appears to be subjectively based with little or no scientific data, or analysis, or a WOE approach used to determine when an interaction would be negligible or significant. In addition, a decision-making process based on consultation with various groups is the process for also identifying interactions that would result in measurable change or adverse effects. It is unclear how this was done. In a scientific process, knowledge or a predicted exposure risk would be estimated for each COPC, and then the literature examined to determine the potential for an adverse effect from data on whales or the mammalian literature. It is unclear if a similar process was followed; without using the available scientific information in this manner (e.g. WOE approach), the inclusion/exclusion of a significant interaction is subjective. Equally unclear is the process (other than consultation) of determining mitigation success, which has direct bearing on exposure risk, and ultimately the potential for adverse effects. Also, while it is unlikely that several accidents would occur within time and space, it is possible, and cumulative effects should be considered to some extent, with potential interactions noted.

## **Section 10.3.3.1 Plausible Accident or Malfunction #1: Hard Grounding Resulting in a Spill p. 10-14**

*In this section the proponent discusses the potential for the release of a heavy fuel oil, in the spring, of a volume of 8250 m<sup>3</sup> as a worst-case scenario.*

For the heavier fuel oil modeled in the worst case scenario, the organic compounds of concern would include: petroleum hydrocarbons (e.g., benzene, toluene, ethyl benzene and xylenes (BTEX)), total petroleum hydrocarbon (TPH) fractions, asphaltenes, polycyclic aromatic hydrocarbons (PAH), phenolic compounds, and volatile organic compounds (VOCs) and trace metals. Heavy fuel oils typically have low API gravity and densities approaching, and sometimes exceeding, that of water (National Research Council 1999, Neff et al. 2003). Therefore, heavy fuels may float on water, sink, or resurface after they sink, depending on meteorological and oceanographic conditions (Michel and Galt 1995, National Oceanic and

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Atmospheric Administration 1997). Compared to light oils, heavy fuel oils have minimal fraction of volatiles and hence are less dispersible in water and may be more persistent in the environment (water surface and shorelines). The lighter fractions of heavy fuels may evaporate to the atmosphere or dissolve in water column, but some heavy residual fuel oils may undergo little or no evaporation because of minimal light fraction constituents.

Most of the transported oil in the marine waters in the MSA would be refined petroleum products that may include jet fuel, diesel, and heavy fuel oil. Oil used as fuel for vessels will vary from diesel fuel to heavy fuel oil and in general, heavy fuel oil usage in the marine industry is currently higher than light fuel usage. Due to international regulations a gradual shift from the use of heavy fuel oil to diesel fuel in port areas is expected, and the proportion of diesel fuel to heavy fuel oil is expected to increase in the future, increasing the possibility that spills that involve diesel rather than heavier fuel oils. In this regard, it may have been more appropriate to include a model of a worst-case scenario using diesel or lighter fuel oil as well.

The two main classes of chemical in diesel fuel with the most potential for toxic effects are the monocyclic aromatic hydrocarbons (BTEX) and low molecular weight PAH. Monocyclic aromatic hydrocarbons are relatively water-soluble and are the most bioavailable fraction of diesel oil following a spill. However, the high volatility of this component limits the time frame of exposure, as BTEX will rapidly partition to the atmosphere. Little information exists regarding the toxicity of volatile compounds such as BTEX in marine mammals, but certainly extrapolations from human studies can indicate similar effects on marine mammals if exposures are high enough during direct contact with vapors. Human exposure to BTEX, both through inhalation or ingestion, can have serious health impacts, including neurological disease, cancer, and teratogenic effects. After accidental dermal contact, anuria, renal failure, gastro-intestinal symptoms, and cutaneous hyperkeratosis have been reported (USEPA <https://www.epa.gov/haps/health-effects-notebook-hazardous-air-pollutants>). Toxic lung disease has been observed after accidental ingestion of diesel fuel and subsequent aspiration. In a case-control study of men exposed to diesel fuel, an increased risk for cancer of the lung other than adenocarcinoma was found; a positive association was also seen with prostatic cancer, although a higher risk was noted for the group with 'nonsubstantial' exposure than for that with 'substantial' exposure (Garshick et al. 1987).

*In the addendum, it is stated that 'due to a number of uncertainties, including 1) environmental conditions at the time of the incident, 2) specific characteristics of heavy fuel oil that could be spilled, 3) limitations with respect to modeling evaporation, or 4) level of response to the incident, it is not possible to quantify to an acceptable degree of accuracy the changes to air quality'.*

These caveats must also be applied not only to the exposure of SRKW to volatile components above the water, but to the extent of the slick which develops, the dissolved levels of hydrocarbons and petroleum concentrations in the water column, formations of mousse and emulsions, persistence of the oil on and in the water, or at the water-terrestrial interface. Most importantly, this puts limitations predicting the exposure

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pathways, exposure concentrations, and exposure durations for SRKW or to organisms that support SRKW that may occur in the spill area. Even NOAA states that over the duration of a typical spill, they will revise and reissue forecast maps on a daily basis. These maps include best predictions of where the oil might go and the regions of highest oil coverage, as well as what are known as 'confidence boundaries' which reflect the full possible range in forecasts (Office of Response and Restoration, NOAA).

*In addition, on p. 10-14, it is stated that spill recovery activities would result in most of the oil reaching the shore would be recovered.*

Various estimates in the literature on the persistence of oil following the Exxon Valdez oil spill (EVOS) exist. In 1993 (4 years following the spill), it was reported that 7 km (of 149 km) of shoreline were still contaminated with subsurface oil. Smaller-scale studies dealing with continued cleanup efforts and restoration of oiled mussel beds conducted between 1995 and 1999 showed that oil was persistent and often in a relatively unweathered state, containing high concentrations of toxic and biologically available polycyclic aromatic hydrocarbons (PAH) (NMFS 2001). A survey in 2001 indicated that a total area of approximately 20 acres of shoreline in Prince William Sound were still contaminated with oil. Oil was found at 58 percent of the 91 sites assessed and is estimated to have the linear equivalent of 5.8 km of contaminated shoreline, more than a decade after the spill and cleanup efforts (NMFS [2001]). A further study conducted by NOAA determined that as of early 2007 more than 98 m<sup>3</sup> of oil remain in the sandy soil of the contaminated shoreline, declining at a rate of less than 4% per year. It has been reported that less than 10% of the oil has been recovered (Skinner et al. 1989).

## **Section 10.5.7.2 Potential Interactions and Effects p. 10-60**

*This section considers the interactions and potential effects of accidents or malfunctions arising from marine shipping associated with the project on marine mammals.*

Table 10-18 summarizes the potential effects of exposure to petroleum products via a spill and contains most of the likely impacts in general categories. The aforementioned health effects in humans that may also occur in marine mammals would fall under 'sublethal effects'.

### *Potential Effect #1 – Exposure to Heavy Fuel Oil due to an Accident or Malfunction p. 10 - 61*

This section highlights several of the aforementioned mammalian effects due to exposure to volatile components of fuel oils such as BTEX and includes categories of effects that may occur through ingestion of contaminated water/food, or through inhalation of volatilized chemicals at the surface. The list is reasonably comprehensive, but several categories are vague and non-specific (e.g. health effects due to physiological stress) and not informative. Direct mortality, some of the more severe physiological alterations (e.g. renal failure), and other serious effects (e.g. cancer) are not listed.

### *Southern Resident Killer Whales p. 10-62*

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The statement ‘*An accidental oil spill is a potential threat to SRKW and its critical habitat*’ is a clear and straightforward summary of this section, indicating and referencing evidence that contamination from such an event could have population-level effects. The statement is supported by data and evidence from studies of killer whales following the event of the Exxon Valdez oil spill (EVOS), even though the addendum then weakens the argument by stating ‘a precautionary approach could assume that mortalities were due to spill effects’ as well as stating that ‘lethal disturbances implies it is possible that oil exposure contributed’. Matkin et al. (2008) used photo-identification methods to monitor 2 killer whale populations 5 yr prior to and for 16 yr after the EVOS. These pods suffered losses of 33 and 41% in the year following the spill. Sixteen years after the EVOS, one pod had not recovered to pre-spill numbers and its rate of increase was significantly less than that of other resident pods that were not exposed to oil. The second pod that lost 9 members following the EVOS, continued to decline in numbers with the loss of individuals including reproductive-age females. The synchronous losses of unprecedented numbers of killer whales from 2 ecologically and genetically separate groups (in the absence of other perturbations) gives evidence of mortality and population level effects from exposure to petroleum hydrocarbons.

*As there is a lack of quantified evidence linking spilled oil and health effects, it is impossible to determine with certainty if a spill of this volume and fuel type would result in adverse effects to SRKW individuals or the population. p. 10-62.*

This statement reverses the conclusions and evidence that support the opposite of the above statement. It is more likely given the data and evidence that such effects will occur given similar exposure levels in the worst case scenario example, and in particular if a diesel fuel was modeled which would increase the inhalation component of exposure. There is a clear contradiction between data and evidence from the literature, stated adverse effects in these and other mammalian species, and the weakening statement above and elsewhere.

*Evidence suggests that salmon populations are resilient and capable of making a full recovery. Productivity will rebound due to natural recruitment and immigration processes, and SRKW prey will not be significantly affected (see section 10.5.6.4).*

The effects of the components of oil on fish including salmonids are well known. The proponent relies on their conclusions that salmonids are resilient and capable of making a full recovery from only 4 publications. Below is a summary of evidence outlining current knowledge that the statements by the proponents are not supported:

### *Acute toxicity*

The tolerance to oil is similar among salmonid species (Moles et al. 1979). The LC<sub>50</sub> for crude oil is approximately 1.2 – 1.7 mg/L total aromatics in pink salmon, depending on the exposure method (static v. flow through tests; Moles 1998), with median tolerance limits of 2.7 – 8.0 mg/L for salmonids, depending on the life stage (Moles et al. 1979).

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### *Biochemical indicators*

Several studies were completed with Chinook salmon parr (Van Scoy et al. 2010) and smolts (Lin et al. 2009) following exposure to crude oil, using metabolomics to identify metabolic processes that were impacted by oil exposure. After 96 hours of exposure to the WSF of Prudhoe Bay crude oil (3.5 – 8.7 mg/L total petroleum hydrocarbons), liver and muscle tissues were examined for their metabolic profiles. In smolts, increases in amino acid and decreases in organic osmolytes were observed, suggesting the fish were shifting their energy sources in response to stress. Increased amino acids (to synthesize proteins) may also be required to help repair cellular damage, and an imbalance in amino acids can lead to reduced development, reproduction or ability to adapt to additional stressors. Alterations in osmolyte profile may also make it more difficult for fish to adjust to osmotic stress during seaward migration (Lin et al., 2009).

In the parallel study with Chinook salmon parr, Van Scoy et al. (2010) found that the WSF of Prudhoe Bay crude oil (4.2 – 11.2 mg/L total petroleum hydrocarbons) also changed the metabolic profile in muscle of salmon. Decreases in lactate and ATP content were noted, while some amino acids and organic osmolytes increased. Some of these changes persisted for up to 3 months after exposure, but did not result in changes to growth. The alterations may be bioindicators of cellular repair processes, changes in cellular structure or responses to overall stress (Van Scoy et al. 2010).

### *Growth impairments or somatic indicators of toxicity*

Wang et al. (1993) conducted a study where juvenile pink salmon were fed with crude oil-contaminated food. Fish that received 34.83 mg crude oil/g of food experienced much lower growth after 6 weeks compared to unexposed fish. Similarly, Lockhard et al. (1996) reported that juvenile rainbow trout exposed to Norman Wells crude oil (0.15 to 1.5 mg/L total dissolved hydrocarbons) experienced a decrease in growth as measured by length of fish after 55 days. These fish also experienced fin erosion and imbalances in water content, which increased over time.

In a different type of study, Thomas and Rice (1975) examined the opercular rate (respiration rate) of pink salmon exposed to the water-soluble fraction (1.05 – 3.46 mg/L dissolved total hydrocarbon) of Prudhoe Bay crude oil. They found that at concentrations of 2.83 mg/L or more, opercular rate was elevated within 3 hours of exposure and remained elevated through at least 9-12 hours of exposure, before returning to normal at 23 hours of exposure. This response may be adaptive in the short-term, but in the long term may place additional energy demands on the fish.

### *Histopathology*

Pink salmon fry that were exposed to the WSF (predominantly MAHs and naphthalene) of Alaska North Slope crude oil for a period of 10 days were examined for histological abnormalities. Exposure concentrations were either 25-54 µg/L or 178-348 µg/L total dissolved hydrocarbons. WSF-exposed salmon exhibited greater histological abnormalities in the liver (steatosis, nuclear pleomorphism, megalocytosis and



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necrosis), head kidney (increased interrenal cell diameter) and gill tissue (epithelial lifting, fusion, mucus cell hyperplasia and vascular constriction).

Hawkes et al. (1980) conducted a study in which Chinook salmon were fed a model mixture of petroleum hydrocarbons including equal amounts of various substituted thiophenes and naphthalenes, fluorine, phenanthrene and several aliphatic hydrocarbons, with 8 chemicals in total. They found that, while the gut mucosal cells remained intact at the macroscopic level in the hydrocarbon-fed fish, the cells themselves underwent changes at the microscopic level. These changes were described as alterations in the columnar cells of the mucosa and development of inclusions in the cells, which were not observed in untreated fish.

### *Reproductive toxicity*

Adult pink salmon (*Oncorhynchus gorbuscha*) returned to PWS during late summer and early fall 1989 to spawn, and spawning often occurred near heavily oiled habitats from the EVOS. Terrestrial anadromous spawning habitat is limited in PWS because this region is geologically immature, with numerous but short streams suitable for salmon spawning, so pink salmon have adapted to spawn in the intertidal segments of streams there. These stream segments were mostly protected from direct oiling from the EVOS by the freshwater streamflow that diverted oil away from the incised stream channels on these beaches. However, at some streams, the adjacent beaches were heavily oiled at elevations just above the stream grade, and oil-contaminated water could flow into these streams and affect salmon eggs incubating there (Carls et al., 2003). Studies that compared the survival of salmon embryos in streams near heavily-oiled beaches and in streams on unoiled beaches found patterns of mortality that persisted through 4 successive years of pink salmon spawning events (Bue et al. 1996, 1998).

### *Developmental toxicity*

Heintz et al. (1999) looked at exposure of pink salmon embryos to 3 types of oil contamination: direct contact with oil-coated gravel, effluent (containing dissolved PAHs) from oil-coated gravel and direct contact with gravel coated with very weathered oil. They found that mortality of pink salmon embryos increased, as did PAH accumulation under all three scenarios, indicating that it is the PAHs dissolved in water that are being taken up. A total PAH concentration of 1.0 µg/L derived from the fresher oil resulted in mortality, but the same amount of total PAH did not affect mortality when it came from the very weathered oil since it was associated with the higher molecular weight PAHs.

Marty et al. (1997) found that development of pink salmon was impaired when concentrations of Prudhoe Bay crude oil were as low as 55.2 µg/g gravel. Toxicity was observed at concentrations of total PAHs in the water of 4.4 µg/L. Examples of the effects included induction of CYP1A, development of ascites, and increased mortality. There was evidence of premature emergence in oil-exposed pink salmon including greater amounts of yolk and liver glycogen stores compared to unexposed control fish.

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Moles et al. (1987) examined the sensitivity of pink salmon alevins to the water-soluble fraction (WSF) of Cook Inlet crude oil using a simulated tidal cycle (switching from fresh to salt water). Alevins exposed to the simulated tidal cycle were more sensitive to oil, had lower yolk sac reserves and accumulated more hydrocarbons than fish in freshwater. Older alevins (60 days) were more sensitive to toxic effects than younger alevins (5 days post-hatch).

Heintz et al. (2000) incubated pink salmon eggs in water that had percolated through gravel contaminated with crude oil. As the water passed through the gravel it became contaminated with PAHs, which were predominantly substituted naphthalenes and larger PAHs. Some fish were tagged and then released to the marine environment to complete their lifecycle. When those salmon returned at maturity 2 years later, those that had been exposed to as little as 5.4 µg/L total PAHs had a 15% decrease in marine survival relative to the control group. Following exposure, some salmon were retained to assess the effects of early life stage exposure on subsequent developmental stages. Fish exposed to more than 18 µg/L total PAH experienced decreased growth, which became apparent in the juvenile stage.

In contrast to the study done by Heintz et al. (2000), Birtwell et al. (1999) conducted exposures of pink salmon to the WSF of North Slope crude oil, using sublethal concentrations of 25-54 µg/L or 178-349 µg/L for 10 days. The WSF consisted mainly of MAHs (BTEX). After the exposures, tagged pink salmon were released to the marine environment to complete their lifecycle. There was no apparent treatment effect of the oil on pink salmon growth prior to release or on the proportion of adults returning to their natal stream to spawn. By comparing these findings to those of Heintz et al. (2000), it appears that exposure to PAHs, particularly those of higher molecular weight, is required before long term consequences of early life stage exposure becomes apparent.

Taken together, the various studies which examined the effects of crude oil exposure to pink salmon, both in the short term and in the long term, suggest that toxicity can occur at low concentrations of PAHs which would be expected to occur in the environment. The types of toxicity observed (mortality, growth, histopathology, poor marine survival and lower adult returns) suggest that these early life stage exposures to crude oil could result in declines at the population level. This is supported by a study using population modelling for pink salmon that found that simulated exposure to 18 nL/L aqueous PAH could result in significant declines in population productivity and an 11% probability of population extinctions (Heintz 2007).

However, it should be noted that there is some disagreement about the impact of crude oil and PAHs on pink salmon development. Research done by US government scientists (NOAA), which include most of the studies cited in this section, shows that pink salmon are impacted by low-level exposures crude oil. Other studies done by predominantly academic or industry-funded scientists have opposite findings (for example, see Brannon et al. (2001) for a review or Brannon et al. (2006)). In these studies, either the effects of crude oil are not observed at all, or they occur at much higher concentrations of toxicant. Disparity in findings may

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be due to differences in sources of fish or oil, experimental methodologies, assay sensitivity, statistical methods, or data interpretation.

### *Behavioural toxicity*

Folmar et al. (1981) reported on the effects of oil exposure on predatory behaviour of Coho salmon. Coho were exposed to the water-soluble fraction of Cook Inlet crude oil (230 – 530 µg/L) and their ability to capture prey items (small rainbow trout) was evaluated. The authors noted that behavioural changes (lethargy, little interest in prey items) could be observed by 10 days of exposure to the WSF, which was associated with reduced predation by the WSF-exposed Coho.

### **Section 10.5.7.4 Residual Effects Assessment and Significance Determination, p. 10-68**

*‘Exposure to heavy oil due to an accident or malfunction could potentially harm an individual SRKW or adversely affect the life functions of individual animals, including foraging, mating, resting and socialising’.*

This statement does not accurately describe the potential harm that exists under this worst-case scenario. Serious health effects including mortality may occur as discussed above, as well as other severe physiological impairments.

### **Section 10.5.7.5, Summary of Assessment, p. 10-69**

*In Table 10 – 20, and in the following paragraph, confidence was rated as low in the determination of significant effects for SRKW due to an apparent lack of causation between loss of killer whales and the EVOS.*

First, it is unclear how a value of low, medium or high is attained or determined in this assessment. It appears subjective and follows no logic pathway, or weight of evidence or ranking approach. As well, the evidence supports the causal link between killer whale mortality and the EVOS as published in Matkin et al. (2008). Equally as convincing is the mammalian data (albeit not killer whales) that supports a range of toxicities upon exposure to various components of crude oil. The conclusion of the ‘Summary of Assessment’ is not supported by the scientific evidence.

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## References:

- Arnot, J. and F. Gobas. (2004). A food web bioaccumulation model for organic chemicals in aquatic ecosystems. *Environ. Toxicol. Chem.* 23: 2343-2355.
- Birtwell, I., R. Fink, D. Brand, R. Alexander and C. McAllister. (1999). Survival of pink salmon (*Oncorhynchus gorbuscha*) fry to adulthood following a 10-day exposure to the aromatic hydrocarbon water-soluble fraction of crude oil and release to the Pacific ocean. *Can. J. Fish. Aquat. Sci.* 56: 2087-2098.
- Brannon, E., K. Collins, J. Brown, J. Neff, K. Parker and W. Stubblefield. (2006). Toxicity of weathered Exxon Valdez crude oil to pink salmon embryos. *Environ. Toxicol. Chem.* 25: 962-972.
- Brannon, E., K. Collins, L. Moulton and K. Parker. (2001). Resolving allegations of oil damage to incubating pink salmon eggs in Prince William Sound. *Can. J. Fish. Aquat. Sci.* 58: 1070-1076.
- Bue, B., S. Sharr and J. Seeb. (1998). Evidence of damage to pink salmon populations inhabiting Prince William Sound, Alaska, two generations after the Exxon Valdez oil spill. *Trans. Am. Fish. Soc.* 127: 35-43.
- Bue, B., S. Sharr, S. Moffitt and D. Craig. (1996). Effects of Exxon Valdez oil spill on pink salmon embryos and pre-emergent fry. *Am. Fisheries Soc. Symposium* 18: 619-627.
- Carls, M., R. Thomas and S. Rice. (2003). Mechanism for transport of oil-contaminated water into pink salmon redds. *Mar. Ecol. Prog. Ser.* 248: 245-255.
- Folmar, L., D. Craddock, J. Blackwell, G. Joyce and H. Hodgins. (1981). Effects of petroleum exposure on predatory behaviour of coho salmon (*Oncorhynchus kisutch*). *Bull. Environ. Toxicol. Chem.* 27: 458-462.
- Garshick, E., M. Schenker, A. Munoz, M. Segal, T. Smith, S. Woskie, S. Hammond and F. Speizer. (1987). A case-control study of lung cancer and diesel exhaust exposure in railroad workers. *Am. Rev. Resp. Dis.* 135: 1242-1248.
- Hawkes, J., E. Gruger Jr. and O. Olson. (1980). Effects of petroleum hydrocarbons and chlorinated biphenyls on the morphology of the intestine of Chinook salmon (*Oncorhynchus tshawytscha*). *Environ. Res.* 23: 149-161.

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- Heintz, R. (2007). Chronic exposure to polynuclear aromatic hydrocarbons in natal habitats leads to decreased equilibrium size, growth, and stability of pink salmon populations. *Integr. Environ. Assess. Manage.* 3: 351-363.
- Heintz, R., J. Short and S. Rice. (1999). Sensitivity of fish embryos to weathered crude oil: Part II. Increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos incubating downstream from weathered Exxon Valdez crude oil. *Environ. Toxicol. Chem.* 18: 494-503.
- Heintz, R., S. Rice, A. Wertheimer, R. Bradshaw, F. Thrower, J. Joyce and J. Short. (2000). Delayed effects on growth and marine survival of pink salmon *Oncorhynchus gorbuscha* after exposure to crude oil during embryonic development. *Mar. Ecol. Prog. Ser.* 208: 205-216.
- Lin C., B. Anderson, B. Phillips, A. Peng, S. Clark, J. Voorhees, H. Wu, M. Martin, J. McCall, C. Todd, F. Hsieh, D. Crane, M. Viant, M. Sowby and R. Tjeerdema. (2009). Characterization of the metabolic actions of crude versus dispersed oil from salmon smolts via NMR-based metabolomics. *Aquat. Toxicol.* 95: 230-238.
- Linkov, I., D. Loney, S. Cormier, K. Sattertrom and T. Bridges. (2009). Weight-of-evidence evaluation in environmental assessment: Review of qualitative and quantitative approaches. *Sci. Total Environ.* 407: 5199-5205.
- Lockhart, W., D. Duncan, B. Billeck, R. Danell and M. Ryan. (1996). Chronic toxicity of the 'water soluble fraction' of Norman Wells crude oil to juvenile fish. *Spill Sci. Tech. Bull.* 3: 259-262.
- Marty, G., J. Short, D. Dambach, N. Willits, R. Heintz, S. Rice, J. Stegeman and D. Hinton. (1997). Ascites, premature emergence, increased gonadal cell apoptosis, and cytochrome P4501A induction in pink salmon larvae continuously exposed to oil-contaminated gravel during development. *Can. J. Zool.* 75: 989-1007.
- Matkin, C., E. Saulitis, G. Ellis, P. Olesiuk and S. Rice. (2008). Ongoing population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. *Mar. Ecol. Prog. Ser.* 356: 269-281.
- Michel, J., and J. A. Galt. 1995. Conditions under which floating oil slicks can sink in marine settings. *International Oil Spill Conference Proceedings* 1: 573-576.
- Moles A. (1998). Sensitivity of ten aquatic species to long-term crude oil exposure. *Bull. Environ. Contam. Toxicol.* 61: 102-107.

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- Moles, A., M. Babcock and S. Rice. (1987). Effects of oil exposure on pink salmon, *Oncorhynchus gorbuscha*, alevins in a simulated intertidal environment. *Mar. Environ. Res.* 21: 49-58.
- Moles, A., S. Rice and S. Korn. (1979). Sensitivity of Alaskan freshwater and anadromous fishes to Prudhoe Bay crude oil and benzene. *Trans. Am. Fish. Soc.* 108: 408-414.
- National Oceanic and Atmospheric Administration (NOAA). 1997. Oil beneath the water surface and review of currently available literature on Group V oils: An annotated bibliography. Report HRMAD 95-8. Updated January 1997. Hazardous Materials Response and Assessment Division. Seattle, USA.
- National Research Council. 1999. Spills of nonfloating oils: Risk and response. The National Academic Press, Washington, DC, USA.
- Neff, J. M., S. A. Stout, P. Beall, and G. S. Durell. (2003). Review of environmental challenges of heavy oils. Report prepared by Battelle Memorial Institute for Statoil, Trondheim, Norway.
- NMFS. (2001). Alaska Fisheries Science Center. AFSC Quarterly Research Reports. <http://www.afsc.noaa.gov/Quarterly/ond2001/divrptsABL2.htm>
- Skinner, S., and W. Reilly. (1989). The Exxon Valdez oil spill; a report to the President.
- Thomas, R. and S. Rice. (1975). Increased opercular rates of pink salmon (*Oncorhynchus gorbuscha*) fry after exposure to the water-soluble fraction of Prudhoe Bay crude oil. *J. Fish. Res. Board Can.* 32: 2221-2224.
- Van Scoy, A., C. Lin, B. Anderson, B. Philips, M. Martin, J. McCall, C. Todd, D. Crane, M. Sowby, M. Viant and R. Tjeerdema. (2010). Metabolic responses produced by crude versus dispersed oil in Chinook salmon pre-smolts via NMR-based metabolomics. *Ecotox. Environ. Safe.* 73: 710-717.
- Wang, S., J. Lum, M. Carls and S. Rice. (1993). Relationship between growth and total nucleic acids in juvenile pink salmon, *Oncorhynchus gorbuscha*, fed crude oil contaminated food. *Can. J. Fish. Aquat. Sci.* 50: 996-1001.



# **TAB E**



Sufficiency Review of Terminal 2 Project's  
Additional Information Request Responses

January 21, 2019

Participant: Dr. Chris Kennedy

Organization (if applicable): Georgia Strait Alliance

Comments on additional information request responses supplied by the Port of Vancouver:

IR #	Topic	Information Sources	Context	Information Request	Sufficiency of Information
IR3-03	Roberts Bank Ecosystem Model - Study Area	EIS Volume 3: Section 10.0 EIS Volume 2: Figures 9.5-1, 9.6-1 and 9.7-1	The Proponent reported in Section 10.3.3 of the EIS that the study area for the RB EwE model covered an area of 54.68 km <sup>2</sup> and included the intertidal and subtidal zones between Canoe Passage and the BC Ferries Tsawwassen Terminal, from shoreline to the 100 metre depth contour or the Canada – United States international border. This study area was selected by the Proponent based on the anticipated direct and indirect Project effects related to changes in coastal geomorphology, surficial geology and marine sediment, and marine water quality, and the influence of these changes on marine intermediate components and valued components. There are differences in the study area used for the RB EwE model (Figure 10.3-1) and the study areas for Coastal Geomorphology (Figure 9.5-1), Surficial Geology and Marine Sediment (Figure 9.6-1) and Marine Water Quality (Figure 9.7-1). For example, the coastal geomorphology local assessment area includes all of Canoe Passage which is absent from the RB EwE study area.	Clarify how the RB EwE model study area was extracted from the larger study areas that were adopted for Coastal Geomorphology, Surficial Geology and Marine Sediment and Marine Water Quality.  Provide rationale to support the use of spatial boundaries based on Coastal Geomorphology, Surficial Geology and Marine Sediment and Marine Water Quality to define the relevant spatial scale for modelling effects on functional groups in the RB EwE model study area.  Provide rationale as to why the RB EwE model study area was defined on the south by the Canada – United States of America border and not by ecosystem processes.	<b>Sufficient.</b> The proponent suggests that the Roberts Bank ecosystem model (RB model) study area was not extracted from the larger study areas of coastal geomorphology, surficial geology and marine sediment, and marine water quality, but was informed by them.  <b>Sufficient.</b> The areas of forecasted changes in these model outputs were smaller than the selected study areas for coastal geomorphology, surficial geology and marine sediment, and marine water quality, because the areas of predicted changes to coastal processes are smaller.  <b>Insufficient.</b> No rationale was given as to why the RB EwE model study area was defined on the south by the Canada – United States of America border and not by ecosystem processes. If forecasted changes outlined in the model outputs for coastal geomorphology, surficial geology and marine sediment, and marine water quality indicated that changes occur south of the border, the RB EwE model should incorporate this area.

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IR #	Topic	Information Sources	Context	Information Request	Sufficiency of Information
IR3-04	Roberts Bank Ecosystem Model - Study Area	EIS Volume 3: Appendix 10-C Appendix 10-D	<p>The Proponent defined the RB EWE model area as 54.68 km<sup>2</sup> (without the proposed Project) and utilized a uniform grid of 100 x 100 m (1 ha) cells, which generated 8694 grid cells, of which 5468 were included in the model calculations (Appendix 10-C, Figure 2-7)</p> <p>Sensitivity analyses of the RB EWE model considered:</p> <ul style="list-style-type: none"> <li>increases and decreases in the predators' ability to influence prey dynamics;</li> <li>effects of omitting one abiotic factor at a time for each functional group;</li> <li>increases and decreases in the forecasted effects of the proposed Project on abiotic factors; and,</li> <li>sensitivity to input parameter uncertainty.</li> </ul> <p>The Proponent's conclusion from the RB EWE modeling (Appendix 10-D) was that the proposed Project will have an effect on the study area, that the effect varies between species, and that the findings are robust to parameter uncertainty.</p> <p>Further sensitivity analyses are required to understand the influence of different modeling boundaries and study area configurations and to determine their influence on model outputs.</p>	<p>Undertake sensitivity analyses for 4 scenarios that compare model outputs corresponding to the following number of 100 x 100 m grid cells:</p> <ul style="list-style-type: none"> <li>1400 (25% of 5468 cells utilized in the RB EWE model)</li> <li>2700 (50% of 5468 cells utilized in the RB EWE model)</li> <li>5468</li> <li>8694</li> </ul> <p>Present biomass estimates from key runs, without and with the Project, using the same format as Table 3.2 in Appendix 10-C, and present production estimates from key runs, without and with the Project using the same format as Table 3.3 in Appendix 10-C.</p> <p>Provide a comparison of the biomass and production differences, without and with the Project, for the four different scenarios.</p>	<p><b>Insufficient.</b> The proponent did not undertake sensitivity analyses for 4 scenarios that compare model outputs corresponding to the following number of 100 x 100 m grid cells:</p> <ul style="list-style-type: none"> <li>1400 (25% of 5468 cells utilized in the RB EWE model)</li> <li>2700 (50% of 5468 cells utilized in the RB EWE model)</li> <li>5468</li> <li>8694.</li> </ul> <p>The proponent cited several reasons for each of the 1400, 2700 and 8694 grid cells. For example, the proponent cited model limitations for including the largest grid number. The potential for possible alterations to biological outputs for the entire area using all of the site would be more appropriate (limitations of the model notwithstanding).</p> <p><b>Insufficient.</b> Tabulation of biomass and production estimates from key runs, as well as comparison of biomass and production differences without and with terminal and causeway footprints for the four different scenarios requested were not provided.</p>
IR3-05	Roberts Bank Ecosystem Model Exchange with Adjacent Ecosystems	Canadian Environmental Assessment Registry Document (CEAR Doc) #547 EIS Volume 3: Section 10.3 Appendix 10-B Appendix 10-C	<p>According to the Proponent, in CEAR Doc #547, the relatively small spatial scale of the RB EWE model was justified because the model was specifically chosen for assessing productivity changes, and because the relative influences of external exchanges were assumed to be identical with and without the proposed Project. The RB EWE model study area was limited only to Roberts Bank and parts of the foreslope even though the spatial extent of the coastal geomorphology model covered the central and southern parts of the Strait of Georgia and had forecasted minimal geomorphology changes outside Roberts Bank as a result of the Project</p> <p>As identified in Appendix 10-C, an assumption used for the RB EWE model was that highly mobile species with broad prey bases would be partially sustained by external energy from outside the model system.</p>	<p>Provide further clarification on how the RB EWE model captures exchanges with adjacent ecosystems, including exchanges of water and organic matter from beyond the boundaries of RB EWE model study area.</p> <p>Provide a qualitative assessment of migration behavior and migration rates of marine mammals, birds and fish between the RB EWE model study area and adjacent areas.</p> <p>Describe how the RB EWE model results for marine mammals, birds and fish functional groups would change by including net migration of these components, and/or including</p>	<p><b>Sufficient.</b> Further clarification on how the RB EWE model captures exchanges and interactions with adjacent ecosystems in terms of biomass and water (although vague in terms of water) are given.</p> <p><b>Insufficient.</b> Further clarification on how the RB EWE model captures exchanges and interactions with adjacent ecosystems with organic matter were not given.</p> <p><b>Sufficient.</b> A qualitative description of migration behavior and migration rates of marine mammals, birds and fish between the RB EWE model study area and adjacent areas was given.</p>

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IR #	Topic	Information Sources	Context	Information Request	Sufficiency of Information
			<p>According to the Proponent, average annual biomasses were used to provide estimates that would reflect the highly mobile species energy supply and demand within the Roberts Bank system and to account for tidal exchanges and seasonal animal migrations through the study area. Seasonally varying parameters (such as salinity, bottom current, and wave height) were captured in the RB EwE model by the use of annual averages for abiotic parameters. The Proponent in Appendix C of Appendix 10-D, identified that the RB EwE model was also reviewed to ensure that there was no match-mismatch between predators and prey - that each predator only fed on prey that were present at the same time. A seasonal biomass matrix (Table C-1) was constructed for functional groups and compared to the diet matrix. The Proponent reported that while there were no match-mismatches between predators and their prey, there were some instances where predators were feeding on prey outside of the prey's peak season.</p> <p>According to Fisheries and Oceans Canada, EwE models work best when the exchanges within the system being modelled are greater than the exchanges between the modelled system and the 'outside' world. The section of the Roberts Bank ecosystem that is included in the EwE model was comparatively small (54.68 km2) and complex. It is an intertidally-dominated environment that is subject to strong seasonal influences of both freshwater and marine exchanges across relatively large seaward and shoreward boundaries. The processes taking place outside the modelled ecosystem will contribute to dynamics within the modelled ecosystem (for example, 'outside' food supporting predators which occur in the Roberts Bank ecosystem for only part of the year; predators which may feed in the Roberts Bank ecosystem but export this energy when they migrate out of the region), but which may not be well-resolved by the RB EwE model. The distributions of organisms may differ, however, with and without the Project, which may affect their interactions with areas</p>	<p>exchanges of water and organic matter into the RB EwE model study area, with and without, the proposed Project.</p>	<p><b>Insufficient.</b> The RB EwE model results for marine mammals, birds and fish functional group changes including exchanges with organic matter into the RB EwE model study area were not given.</p>

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IR3-10	Roberts Bank Ecosystem Model - Mortality	EIS Volume 3: Appendix 10-C	<p>outside of the modelled system, and the use of diets from outside the modelled system may not reflect the impacts of the Project. An ecosystem which is open to frequent exchanges of water and organic matter from beyond its boundaries, such as the Roberts Bank ecosystem, would be more robust to local disturbances.</p> <p>As mentioned earlier, two master equations, identified in Appendix 10-C, were used by the Proponent for parameterisation in Ecopath. The Proponent stated that Ecopath aimed to describe all mortality factors, hence what is termed as other mortality should only include minor factors such as mortality due to old age or diseases.</p> <p>Fish, marine mammals, waterfowl, shorebirds and invertebrates in the regional assessment area serve as hosts for many pathogens, including nematodes, protozoans, bacteria, viruses, and crustaceans. A suite of environmental and ecological factors may affect the population-level impacts of disease.</p>	<p>Identify pathogens that occur within functional groups evaluated by the RB EwE model and summarize any documented disease outbreaks that have occurred over the past 50 years. Provide rationale for considering disease as a minor factor and evaluate the impact this could have on model predictions of including disease as an input to the Ecopath model.</p>	<p><b>Insufficient.</b> It is not clear what databases and searches were conducted for identifying pathogens that occur within functional groups evaluated by the RB EwE model. Summaries of any documented disease outbreaks that have occurred over the past 50 years were not given. Some studies are cited, but it is unclear if this is comprehensive in any way. The proponents with the above information have not indicated how this information may have impacted their decision to warrant disease as a minor factor in the Ecopath model.</p>
IR3-25	Surficial Geology and Marine Sediment - Contaminant Levels in Sediment	EIS Volume 1: Section 4.2 EIS Volume 2: Section 9.6 Appendix 9.6-B	<p>As stated by the Proponent in the EIS, changes in sediment contaminant concentrations are not expected, as sediments that will be re-suspended and deposited as a result of construction phase activities will not be contaminated. The assessment of sediment contamination was based on the following sediment sampling depths:</p> <ul style="list-style-type: none"> <li>for the dredge basin and tug basin areas: surface to depths of 2m; and</li> <li>for the intermediate Transfer Pit (ITP), Fraser River, and candidate Disposal at Sea (DAS) areas: surface only.</li> </ul> <p>For some contaminants, such as copper and polychlorinated biphenyls (PCBs), concentrations varied with the depth of sediments. However, there is no information on contaminant concentrations provided at the depths where sediment would be mobilized for various construction phase activities.</p>	<p>Determine the values for all parameters outlined in Table 9.6-4 of Section 9.6 of the EIS for the dredge basin, tug basin and ITP (as it is no longer proposed) as a function of depth, down to the depth that the sediments will be mobilized (30 and 6 m respectively); these were compared these to applicable standards. Results are presented in tables that clearly identify the depth of sample, sample size, and the mean, minimum, maximum, and standard deviation for contaminant concentrations for each of the locations requested. For samples where metals, PAHs, and PCBs are detected, figures are provided that display the vertical distribution of the parameters sampled and trends in the vertical distribution are described. A map that indicates sampling locations is provided.</p>	<p><b>Sufficient.</b> Values were determined for all parameters outlined in Table 9.6-4 of Section 9.6 of the EIS for the dredge basin, tug basin and ITP (as it is no longer proposed) as a function of depth, down to the depth that the sediments will be mobilized (30 and 6 m respectively); these were compared these to applicable standards. Results are presented in tables that clearly identify the depth of sample, sample size, and the mean, minimum, maximum, and standard deviation for contaminant concentrations for each of the locations requested. For samples where metals, PAHs, and PCBs are detected, figures are provided that display the vertical distribution of the parameters sampled and trends in the vertical distribution are described. A map that indicates sampling locations is provided.</p>

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IR3-26	Surficial Geology and Marine Sediment - Contaminant Levels in Sediment	EIS Volume 2: Section 9.6 Appendix 9.6-B	<p>For example, according to Section 4.2, the dredge basin is to be dredged to a depth of -30 m CD (20 m below existing seabed), but samples were only collected at the surface to a depth of 2 m. In consideration of the Proponent's proposal to carry out dredging in the berth pocket and the tug basin, loading and unloading of the ITP, and the reuse of certain materials for Project construction, the vertical profile of the contaminants in the sediment from areas which will be mobilized is required.</p> <p>As stated by the Proponent in Section 9.6 of the EIS, copper levels in Project activity areas are not considered to be contaminated relative to natural conditions. Although Appendix 9.6-B identified that the elevated copper sediment concentrations likely reflect naturally occurring concentrations rather than recent anthropogenic inputs, this conclusion cannot be verified by looking at the values shown in Table 9.6-4 of Section 9.6. To validate this conclusion, it is necessary to do a valid statistical test using the data collected on copper concentrations.</p>	<p>Appendix 9.6-B that display the vertical distribution of the parameters sampled in part 1 of this information request and describe any trends in the vertical distribution. Provide a map that indicates sampling locations.</p>	<p><b>Sufficient.</b> Using the original data presented in Section 9.6 of the EIS and new data astatistical analysis was performed to evaluate the hypothesis that there is no difference in copper concentrations between the dredge basin, the tug basin, Fraser River dredgeate, and the Proponent's candidate DaS areas. However, differences were seen between sites, bu the conclusions drawn by the proponent were the same as stated previously by the proponent that copper levels in Project activity areas are not considered to be contaminated relative to natural conditions may be a misinterpretation.</p>
IR3-27	Surficial Geology and Marine Sediment - Contaminant Levels in Sediment	EIS Volume 2: Section 9.6 Appendix 9.6-B	<p>Table 9.6-4 of the EIS presented the analytical results of sediment samples collected in 2013 for contaminant analyses as ranges of values. Table 5-1 of Appendix 9.6-B of the EIS presented the statistical summary of the sediment chemistry results, and included averages for contaminants. Table 9.6-4 and Table 5-1 showed exceedances of either Disposal at Sea (DAS) regulations reference criteria or Canadian Council of Ministers of the Environment interim sediment quality guidelines (CCME ISQG) for arsenic, cadmium, and copper by at least some of the sediment samples. However, neither table displays variance measures. In the case of parameters with smaller sample sizes and showing exceedances, such as for arsenic and cadmium, all the data points should be shown to evaluate whether or not exceedances represent outliers.</p>	<p>Provide a table that includes the following:</p> <ul style="list-style-type: none"> <li>all the parameters measured in Table 5-1;</li> <li>data from the dredge basin, tug basin, ITP, Fraser River maintenance dredging sites, and Roberts Bank candidate DAS areas;</li> <li>sample size, mean, minimum, maximum and standard deviation for each of the above;</li> <li>the method detection limit for each parameter; and</li> <li>a comparison with the more stringent criteria between the CCME ISQG or DAS regulations.</li> </ul> <p>For arsenic and cadmium, provide a table showing all the individual data points and the locations where they</p>	<p><b>Sufficient.</b> A table was provided showing: Provide a table that includes the following:</p> <ul style="list-style-type: none"> <li>all the parameters measured in Table 5-1;</li> <li>data from the dredge basin, tug basin, ITP (no longer proposed so not included), Fraser River maintenance dredging sites, and Roberts Bank candidate DAS areas;</li> <li>sample size, mean, minimum, maximum and standard deviation for each of the above;</li> <li>the method detection limit for each parameter; and</li> <li>a comparison with the more stringent criteria between the CCME ISQG or DAS regulations.</li> </ul> <p>For arsenic and cadmium, a table was provided showing all the individual data points and the locations where they were collected (map). The complete sediment analytical data was provided for metals and PAHs to complete the information in Appendix C of Appendix 9.6-B.</p>

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IR3-28	Surficial Geology and Marine Sediment - Contaminant Levels in Sediment	EIS Volume 2: Appendix 9.6-A	<p>Contrary to the first paragraph of Section 5.1 of Appendix 9.6-B, Appendix C does not show the complete sediment analytical data for metals or PAHs.</p> <p>In Table 13 of Appendix 9.6-A of the EIS, the Proponent compared the analytical results for various contaminant parameters against CCME sediment quality guidelines. The results in the table identified that there were some exceedances of arsenic, chromium, copper, mercury, and several PAHs at Roberts Bank. Although there are numerous maps included in Appendix 9.6-A to demonstrate the spatial distribution of various parameters, there are no maps indicating the location of samples of arsenic, chromium, copper, mercury, and PAHs that were found to be in exceedance of the CCME guidelines.</p>	<p>were collected. Provide the complete sediment analytical data for metals and PAHs to complete the information in Appendix C of Appendix 9.6-B.</p> <p>Using the sample data input into Table 13 of Appendix 9.6-A of the EIS, provide maps indicating the location and concentrations of all individual samples found to exceed CCME Sediment Quality Guidelines for the Roberts Bank area.</p> <p>Provide a discussion of the exceedance(s) of arsenic, chromium, copper, mercury and PAHs, and describe any spatial trends observed in the Roberts Bank area.</p>	<p><b>Sufficient.</b> Sample data input into Table 13 of Appendix 9.6-A of the EIS was used to provide maps indicating the location and concentrations of all individual samples found to exceed CCME Sediment Quality Guidelines for the Roberts Bank area.</p> <p>As well a discussion was provided of the exceedance(s) of arsenic, chromium, copper, mercury and PAHs, any spatial trends observed in the Roberts Bank area were described.</p>
IR3-29	Surficial Geology and Marine Sediment - DDT Levels in Sediment	EIS Volume 2: Sections 9.6 and 9.7	<p>In Section 9.7 of the EIS, the Proponent stated that PAHs, PCBs, dichlorodiphenyltrichloroethane (DDT), and other persistent toxic contaminants are highly hydrophobic contaminants, and they preferentially associate with sediments. The Proponent indicated that the most appropriate method for evaluating the presence of these substances in the local study area is through the collection and analysis of surficial sediment samples. Although information on PAHs and PCBs was presented in Section 9.6, Appendix 9.6-A, and other Sections, there is no description of DDT baseline levels in the local study area.</p>	<p>Provide a description of DDT levels in sediment in the local study area. Describe whether there are any activities from Project construction or operation that would result in the mobilization of DDT, and that are likely to result in a measurable change to DDT levels in sediment in the local study area.</p>	<p><b>Insufficient.</b> A description of DDT levels in sediment in the local study area was not given. The proponent used total PCBs as a proxy for DDT levels due to some similarities in chemical characteristics such as hydrophobicity and overlap in the decadal time frame of use. Although there are some overlaps in general characteristics, there will be differences in the environmental partitioning and persistence between DDT and PCBs. Even among PCB congeners, these differences can be large. PCBs, except on a broad scale, will not give accurate indications of DDT levels in the LSA. The proponent describes the activities from Project construction and operation that would result in the mobilization of PCBs but not DDT, and suggests that they are unlikely to result in a measurable increase in DDT levels in sediment in the local study area due to the dilution of buried sediments or at least similar levels that exist now. The proponent does not recognize that</p>

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					<p>sediments contaminated with DDT buried and not accessible to marine life may be remobilized could result in higher concentrations because currently DDT is not used in the LSA and top sediment layers would have lower concentrations than buried layers.</p>
IR3-30	<p>Surficial Geology and Marine Sediment - Sediment Dispersion Modeling</p>	<p>EIS Volume 2: Appendix 9.6-C</p>	<p>As stated by the Proponent in Appendix 9.6-C of the EIS:</p> <ul style="list-style-type: none"> <li>the amount of dredge basin dredgeate solids that would not be retained by the containment cells and would be discharged through disposal at sea was assumed to be 15%; and</li> <li>this estimate is based on previous experience and assumes the residence time for dredgeate liquids in the containment cell to be relatively short.</li> </ul> <p>The sediment dispersion modelling assumed 15% non-retention rate and also carried out further simulations using much lower non-retention rates, but did not use higher non-retention rates. Table 5.3.2 of Appendix 9.6-C provided a summary of containment cell settling efficiency. The table indicated that the settling efficiency of "fines only" varies from 71% to 87%. The use of higher non-retention rates in the sediment dispersion modeling would represent more conservative estimates.</p>	<p>Re-run the sediment dispersion modeling for the discharge of unsettled fines from the dredge basin at a depth of -45 m CD and using a non-retention rate of 30%. Compare these results with the previous modeling results that used a non-retention rate of 15%, and a depth of -45 m CD.</p> <p>Provide figures similar to that of Figure 5.4.1 to 5.4.7 of Appendix 9.6-C for the above analysis, ensuring that the entire extent of the plume is visible on the maps.</p>	<p><b>Insufficient.</b> The proponent describes how the overall retention rates (2.7-15%) were determined and indicates that the range of fine sediment non-retention rates in this estimate range include a range of (12.7-71.8%) and suggest that the scenario and information request has already been fulfilled. However, the request was for an overall non-retention rate of 30% be used and then a comparison of these results with the previous modeling results that used an overall non-retention rate of 15%, and a depth of - 45 m CD.</p>
IR3-31	<p>Surficial Geology and Marine Sediment - Sediment Dispersion Modeling</p>	<p>EIS Volume 2: Appendix 9.6-C</p>	<p>In Appendix 9.6-C of the EIS, the Proponent carried out sediment dispersion modeling for the discharge of supernatant water using both 3% and 15% non-retention rates. The Proponent indicated that it also used the 3% non-retention rate for additional simulations at outfalls depths of 60 metres and 75 metres. It is not clear why the Proponent did not carry out additional simulations that used a non-retention</p>	<p>Provide a rationale for why the 15% non-retention was not used in additional simulations using outfall depths of 60 metres and 75 metres.</p>	<p>Sufficient. A rationale was provided for why the 15% non-retention was not used in additional simulations using outfall depths of 60 metres and 75 metres. The Proponent states that The 3% non-retention scenario, was simulated for all three outfall depths as a best-estimate case and from these simulations it was clear that, of the three depth cases, the -45 m CD discharge pipe depth resulted in the farthest TSS plume</p>

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IR3-32	Surficial Geology and Marine Sediment - Sediment Dispersion Modeling	EIS Volume 2: Appendix 9.6-C	<p>rate of 15% at depths of 60 metres and 75 metres.</p> <p>In Section 2.4 of Appendix 9.6-C of the EIS, the Proponent described the perimeter dyke permeability of the containment cells for the proposed Project. The Proponent indicated that there is a potential for a steep instantaneous hydraulic gradient across the dyke during portions of the tidal cycle, which can drive flow through the perimeter dykes. The Proponent indicated that if this is not managed appropriately, that the flow could result in fugitive losses of water and associated suspended sediments. The Proponent outlined that for the sediment dispersion modeling, it assumed that these fugitive losses would be appropriately managed through engineering design and contractor means and methods.</p> <p>When determining the settlement of entrained fine sediment following disposal at sea, the Proponent estimated that 85% of dredge basin solids will be retained in the containment cells. This number, which originated from Project planning documents, differed from the settling model results presented in Appendix 9.6-C, which indicated that over 97% of the solids would be retained. The Proponent indicated that this discrepancy is due to differences in assumptions about hydraulic control of the containment cells and the uncertainty associated with the contractor's methods.</p> <p>Further information is required to determine what</p>	<p>Describe the potential engineering design and contractor methods that could be used to manage fugitive losses from the perimeter dyke.</p> <p>Describe the potential contractor methods that could be used to manage sediment and water within the containment cells, and describe how these methods would affect the retention of dredge basin solids.</p>	<p>dispersal. The -45 m CD site is a more dispersive location for two main reasons: 1) tidal, estuarine, and wind-driven currents in the Strait of Georgia tend to be stronger at shallower depths than at deeper depths; and 2) the shallower -45 m CD site is subject to stronger up-slope flows during flood tides, potentially bringing comparatively more suspended sediment onto Roberts Bank. Since the purpose of the 15% non-retention scenario was to define a worst-case scenario, a 15% non-retention rate was only simulated for the -45 m CD depth case.</p> <p><b>Sufficient.</b> Standard design criteria and methods used to manage fugitive losses from dykes are well understood within the marine engineering community, and are outlined in the US Army Corps of Engineers Coastal Engineering Manual. Retention, permeability, and internal stability criterion can be specified. Examples of how these criteria can be achieved through design and contractor methods include the following: dyke core material gradation, dyke core width, and filter layers.</p> <p>A method that could be used by potential contractors to manage sediment and water and retain materials within the containment cell perimeter dykes is to establish a series of retention ponds separated by weirs. The height of the weirs could be adjusted to maintain a minimum water depth above the deposited sediment to promote settling of solids.</p>



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IR3-33	Surficial Geology and Marine Sediment - Sediment Dispersion Modeling	EIS Volume 2: Appendix 9.6-C	<p>engineering design and contractor methods could be used to minimize fugitive losses from the perimeter dykes, and that would influence the amount of dredge basin solids that would be retained in containment cells.</p> <p>In Appendix 9.6-C of the EIS, the Proponent modelled the sediment dispersion plumes and total suspended solids (TSS) that would be produced from the combined activities of dredge basin excavation and ITP loading and unloading. Figures 5.2.8 to 5.2.10 showed the predicted fate of TSS plumes originating from the combined dredge basin and ITP operations. However, Figures 5.2.11 and 5.2.12 did not show a plume originating from the ITP, despite the fact that modeling was carried out for dredge basin excavation and ITP loading. The Proponent indicated that the most extensive far-field TSS plume occurred between ITP loading dumps, and so the suspended sediment plume originating from loading the ITP was not present in these figures. A similar explanation was given for why a plume surrounding the ITP is not visible in Figures 5.2.18 and 5.2.19. Given that loads of Fraser river sands would be imported several times daily, modeling the dumping of a load of Fraser river sands to the ITP at the same time as dredge basin excavation would have been a more conservative modeling approach.</p>	<p>Update Figures 5.2.11, 5.2.12, 5.2.18 and 5.2.19 of the EIS to display the instantaneous TSS extent originating from the ITP in addition to those plumes already displayed in those figures.</p>	<p><b>Sufficient.</b> The intermediate transfer pit (ITP) is no longer proposed for use as a temporary storage site for Fraser River sand, as described in the Preamble at the beginning of the response package provided by the proponent. The figures have therefore not been updated to display the instantaneous total suspended solids (TSS) extent originating from the ITP as requested by the Panel; however, clarification is provided by the proponent regarding the TSS plumes represented in these figures in the EIS in their response.</p>
IR3-34	Surficial Geology and Marine Sediment - Sediment Dispersion Modeling	EIS Volume 2: Section 9.6.8.1 Appendix 9.6-C	<p>In Table 9.6-5 of the EIS, the Proponent reported that the following four modelled scenarios specific to construction activities, including dredging, vibro-densification resulting in vibro-replacement expressed fines (VEF) materials, loading and unloading of the ITP, and DAS, would result in sediment suspension and deposition:</p> <ul style="list-style-type: none"> <li>dredge basin dredging, loading and unloading of ITP;</li> <li>DAS discharge of sediment-laden water from</li> </ul>	<p>For all disposal at sea activities that could occur simultaneously to dredging activities, carry out sediment dispersion modeling to:</p> <ul style="list-style-type: none"> <li>quantify the suspended sediment generated by the activities and provide a comparison with applicable guidelines;</li> <li>describe the spatial extent of the resultant plume(s), and</li> </ul>	<p><b>Insufficient.</b> The proponent did not simulate the activities simultaneously, as they state that the combined scenario represents neither a worst-case nor best-case scenario.</p> <p>Only the -45 m CD level is being considered for the pipeline outfall depth (due to increased operational challenges with the deeper outfall depths), and modelling results for supernatant</p>

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IR3-41	Marine Water Quality - Baseline	EIS Volume 2: Section 9.7.6 Appendix 9.6-A	<p>dredge basin dredgeate (including VEF) via pipe to the DAS site;</p> <ul style="list-style-type: none"> <li>DAS discharge of sediment-laden water containing ITP stockpile materials via pipe to the DAS site;</li> <li>re-suspension of sediments from tug basin dredging and disposal of dredgeate by surface release to the DAS site.</li> </ul> <p>Figure 1.2 of Appendix 9.6-C of the EIS showed the summary of modelled and scheduled sediment handling activities. According to Figure 1.2, disposal at sea activities will occur at the same time as different dredging activities. Although the Proponent modelled the sediment dispersion plumes and deposition resulting from multiple simultaneous dredging activities, it did not model the plumes that would occur from dredging activities that occur simultaneous to disposal activities.</p> <p>Further, in Section 9.6.8.1 of the EIS, the Proponent reported that the following activities were not included in the four modelled scenarios:</p> <ul style="list-style-type: none"> <li>construction of dykes and terminal caisson wall;</li> <li>rock and rip-rap placement;</li> <li>other modifications within the dredge basin; and</li> <li>storm water discharge.</li> </ul> <p>Further information is required to quantify the suspended sediment generated by simultaneous dredging and disposal at sea activities, and to determine whether other activities not included in the model could result in measurable changes in suspended sediment and sediment deposition.</p> <p>The Proponent conducted field studies and analyses of water for chemical and physical parameters at monthly or by-monthly intervals over a one-year period (July 2012 to June 2013) and obtained <i>in situ</i> turbidity measurements in June 2013. According to Section 5.0 of Appendix 9.6-A of the EIS, the freshest of 2012 reflected an abnormally large discharge. Because the discharge from the Fraser River may show significant year-to-year variability in flow and</p>	<ul style="list-style-type: none"> <li>describe the deposition that would occur.</li> </ul> <p>The disposal at sea activities should be modeled at depths of -45, -60 and -75 m CD, with a non-retention rate of 15%.</p> <p>Generate figures for peak TSS exceeding 1.0 mg/L, 5.0 mg/L, and 10 mg/L, instantaneous TSS extent during ebb and flood tide, total deposition of fine sediment, and D50 of deposited fine sediment for each group of overlapping activities.</p> <p>Provide a description of the potential changes to suspended sediment and deposition caused by the construction of dykes and terminal caisson wall, rock and rip-rap placement, and other modifications within the dredge basin.</p>	<p>discharge at -45 m CD are provided in the proponent's response.</p> <p>Figures were generated showing the percentage of time that the TSS plume will be present at a given location with a maximum water column concentration exceeding 1 mg/L, 5 mg/L, or 10 mg/L, respectively.</p> <p>Details in the request including instantaneous TSS extent during ebb and flood tide, total deposition of fine sediment, and D50 of deposited fine sediment for each group of overlapping activities do not appear. Instead, in the proponent's figures the values do not represent the instantaneous TSS plume footprint or a static plume position. Instead, they are probability maps representing the likely cumulative percentage of time a given TSS concentration is exceeded at any one location over the entire duration of simultaneous dredging and infilling activities. This cumulative percentage is derived as a composite of maximum TSS concentrations in space and time over the full period (i.e., 2 years) and should not be interpreted as a continuous or prevailing condition: the actual size of the plume at any time will fill only a relatively small part of any of the shaded areas.</p> <p><b>Insufficient.</b> The proponent indicates through discussion that their values are based on existing information, including available water quality databases; therefore they do not provide a revised set of the water quality parameters identified in Appendix F of Appendix 9.6-A of the EIS. The proponent indicates that the characterisation of existing conditions for water quality have been based</p>

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IR3-42	Marine Water Quality Baseline	EIS Volume 2: Section 9.7.6 Appendix 9.6-A	<p>consequent water chemistry, it is necessary to evaluate the influence that using an unusually high flow year may have had on the reporting of baseline water quality parameters.</p> <p>Environment and Climate Change Canada noted that, in the EIS, some marine water quality parameters (conductivity, temperature) were sampled on a seasonal basis and were collected monthly or bi-monthly over one year (July 2012 to June 2013).</p> <p>Hardness, TSS, nutrients and trace elements were analysed using a single sampling event in April 2013. This sampling frequency does not capture seasonal trends.</p>	<p>revised baseline information could influence the Proponent's analysis and conclusions regarding relevant intermediate components and valued components.</p> <p>Provide seasonal estimates of hardness, TSS, nutrients and trace elements in the marine water quality study area (Figure 9.7-1) based on available data sources.</p>	<p>on a range of conditions and do not change conclusions regarding relevant intermediate components and valued components.</p> <p><b>Sufficient.</b> Seasonal estimates of hardness, TSS, nutrients and trace elements in the marine water quality study area are provided based on available data sources which are given.</p>
IR3-43	Marine Water Quality Baseline	Marine Shipping Addendum: Section 7.3.2.2	<p>In Section 7.3.2.2 of the Marine Shipping Addendum, the Proponent indicated that there are no available studies documenting ambient contaminant levels in water in the area of the marine shipping lanes, and identified this as a constraint to its study.</p> <p>The Proponent is to consult with relevant provincial and federal entities in an attempt to obtain appropriate information that could be used to present a baseline characterization of ambient contaminant levels in water within the study area boundaries.</p>	<p>Provide a description of the ambient contaminant levels in water in the marine shipping area.</p>	<p><b>Sufficient.</b> The VFPA attempted to solicit information regarding ambient contaminant levels in water in the marine shipping area from several regulatory entities including the Federal, Provincial and Regional Governments (and departments within). The conclusion is that there are no available studies documenting ambient contaminant levels over the marine shipping lanes.</p>
IR3-44	Marine Water Quality Baseline	EIS Volume 2: Section 9.6	<p>In Section 9.6 of the EIS, the Proponent stated that coal particles, which are lower in density than most rock or mineral matter, tend to remain in suspension longer than coarser grained sediments, and are subject to sediment transport and settling processes similar to finer-grained materials. However, there is no description of how coal dust released from Westshore terminals could affect baseline water quality conditions in the local study area.</p>	<p>Provide an assessment of how coal dust from Westshore terminals would affect baseline water quality conditions in the areas with measurable coal content in sediment, as denoted by Figure 9.6-7 of the EIS.</p>	<p><b>Insufficient.</b> The proponent suggests that changes to baseline water quality conditions in areas with measurable coal content (i.e., greater than 1% coal) incorporated into sediments in the LSA are not expected to be detectable. This is because concentrations of detectable settled coal in these localised areas are low (&lt; 2.9% near the coal terminal, and 1.2% to 2.2% in the upper intertidal zone on the north side of the Roberts Bank causeway) and the marine environment</p>

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IR3-45	Marine Water Quality - Effects of Air Emissions	<p>EIS Volume 2: Section 9.1.1.1</p> <p>EIS Volume 5: Section 31.2</p> <p>EIS Guidelines, Section 10.1.5.</p>	<p>In Section 7.1 of the Marine Shipping Addendum, the Proponent indicated that there would be incremental increases in annual emissions of gaseous and particulate matter compounds from RBT2-associated vessels in the Strait of Georgia, Haro Strait, and Juan de Fuca Strait. Further, the Proponent indicated that the cumulative annual emissions of trace organic contaminants from the transit of marine vessels associated with the Project and existing and projected future marine traffic (referred to as cumulative conditions in the EIS) are conservatively projected to increase by 20% over existing conditions.</p> <p>However, the Marine Shipping Addendum did not describe how particulate matter and trace organic contaminants generated by container ships calling at Roberts Bank would affect water quality in the area around Roberts Bank and in the marine shipping area.</p>	<p>Describe how particulate matter and trace organic contaminants generated by marine shipping associated with the Project would affect water quality in Segment A of the marine shipping area.</p>	<p>provides for substantive dilution and buffering capacity (Ahrens and Morrisey 2005). This conclusion is not supported by any data or evidence at all. One reference is cited as support for this statement.</p> <p><b>Insufficient.</b> The proponent states that considering all known and potential sources of particulate and organic matter to Segment A, that marine shipping associated with the Project is not expected to affect water quality in Segment A of the marine shipping area.</p> <p>This is suggested to be due to the atmospheric dispersion of the majority of PM particles, replacement of older, higher-emitting container ships with newer, lower-emitting ships that meet tighter engine emission standards, inputs from numerous emission sources, the small contribution of RBT2-associated vessels to total vessel movement, the mandated use of low sulphur fuels, and the fact that Segment A water quality is predominantly influenced by Fraser River discharge. While these are factors, no qualitative or quantitative attempt at directly assessing this has been done.</p>
IR4-03	Vessel Traffic Projections - Vessel Size and Movement	<p>Marine Shipping Addendum: Appendix 6-A</p>	<p>In Appendix 6-A of the Marine Shipping Addendum, the Proponent indicated that the George Massey Tunnel replacement project is a road infrastructure project located inland and is not expected to influence the number of vessels in the marine shipping area.</p> <p>Vessels transiting through the south arm of the Fraser River could contribute to vessel movements in the marine shipping area and additional information is required.</p>	<p>Provide an estimate of number of movements and size of vessels in 2025 that would pass through the south arm of the Fraser River and past the replacement of the George Massey Tunnel.</p>	<p><b>Sufficient.</b> An estimate is provided for number of movements and size of vessels in 2025 that would pass through the south arm of the Fraser River and past the replacement of the George Massey Tunnel.</p>

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IR4-04	Vessel Traffic Projections - Vessel Size and Movement	<p>Marine Shipping Addendum: Section 4.2.13 Figure 10-1</p> <p>Proponent Response to IR1-05 (CEAR Doc#897): Table IR1-05-1, Table IR1-05-2</p> <p>Table IR1-05-3 Appendix IR1-05-A; Revised Figure 4-2 and Figure 4-3</p>	<p>The Proponent, in response to Review Panel information request IR1-05, updated information and maps about vessel movements through Segments A to D and F for 2012 and 2030 and, in Table IR1-05-3, provided information about vessels to and from Puget Sound to the Port of Vancouver Container terminals.</p> <p>In Section 4.2.1.3 of the Marine Shipping Addendum, the Proponent stated that vessels calling on both U.S. and Canadian ports will require transiting through Segment G and may travel through Segment G twice on the inbound or outbound routes. Segment G (between Haro Strait and Puget Sound via Hein Bank) connects Segment B to C, or Segment F to C, or Segments B, C or F to Puget Sound.</p> <p>Information is required for all categories of vessels in segments A-G of the marine shipping area including the inbound and outbound traffic for container ships routing between Haro Strait and Puget Sound using the traffic separation via Hein Bank (Segment G).</p>	<p>Update the information provided in response to Review Panel information request IR1-05 and include information about all vessel types that transit through Segment G of the marine shipping area.</p> <p>Explain how values for each segment were calculated, including how the results reflect vessels that may travel through Segment G more than once.</p> <p>Update figures in Appendix IR1-05-A to include information about Segment G.</p> <p>In tables IR1-05-1, IR1-05-2 and IR1-05-3, provide values for Segment G for all categories of vessels and explain how they are included or not in values given in these tables and in figures in Appendix IR1-05A for Segments B, C, and D.</p>	<p><b>Sufficient.</b> Update the information provided in response to Review Panel information request IR1-05 and include information about all vessel types that transit through Segment G of the marine shipping area. Tables 4-2 and 4-7 of the Marine Shipping Addendum have been updated to include vessel movement through Segment G (in Tables IR4-04-1 and IR4-04-2 for 2012 and 2030 vessel movements, respectively).</p> <p>The proponent adequately describes how traffic information for each segment is calculated including how the results reflect vessels that may travel through Segment G more than once.</p> <p>Revised Figure 4-2 of Appendix IR1-05-A has been updated as Figure IR4-04-A1 in Appendix IR4-04-A and provides the location and data for each of the cross-sections used to determine vessel movements per segment.</p> <p>Tables IR1-05-1 and IR1-05-2 have been updated to include Segment G and are provided in Tables IR4-04-1 and IR4-04-2. All vessel categories are included in the values given in these tables.</p>
IR4-05	Vessel Traffic Projections - Small Vessels	<p>EIS Volume 2: Section 9.2 Section 9.8.5.3</p> <p>Proponent Response to IR1-05 (CEAR Doc#897): Table IR1-05-01, Table IR1-05-02 Appendix IR1-05-A; Revised Figure 4-2 and Figure 4-3</p> <p>Marine Shipping Addendum: Section 9.2</p>	<p>Throughout the EIS and the Marine Shipping Addendum, the Proponent indicated the types of vessels that it included in its analysis. Small vessels of certain types were included in some of the assessments, but have not been included in others.</p> <p>In Section 9.2 of the Marine Shipping Addendum, the Proponent indicated that the Pacific Whale Watch Association members conduct approximately 13,600 tours using 86 vessels in an average year. Further, in Table A-2 and Section A-2.7 of Appendix A of Appendix 10-A of the Marine Shipping Addendum, data is given for small vessel movements in Segment A under the other/unknown category. The volume of small vessels reported in Section 9.2 and Appendix 10-A of the Marine Shipping Addendum do not support the lack of inclusion of small vessels in the</p>	<p>Clarify whether small vessels, including whale watching boats, are included in the other/unknown category of Tables IR1-05-1, IR1-05-2, and revised Figures 4-2 and 4-3 of the Proponent's response to Review Panel information request IR1-05. If small vessels are not included, provide an estimate of the number of movements of small vessels and update these tables and figures accordingly.</p> <p>Provide map(s) of the marine shipping area that display the actual (2012) and projected (2030) small vessels</p>	<p><b>Sufficient.</b> Small vessels equipped with Automatic Identification System (AIS) transponders, including recreational and whalewatching boats, were included in the 'other/unknown' vessel category for 2012 and 2030 (from calculated projections) in the tables and figures provided in IR1-05 of CEAR Document #897. Small vessels not equipped with AIS were not included in the other/unknown category in the tables and figures provided in IR1-05. The information provided in IR1-05 has been superseded by Figure IR4-04-2 in IR4-04, which provides movement data for Segments A to G (except Segment F).</p> <p>In the absence of mapped information for small vessel movements for each segment, density</p>

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		<p>on 9.2.10 Appendix A of Appendix 10-A</p> <p>Section A-2.7, Table A-2</p>	<p>assessment.</p> <p>In Table IR1-05-01, Table IR1-05-02, revised Figure 4-2 and revised Figure 4-3 of its response to Review Panel information request IR1-05, the Proponent described vessel movements by vessel type but it is unclear whether small vessels were also included in the figures and tables under the category other/unknown.</p> <p>Clarification of the numbers and movements of small vessels and the areas where they would congregate in the marine shipping area and especially in Segment A is required.</p>	<p>movements for each segment.</p>	<p>maps showing movement patterns in the Salish Sea (including within Segments A to G) are provided for January and July 2015, based on 2015 AIS data for recreational vessels (Figures IR4-05-1and IR4-05-2, respectively) and calculated data for whale watching vessels (Figures IR4-05-3 and IR4-05-4, respectively).</p>
IR4-06	<p>Vessel Traffic Projections – Population</p>	<p>EIS Volume 5: Appendix 30-A, Appendix B, Table B-2</p> <p>Marine Shipping Addendum: Appendix 6-A</p> <p>Proponent Response to IR1-05 (CLEAR Doc# 897)</p>	<p>The Proponent, in Table B-2 of Appendix B of Appendix 30-A of the EIS and Appendix 6-A of the Marine Shipping Addendum, indicated that 80 Panamax bulkers (100,000 tons vessel capacity) and 500 cargo barges (16,000 tons vessel capacity) will call each year at the coal port planned at Fraser Surrey Docks to transport 8 million metric tonnes/year (MMT/year) of coal for each vessel type.</p> <p>The annual amount of coal exported from the Fraser Surrey Docks Coal Transfer project would have a direct influence on the number of Panamax bulker and cargo barges movements through the south arm of the Fraser River and in the marine shipping area.</p> <p>Updated information about the amount of coal exported from Fraser Surrey Docks and the number of vessels associated with the coal export operations at Fraser Surrey docks is required.</p>	<p>Confirm the amount of coal (MMT/year) which will be transported from Fraser Surrey Docks each year.</p> <p>In accordance with what will be transported, indicate the number of Panamax Bulklers and cargo barges that will call each year at the coal port planned at Fraser Surrey Docks.</p> <p>If a correction is needed, update the tables and figures in the Proponent's response to Review Panel information request IR1- 05.</p>	<p><b>Sufficient.</b> On August 21, 2014, the VFPA issued a Project Permit (PP 2012-072) to Fraser Surrey Docks LP (FSD) for the development of a direct transfer coal facility to handle up to 4 million metric tonnes (MMT) of coal per year.</p> <p>The exclusive use of Panamax bulkers by FSD is the preferred operational scenario and as such, 100% use of Panamax bulkers, with 80 vessel calls (160 movements) per year is expected.</p> <p>A to update the tables and figures in the Proponent's response to Review Panel information request IR1- 05 was not required.</p>

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IR4-07	Vessel Traffic Projections	EIS Volume 1: Section 4.4.2.2 Figure 4-27	<p>The Proponent, in Section 4.4.2.2 of the EIS, reported that due to seasonal fluctuations, import container traffic can cause the 2.4 million vessel TEUs per year terminal capacity target to be exceeded during certain peak days or weeks. The preliminary design of the wharf considered peak periods and terminal equipment was designed to be capable of handling 3.0 million vessel TEUs per year and maintaining the average 2.4 million vessel-TEU design capacity.</p> <p>Figure 4-27 of the EIS reported the annual ship movements for 2012 and 2030 at the Roberts Bank terminals.</p> <p>More detailed information about the weekly peak and non-peak ship traffic movements (high and lows) at the four terminals at Roberts Bank is required.</p>	<p>Provide a figure, similar to Figure 4-27, to illustrate the weekly peak and non-peak ship traffic movements (highs and lows) at the proposed Roberts Bank Terminal 2, Westshore Terminals, Deltaport Terminal and B.C Ferries Terminal for 2012 and 2030, with and without the Project.</p>	<p><b>Sufficient.</b> Figure included all traffic movements except for Westshore Terminals. There is no publicly available information to determine peak weekly movements. Market conditions for coal affect the competitiveness of Westshore's customers and, together with changes in customers' mine output, affect the volume of coal handled by Westshore and, therefore, the number of vessels calling at the terminal.</p>
IR4-09	Vessel Traffic Projections	<p>EIS Volume 5: Appendix 30-A, Appendix B, Table B-2</p> <p>Marine Shipping Addendum: Appendix 6-A, Appendix 10-A, Appendix A</p> <p>Proponent response to Additional Information Requirements of April 8, 2016 (CEAR Doc#391): IR6</p> <p>IR7, Table IR7-2</p> <p>Proponent</p>	<p>Appendix 6-A of the Marine Shipping Addendum and Appendix B, Table B-2 of Appendix 30-A of the EIS differ in their list of projects included and ship population. For instance, Kinder Morgan Trans-Mountain Pipeline Expansion Project is presented in both documents but Appendix 6-A of the Marine Shipping Addendum adds 360 tugs. Gateway Pacific Bulk Terminal is excluded in Appendix 6-A of the Marine Shipping Addendum. Gateway Pacific Terminal at Cherry Point is not in Table B-2 of Appendix 30-A of the EIS. Further, Appendix A of Appendix 10-A of the Marine Shipping Addendum discusses the need for reconciliation of vessel traffic data used in Appendix 30-A of the EIS and Appendix 10-A of the Marine Shipping Addendum. Some projects are not included in either Appendix 6-A of the Marine Shipping Addendum or Appendix 30-A of the Environmental Impact Statement and information is required on these projects.</p> <p>In Appendix 6-A of the Marine Shipping Addendum rationale provided for the exclusion of some projects in the assessment was that it was too early in the</p>	<p>In a table, list, complete and reconcile the information given in Appendix 6-A of the Marine Shipping Addendum and Appendix B, Table B-2 of Appendix 30-A of the EIS in terms of vessel population, transits and movements for the relevant segments and categories of vessels for 2012 and 2030, with and without the Project.</p> <p>Include, where appropriate, the following projects:</p> <ul style="list-style-type: none"> <li>Westpac Tilbury LNG Project</li> <li>Westpac Tilbury Marine Jetty Project</li> <li>Woodfibre LNG Project</li> <li>Centerm Terminal Expansion</li> <li>BURNCO Aggregate Project</li> <li>Lehigh Hanson Aggregate Facility</li> <li>Discovery LNG, Campbell River</li> </ul> <p>BCWest Coast Reduction</p> <ul style="list-style-type: none"> <li>PMV Viterra Grain Terminal</li> <li>PMV Westridge bitumen Terminal</li> </ul>	<p><b>Insufficient.</b> The increase in future vessel traffic in segments of the marine shipping area was not based on anticipated traffic increases associated with certain or reasonably foreseeable projects. Given the uncertainty associated with proposed projects proceeding through permitting or proceeding once permitted, the growth rate approach was used by the proponent stating that it provides reasonable future vessel traffic projections, and is an accepted approach for the assessment of marine shipping activities. The approach taken has been reviewed by Transport Canada's Economic Analysis (TEA) team (CEAR Document #982).</p>

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		<p>Response to IR1-05 (CEAR Doc#897): Table IR1-05-1, Table IR1-05-2</p> <p>Revised Figure 4-2 and Figure 4-3</p>	<p>environmental review process to have the required information; others were not listed because they were not considered to be reasonably foreseeable.</p> <p>Some of the excluded projects have passed the preliminary design stage and information is now available. Information is also required on all vessel traffic whether considered by the Proponent to be negligible or not.</p>	<p>Pacific Coast Terminals (canola)</p> <ul style="list-style-type: none"> <li>Steelhead Malahat LNG Project (Island Gas LNG)</li> <li>Shell refinery expansion, Anacortes WA</li> <li>Tesoro Refining, Anacortes WA</li> <li>Northwest Seaport Alliance Container Terminal, Seattle and Tacoma WA (data for existing and on-going expansions)</li> </ul> <p>Adjust Tables IR-05-1 and IR1-05-2 and revised Figures 4-2 and 4-3 as necessary.</p>	
IR4-36	Storm Water Runoff – Widened Causeway	<p>EIS Volume 1: Section 4.4.2.3 Appendix 4-A Appendix 4-B</p> <p>EIS Volume 2: Section 9.6.8.1</p> <p>Proponent Response to IR1-15 (CEAR Doc#897)</p> <p>EIS Volume 5: Section 31.2.1.1</p>	<p>The Proponent, in Section 9.6.8.1, reported that during construction storm water discharge from existing and newly created terminal and causeway areas disturbed by construction activities have potential to lead to changes in sediment dispersion and increase in sediment deposition. The Proponent also stated in Section 31.2.1.1, that during Project construction, heavy rainfall may result in the erosion of granular surfaces or pre-load areas within the containment dykes at the terminal and along the widened causeway. Sediments carried into the marine environment via surface runoff and deposited in intertidal or subtidal areas may adversely affect marine habitat and water quality. Proposed mitigation would be that construction activities would be conducted in accordance with the Construction Environmental Management Plan to minimize changes to marine water quality from storm water runoff.</p> <p>The Proponent also reported that during operations, storm water would be collected from the 108 hectare terminal site and discharged at outfalls along the Terminal 2 berth face. Collected drainage water at the terminal, would be passed through oil-water separators to collect surface oil and grit. Each storm water outfall would be fitted with a shutoff valve to</p>	<p>Provide a detailed description of how storm water will be managed within the widened causeway area, including the paved road, overpass and rail infrastructure during construction and operation of the proposed Project.</p> <p>Describe the proposed mitigation measures to address the environmental effects from storm water runoff from the widened causeway, including the effects from paved road, overpass and rail infrastructure.</p>	<p><b>Sufficient.</b> Provide A detailed description of how storm water will be managed within the widened causeway area, including the paved road, overpass and rail infrastructure during construction and operation of the proposed Project is given and well as the proposed mitigation measures to address the environmental effects from storm water runoff from the widened causeway, and the effects from coal dust, surface oil and grit from the paved road, overpass and rail infrastructure are addressed.</p>



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			<p>allow termination of flows in the event of a hazardous material spill, and effluent velocities would be controlled to minimize scouring within the berth pocket. Conceptual design plans for stormwater management within the following proposed areas were identified in Appendix 4-B (Diagrams CI 260-26). The Proponent, in its response to IR1-15 (CEAR Doc#897), predicted that there would be an annual storm water discharge volume of 1,080,000 m<sup>3</sup>/year from the 108 hectare terminal area.</p> <p>The area for the proposed 108 hectare terminal does not include the 42.4 hectares for the proposed 5.2 km widened causeway. The Proponent, in Appendix 4-A, proposed that the basis of design for roads on the causeway would be graded for storm water to drain into and infiltrate through the gravel shoulder. The designs of the paved road, Roberts Bank Terminal 2 overpass, and rail infrastructure would also promote drainage and prevent ponding.</p> <p>According to the Proponent, in Section 4.4.2.3, inbound and outbound trains would likely not be RBT2 pure trains. Trains would require sorting or reassembly at other terminal yards or repositioning to the mainline tracks between the T-Yard and the DPU/Bad Order Setout Yard.</p> <p>Information about the management and effects of storm water runoff (during construction and operation of the proposed Project) from the 42.4 hectare (5.2 km) widened causeway (causeway rail addition and improvement, causeway road addition and improvement, and causeway utility corridor) is required.</p>		

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IR4-37	Marine Water Quality - Extreme Weather Event	<p>EIS Volume 2: Section 9.7.8.2; Section 9.7.10</p> <p>EIS Volume 5: Section 31.2.1.1</p>	<p>The Proponent, in Section 9.7.8.2 of the EIS, indicated that storm water collected across the terminal area would be passed through oil interceptors, while storm water collected in fuelling areas and oil-filled electrical transformer areas would pass through oil-water separators prior to discharge from the terminal. Storm-water discharge will be managed according to standard management practices and in accordance with regulations, and are not expected to result in measurable changes in water quality.</p> <p>The Proponent, in Section 31.2.1.1, further identified that the storm drainage system would be able to accommodate flows generated during a 1 in 10-year rain storm, with a 15-minute time of concentration.</p> <p>During Project construction, heavy rainfall may result in the erosion of granular surfaces or pre-load areas within the containment dykes at the terminal and along the widened causeway. Sediments carried into the marine environment via surface runoff and deposited in intertidal or subtidal areas may adversely affect marine habitat and water quality. While during Project operation, prolonged heavy rain or the accumulation of snow, followed by rapid melt during a heavy rainfall, may result in a pulse of increased surface runoff from paved areas in the terminal, which may temporarily exceed the capacity of the storm water system. An increase in storm water discharge would have a negligible effect on the subtidal environment to which it discharges (based on volume of the receiving environment).</p> <p>The Tsawwassen First Nation has indicated that it is possible that community members utilize the beach area near the BC Ferry Terminals on a routine basis. As well, the local assessment area has been identified as an area for recreational use and traditional harvesting.</p> <p>Additional information about storm water and</p>	<p>Assess the effects from a pulse of increased surface runoff not captured by the storm water system at the terminal or by the widened causeway area, including sources from the tug Basin and the widened causeway area. Include the considerations of the effects from all contaminants from the Project site on human health, biophysical environment, and the proposed onsite habitat compensation features.</p> <p>Provide a description and justification of the techniques and assessments that would be used for detecting and addressing any storm water pollution, particularly as it relates to post-storm marine contamination or human health.</p> <p>Provide a comparison of these results to applicable water quality standards.</p>	<p><b>Insufficient.</b> The proponent does not assess in any qualitative or quantitative way the effects from a pulse of increased surface runoff not captured by the storm water system but simply state without supporting evidence or data that 'Pulse events are not expected to contain high concentrations of these substances due to the types of activities that occur at a container terminal'.</p> <p>No description or justification of any techniques and assessments that would be used for detecting and addressing any storm water pollution, particularly as it relates to post-storm marine contamination or human health were addressed. All discussion in this section detailed preventative measures. The information requested was post-spill assessments and detection methods for already occurred marine contamination and potential human health risks.</p> <p>Although not described (the results of techniques and assessments of non captured storm water runoff), the proponent does describe applicable standards, acts, and regulations will be reviewed to determine applicable water quality standards for the stormwater pollution risk identified from the issues identification and the risk analysis. At a minimum, monitoring results (for captured storm water not released water not captured) will be compared to the relevant water quality standards outlined in the Canadian Water Quality Guidelines for the Protection of Aquatic Life developed through the Canadian Council of Ministers of Environment (CCME 1999).</p>

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IR4-38	Waste-water System	<p>Proponent Response to IR1-16 (CEAR Doc#897)</p>	<p>contaminants released from the storm water facilities, tug basin area and from the widened causeway area into the marine environment in periods of heavy rainfall is required.</p> <p>The Proponent's response to Review Panel information request IR1-16 identified that the sewage treatment facility will be designed to treat a volume of 60 cubic meters (m3) of effluent per day and the specific processes (means and methods) for sewage treatment will be determined at a later stage by the Infrastructure Developer in the Project planning.</p> <p>It was further identified that for the Infrastructure Developer contract, the Proponent will utilize a Design Build Finance Maintain (DBFM) procurement process which places the responsibility for the meeting of the detailed design specification and performance on the Infrastructure Developer. The Proponent's role is to monitor the Infrastructure Developer for compliance with its contract.</p> <p>As part of the response to IR1-16, the Proponent also identified that it will ensure that the proposed wastewater system is capable of achieving the applicable effluent standards under the federal <i>Fisheries Act and Wastewater Systems Effluent Regulations</i>.</p> <p>Additional information about the DBFM procurement process is required.</p>	<p>Provide an explanation of the Design Build Finance Maintain (DBFM) procurement process, and how the DBFM procurement process will ensure that the sewage treatment system, as determined by the Infrastructure Developer, will meet the standards set out under federal legislation.</p>	<p><b>Insufficient.</b> The proponent states that it is important to note that the standards set out under federal legislation—including the federal <i>Fisheries Act and Wastewater Systems Effluent Regulations</i>—are binding in their own right and such legislated requirements must be complied with regardless of the procurement process used. The performance-based technical specifications and the 'Payment Mechanism' employed in a DBFM contract structure are intended only as mechanisms to create incentives for the Infrastructure Developer and to drive contractor performance. This incentivizes the contractor (who it is assumed does not get compensated if the design does not meet standards and regulations), however, legislation itself are binding but it is still unclear who is responsible if the design does not meet standards and regulations. If the constructed sewage facility does not meet standards, how will it be amended, by who, and who is ultimately responsible?</p>

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IR4-39	Dredging - FRPD 309	<p>EIS Volume 1: Appendix 4-E</p> <p>EIS Volume 2: Appendix 9.6-C</p> <p>Proponent Response to IR1-11 (CEAR Doc#897) Table IR1-11-1</p>	<p>The Proponent, in response to Review Panel information request IR1-11, identified that FRPD309 - with its pump ashore capability, large hopper size, and acceptable dredging depth capability - would be an alternative second dredge during sand reclamation from the intermediate transfer pit. In the IR response, the Proponent provided a brief comparison of the potential changes to air and noise and the effects of those changes on human health, marine fish, marine mammals and coastal birds.</p> <p>As set out in Appendix 9.6-C of the EIS, an unnamed second dredge would be used to unload the intermediate transfer pit into the Roberts Bank Terminal 2 footprint from October 1 to March 31, 2020 and that suspended material would be added to the water column via both the Columbia at the dredge basin and the Unnamed Second Dredge at the intermediate transfer pit. The overlap in operations in both dredge basin and intermediate transfer pit suspended sediment could result in interactions of sediment re-suspension plumes from the two Project areas, and elevated total suspended solids concentrations in the vicinity of the Project site.</p> <p>Additional Information about the environmental effects of using FRPD 309 is required.</p>	<p>Update the alternatives analysis in Table IR1-11-1 of the Proponent's response to Review Panel information request IR1-11. Include the consideration of effects on water quality (total suspended solids) and sediment deposition in the evaluation of potential environmental effects for each vessel, and if necessary, update the alternative means analysis conclusions.</p>	<p><b>Sufficient.</b> As described in the Preamble at the beginning of the responses to Information Request Package 3 (CEAR Document #9842), the VFPA no longer requires the ITP to construct the Project, thus eliminating any potential overlap in operations. Based on the updated construction activities, therefore, an alternative means analysis for reclaim dredging of the ITP, including an assessment of changes to water quality (total suspended solids) and sediment deposition, is unnecessary.</p>
IR5-01	Marine Shipping - Anchorages	<p>EIS Volume 1: Section 4.4.2.1</p> <p>Marine Shipping Addendum: Section 4.2.2.2</p> <p>EIS Volume 5: Section 30.4.5</p> <p>Proponent Response to IR1-01 (CEAR</p>	<p>In Section 4.4.2.1 of the EIS, the Proponent stated that there are no plans, or foreseen terminal operating requirements, for off-terminal anchoring of container ships waiting for a berth at the new marine terminal and that container ships operate on a scheduled service, usually between Asia and the West Coast, and adjust their speeds as required to arrive at the terminal within their assigned berthing window.</p> <p>The Proponent further stated that exceptions could occur in the event of an extreme storm in the Pacific, resulting in a refuge anchorage requirement for safety reasons, or to accommodate unexpected ship-</p>	<p>Provide a map showing the location of existing anchorage sites - both under and outside of the Proponent's jurisdiction - that could be used by Roberts Bank terminal vessels during construction and operation of the proposed Project.</p> <p>Provide details of contingency plans to meet anchorage needs of the existing Roberts Bank terminals during potential disruptions from Project construction, such as an emergency</p>	<p><b>Insufficient.</b> Provide A map is provided showing the location of existing anchorage sites - both under and outside of the Proponent's jurisdiction - that could be used by Roberts Bank terminal vessels during construction and operation of the proposed Project.</p> <p>No additional contingency plans are anticipated by the proponent to be required for emergency anchorages, therefore the proponent has not provided any details for any contingency plan.</p> <p>If a vessel has stayed for seven days and the anchorage is not required by another vessel, the</p>

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		<p>Doc#897, Section 14.6 Appendix IR1-01-A</p>	<p>specific maintenance, accidents, personnel or operation issues that may arise.</p> <p>According to the Proponent, container ship anchorages for Deltaport Terminal in 2012 and 2013 had a frequency range of 3 to 4 per year out of an approximate annual total of 270 ship calls. The Proponent proposed that the same frequency can be assumed for the proposed Project, resulting in approximately one unforeseen container ship anchorage every 1.5 to 2 months (6-8 per year) for the two Roberts Bank container terminals, or one anchorage every three to four months (3-4 per year) for the Project alone. These vessels would use existing anchorages in English Bay, or in the Gulf Islands, as determined by the pilot and the port authority having jurisdiction. The Proponent stated that, in the case of an accident, a decision could be taken to tow the vessel with tug assistance to a safe anchorage. In such a case, there is no reference to priority sites.</p> <p>Some participants in the environmental assessment, including Indigenous groups, have questioned these estimates of current and future frequency of anchorage use by Roberts Bank terminal vessels. They have underlined the lack of contingency plans for potential disruption during construction requiring last minute refuge for ships.</p> <p>In Appendix IR1-01-A of its response to Review Panel information request IR1-01, the Proponent presented the list of anchorage sites under its jurisdiction; the practices and procedures that would be applied to these anchorages such as the maximum length of stay; and the non-availability of anchorage sites.</p> <p>No information was given on the current or projected use of anchorage sites in the Gulf Islands by the Proponent; the need or projected need for additional sites under the Proponent's jurisdiction; or contingency plans for potential disruptions during</p>	<p>navigation closure, that may occur during the five and a half year construction period of the proposed Project.</p> <p>Describe measures that would be taken when the maximum number of days (seven) allowed at anchorages under the Proponent's jurisdiction is reached.</p> <p>Confirm the need for any new anchorage sites for the Project that would be located under the Proponent's jurisdiction during construction and operation of the Project.</p>	<p>VFPA can extend the anchorage period upon request.</p> <p>Neither the construction phase nor the operation phase of RBT2 will require new anchorages according to the proponent.</p>

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			<p>construction and operation of the Project.</p>		
IR5-13	<p>Marine Invertebrates - Negligible Effects, Total Suspended Solids</p>	<p>Review Panel Information Request Package 3 of February 14, 2017 (CEAR Doc#929): IR3-34</p> <p>EIS Volume 1: Appendix 4-E</p> <p>EIS Volume 2: Appendix 9.6-C Figure 5.2.29</p> <p>EIS Volume 3: Section 12 Section 13</p>	<p>The Proponent, in Appendix 9.6-C, reported on the probability of total suspended solid (TSS) plumes exceeding 1.0 mg/L, 5.0 mg/L, and 10 mg/L, the extent of instantaneous TSS plumes during ebb and flood tide, total deposition of fine sediment, and D50 (median particle size) of deposited fine sediment from the following activities:</p> <ul style="list-style-type: none"> <li>• dredging operations;</li> <li>• disposal at sea activities; and</li> <li>• tug basin dredging.</li> </ul> <p>In IR3-34, the Review Panel requested that the Proponent carry out further modelling to quantify the suspended sediment generated by simultaneous dredging and disposal at sea activities, and to determine whether other activities not included in the model could result in measurable changes in suspended sediment.</p> <p>The Proponent used 25mg/L TSS concentrations as the basis for its assessment of potential effects of the Project on marine invertebrates and marine fish based on the flow guidelines from the Canadian Council of Ministers of the Environment's <i>Canadian Water Quality Guidelines for the Protection of Aquatic Life</i>. Additional information about TSS is required.</p>	<p>Provide maps, similar to the figures in Appendix 9.6-C, to illustrate the percentage of time that peak TSS exceeds the threshold of 25 mg/L, for the following proposed Project activities:</p> <ul style="list-style-type: none"> <li>• dredging operations planned for the first year (spring, summer and fall) and second year (winter) of construction;</li> <li>• disposal at sea activities at 45 metre outfall with a non-retention rate of 15% for east basin intermediate transfer pit and dredge basin sediment;</li> <li>• tug basin dredging; and</li> <li>• simultaneous dredging and disposal at sea activities. Provide maps, using an appropriate TSS scale from 1 to the maximum predicted value (in intervals of 25mg/l) to illustrate the extent of the instantaneous TSS plume during ebb and flood tides for the following proposed Project activities:</li> <li>• disposal at sea activities at 45 metre outfall with a non-retention rate of 15% for east basin intermediate transfer pit and dredge basin sediment; and</li> <li>• simultaneous dredging and disposal at sea activities. Provide a map displaying the percentage of time that peak TSS exceeds the threshold of 25 mg/L for the full period of dredge basin dredging operations similar to</li> </ul>	<p><b>Insufficient.</b> Maps, similar to the figures in Appendix 9.6-C, to illustrate the percentage of time that peak TSS exceeds the threshold of 25 mg/L, for the following proposed Project activities disposal at sea using 15% non-retention of fines, and not total.</p>

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IR5-37	<p>Marine Mammals – Contaminant Uptake</p>	<p>Recovery Strategy for the Northern and Southern Resident Killer Whales in Canada (Attachment to CEAR Doc#263): Table 1.</p> <p>EIS Volume 2: Appendix 9.6-A Appendix 9.6-B</p> <p>EIS Volume 3: Section 14 Appendix 14-D</p>	<p>The recovery strategy for SRKW identified environmental contaminants as a current threat to SRKW. Table 1 of the recovery strategy provided a list of persistent organic pollutants that may pose a risk to resident killer whales. As stated in the EIS guidelines, the Proponent was required to carry out a characterization of the contaminant loading in fish species and aquatic species at risk and the pathways of bio-accumulation, for those species whose contaminant loadings may be affected by the proposed Project.</p> <p>In Section 14 of the EIS, the Proponent stated that while SRKW and Steller Sea Lion are vulnerable to accumulating a wide range of persistent, lipophilic organic contaminants, including chlorinated pesticides such as chlordane, dichlorodiphenyltrichloroethane (DDT) and polybrominated diphenyl ethers (PBDEs), no substance other than polychlorinated biphenyls (PCBs) appear to approach or exceed thresholds resulting in toxicological effects. Although there is information presented in Appendix 9.6-A, Appendix 9.6-B and Appendix 14-D of the EIS on some of the persistent organic pollutants specified in Table 1 of the recovery strategy (such as PCBs and PAHs) it is unclear how the Proponent came to the conclusion that no substance other than PCBs approached or exceeded thresholds for toxicological effects. Further information is required to determine whether there is the potential for contaminants other than PCBs to result in adverse effects to marine mammals.</p>	<p>Figure 5.2.29 of Appendix 9.6-C of the EIS.</p> <p>Provide a map displaying the percentage of time that peak TSS exceeds the threshold of 25 mg/L for the full period of dredge basin dredging operations similar to Figure 5.2.29 of Appendix 9.6-C of the EIS.</p> <p>For all pollutants identified in Table 1 of the recovery strategy for the SRKW, provide the following:</p> <ul style="list-style-type: none"> <li>concentrations in sediment likely to be mobilized through dredging in the Fraser River, tug basin and dredge basin;</li> <li>comparison with Canadian Council for Ministers of the Environment (CGME) interim sediment quality guidelines or other applicable guidelines; and</li> <li>potential for the pollutant to result in toxicological effects on SRKW and Stellar Sea Lion.</li> </ul>	<p><b>Insufficient.</b> The proponent states that PCB concentrations of suspended sediments during construction are the same as concentrations in the existing environment, when expressed on the basis of normalised organic carbon or normalised percent fines concentrations (EIS Appendix 14-D; see IR3-29 of CEAR Document #984). The assumption that producing suspended sediments with associated PCBs will not increase the bioavailability of PCBs that enter the food chain may not be supported; it is a possibility.</p> <p>They also state that based on the distribution of PCBs in sediments, the water column, and biota, the food web-based risk assessment model predicts that PCB concentrations in SRKWs from the re-distribution of sediments during Project construction were negligible compared to levels in SRKW predicted during existing conditions (EIS Section 14.6.1.4, EIS Appendix 14-D; see IR3-29 of CEAR Document #984). Although based on the latest science, such food web model predictions may be out orders of magnitude in their predictions and have not been ground truthed. The proponent states that overall, the available scientific knowledge, including guidance from DFO, suggests that potential health risks to predatory marine mammals using PCBs as a surrogate for other contaminants should lead to similar conclusions about their risk potential. This is misleading. Using PCBs as a conservative surrogate for modelling and biomagnification to SRKW may be valid, however, as a surrogate for</p>

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IR5-38	Marine Mammals - Air Pollution	<p>EIS Volume 3: Section 14</p> <p>Marine Shipping Addendum: Section 8.2</p> <p>CEAR Doc#581</p>	<p>In Section 8.2 of the Marine Shipping Addendum, the Proponent indicated that there is the potential for synergistic, additive, and/or antagonistic interactions between the individual components in fuel exhaust and current persistent organic pollutants. However, the Proponent does not elaborate on the potential effects of inhalation of these pollutants by marine mammals.</p> <p>In both Section 14 of the EIS and Section 8.2 of the Marine Shipping Addendum, the Proponent concluded that the potential effect of air pollution on marine mammals is negligible. In Section 8.2 of the Marine Shipping Addendum, the Proponent stated that the North American Emission Control Area (ECA) was implemented with the intention of reducing overall SO<sub>2</sub> emissions from marine vessels by 96% with full implementation in 2015. The Proponent indicated that implementation of the ECA will also reduce emissions of NO<sub>x</sub> and PM<sub>2.5</sub>. According to Environment and Climate Change Canada, the ECA came into effect on January 1, 2015. Further information is required to determine the potential effects of inhalation of pollutants by marine mammals, and to determine whether the</p>	<p>Provide information on the potential effects of the inhalation of the following pollutants on marine mammals:</p> <ul style="list-style-type: none"> <li>• CO;</li> <li>• NO<sub>x</sub>;</li> <li>• SO<sub>2</sub>;</li> <li>• PM<sub>2.5</sub>; and</li> <li>• Hydrocarbons: <sup>1,1,1</sup> CFCs</li> </ul> <p>Describe how the implementation of the North American Emission Control Area may result in a reduction of the potential effects of pollutant inhalation by marine mammals in the local assessment area for marine shipping associated with the proposed Project.</p>	<p>risk in terms of toxicological effects is not warranted. Chemicals act by different mechanisms of action; for example, some PAH are carcinogenic and risk due to slight increases in exposure due to PAH contaminated sediment suspension could be estimated.</p> <p>The proponent is correct that information on the concentrations of various individual Table 1 pollutants in sediment is not useful for managing risks to SRKW in their critical habitat unless accompanied by both estimates of SRKW exposure levels based on biomagnification through the foodweb and relevant toxicological thresholds.</p> <p><b>Sufficient.</b> The proponent states that due to the implementation of the ECA, air contaminant emissions and predicted ambient air concentrations during Project operation are expected to be lower than for existing conditions, and similar or slightly higher in over-water locations immediately adjacent to Roberts Bank compared to expected conditions without the Project (see EIS Section 9.2.10).</p> <p>Potential health effects to marine mammals from air pollution in the LAA due to the incremental contribution of marine shipping associated with the Project are therefore not anticipated; therefore, this potential effect was determined to be negligible in the MSA.</p> <p>A general description of the effects of these air pollutants in humans as a surrogate are given.</p>



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IR5-48	Marine Mammals - Southern Resident Killer Whale, Destruction of Critical Habitat	EIS Volume 3: Section 14 CEAR Doc#919	<p>implementation of the ECA may result in a reduction in the effects of pollutant inhalation by marine mammals.</p> <p>As presented in Figure 14-1 of the EIS, the proposed Project and marine shipping associated with the Project would be located in SRKW critical habitat. The Proponent defined the destruction of critical habitat as resulting if part of the critical habitat is degraded, either permanently or temporarily, such that its biophysical features would not be available when needed by SRKWs for foraging, mating, resting, or socializing. In Section 14.9.2.1 of the EIS, the Proponent concluded that all three of the critical habitat features (acoustic environment, availability of prey, and water and sediment quality) will not be affected by the Project when needed by individuals for their life functions of foraging, mating, resting, or socializing, and that destruction of critical habitat is therefore not anticipated.</p> <p>The Proponent undertook an assessment of changes to the acoustic environment and characterized the residual effects for acoustic disturbance from operational noise. Predictions were provided for the occurrence of low and moderate severity behavioral responses to shipping noise, and although these were characterized by the Proponent as short-term, this could be considered as a temporary loss of function of critical habitat. Further information is required to determine the absolute area of critical habitat that would be temporarily or permanently degraded by the construction and operation of the Project and marine shipping associated with the Project.</p>	<p>Provide an estimate of the absolute area and proportion of total area of SRKW critical habitat that will be temporarily or permanently degraded by acoustic and physical disturbance caused by construction and operation of the proposed Project and marine shipping associated with the Project.</p>	<p><b>Insufficient.</b> The proponent states that the only absolute area that can be provided in this response is in relation to the physical disturbance from the footprint of the Project that overlaps with SRKW critical habitat. The total area of critical habitat for SRKW is 247,844 ha (2,478.44 km<sup>2</sup>) under the Critical Habitat Order of 2009. The combined total marine footprint of the terminal and dredged berth pocket will be approximately 179.9 ha (1.80km<sup>2</sup>) (EIS Section 4.2.1 and EIS Figure 4-24) representing 0.07% of the Critical Habitat Order area (247,844 ha) and 0.02% of all U.S. and Canadian trans-boundary critical habitat (939,280 ha).</p> <p>The proponent states that underwater noise during Project operation was modelled and noise footprints of these activities were presented as sound contour maps and areas of potential behavioural effects to SRKW (EIS Appendix 9.8-A, Figures A-44 and A-45). During operation, Project-related underwater noise will move in space and time; thus, calculation of an absolute area was not technically possible.</p>

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IR8-01	Marine Vegetation - Biomass Estimates, Salinity	<p>EIS Volume 2: Appendix 9.5-A Figure 22</p> <p>EIS Volume 3: Section 11 Table 11-14 Table 11-15 Table 11-16 Table 11-18</p>	<p>The methodology adopted by the Proponent for its prediction of the biomass changes of native eelgrass, <i>Ulva</i>, biomat and intertidal marsh, as a function of salinity for existing and future conditions with the proposed Project during freshet, was not explicitly described in Section 11 of the EIS.</p> <p>In Tables 11-14, 11-15, 11-16 and 11-18 of the EIS, several vegetation biomass estimates were reported that appeared to be anomalous when compared with the expectation that biomass as a function of salinity should be monomodal. For example:</p> <ul style="list-style-type: none"> <li>Table 11-14 reported zero (with Project) native eelgrass biomass for a salinity of 26-28 practical salinity units (PSU). In comparison, salinities of 24-26 PSU and 28-30 PSU had predicted biomass values of 11.0 and 264.4 tonnes respectively;</li> <li>Table 11-15 reported <i>Ulva</i> biomass (without Project) of 307.0 tonnes for salinity of 8-10 PSU in comparison with 722.4 tonnes for salinity of 6-8 PSU and 650.5 tonnes at 12-14 PSU;</li> <li>Table 11-18 reported intertidal marsh (with Project) biomass of 164.6 tonnes under 4-6 PSU in comparison with 276.9 and 269.4 tonnes under salinities of 2-4 and 6-8 PSU respectively.</li> </ul> <p>It is unclear whether the outlier values within the tables represented anomalous maxima or minima or whether they reflected statistical variability or errors in the vegetation biomass calculations as a function of salinity.</p> <p>Tables 11-14, 11-15, 11-16 and 11-18 reported biomass estimates to one tenth of a decimal point, implying a high degree of precision. Additional information is required to substantiate the reported precision presented in these tables.</p> <p>Further, these tables reported biomass estimates as a function of salinity specifically for freshet conditions. The Fraser River hydrograph (Figure 22 of Appendix</p>	<p>Provide graphs of the data contained in Tables 11-14, 11-15, 11-16 and 11-18 of the EIS.</p> <p>Provide an expanded description of the methods used to generate biomass estimates for native eelgrass, <i>Ulva</i>, biomat and intertidal marsh, as a function of salinity, for existing and future conditions with the proposed Project.</p> <p>Provide an explanation for the vegetation biomass outliers as noted in the context for this information request. If the values referenced in the context are statistical artifacts or errors, recalculate the predicted biomass differences in Tables 11-14, 11-15, 11-16 and 11-18 of the EIS.</p> <p>Provide justification for the reported level of precision, down to one tenth of a decimal point, for the vegetation biomass differences with the Project reported in Tables 11-14, 11-15, 11-16 and 11-18 of the EIS.</p> <p>Provide the biomass estimates as a function of salinity for existing and future conditions with the Project for native eelgrass, <i>Ulva</i>, biomat and intertidal marsh for one year, including freshet and non-freshet conditions. Present the results in the same format as Tables 11-14, 11-15, 11-16 and 11-18 of the EIS, as well as graphs. Based on the revised estimates, provide an updated discussion for the evaluation of potential differences in marine</p>	<p><b>Insufficient.</b> The proponent explains that the reviewer requesting the information has misunderstood the data presented. The VFPA clarified that the numbers presented in EIS Tables 11-14, 11-15, 11-16, and 11-18 do not represent a comparison of existing biomass and predicted future biomass as a result of the Project. Rather, these represent the proportion of existing vegetation biomass in tonnes that coincides with the prevailing water column salinity regime, as expressed by salinity contours depicting the 50<sup>th</sup> percentile for both existing and future salinity conditions. The tables are not intended to represent a relationship between biomass and salinity for native eelgrass, <i>Ulva</i>, biomat, and intertidal marsh, nor are they intended to be predictive (i.e., no correlative relationship between salinity and marine vegetation productivity was established and used to estimate future biomass).</p> <p>In addition, changes to productivity, expressed as biomass, that are expected to occur as a result of future changes in salinity were stated to be accounted for within the Roberts Bank ecosystem model and are not presented in EIS Tables 11-14, 11-15, 11-16, and 11-18.</p> <p>The VFPA clarified that productivity changes in relation to Project-induced salinity changes were accounted for within the Roberts Bank ecosystem model along with other abiotic factors; however, the relative contribution of salinity, or any other individual abiotic factor, were not isolated.</p> <p>The methods used to generate existing biomass estimates for marine vegetation sub-components are similar to those reported for the Roberts Bank ecosystem model.</p>

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IR8-02	Marine Vegetation - Biomass Estimates, Salinity	<p>EIS Volume 3: Section 11 Table 11-19 Figure 11-11 Figure 11-12 Figure 11-13</p>	<p>9.5-A) indicated that the freshet is approximately 3 months in duration, while non-freshet conditions occur over the remaining 9 months of the year. An explanation is required as to whether the biomass values in Tables 11-14, 11-15, 11-16 and 11-18 were annual values scaled up from freshet conditions. Additional information is required to allow the prediction of changes in marine vegetation biomass as a function of salinity during non-freshet conditions.</p> <p>Tables 11-14, 11-15, 11-16 and 11-18 of the EIS did not provide an indication of the relative importance of biomass differences to the total biomass in the local assessment area.</p> <p>In Table 11-19 of the EIS, the Proponent reported predictions of mean water column salinity changes of biofilm area during freshet and non-freshet flows that would be attributed to the proposed Project. Estimates were provided for the 5 biofilm zones (upper intertidal, mid-intertidal, lower intertidal, Canoe Passage and inter-causeway).</p> <p>Differences between the mean salinity values for existing conditions and conditions with the Project were utilized to evaluate the potential for reduced productivity for the marine-influenced biofilm assemblage during freshet.</p> <p>Salinity estimates were reported as means with associated standard deviations. Changes in salinity estimates were based on mean differences, but the standard deviations of the differences were not reported.</p> <p>Figures 11-11, 11-12, and 11-13 of the EIS depicted representations of the salinity values used to generate Table 11-19. These figures did not reflect the statistical variability of the differences in salinity. To provide a robust statistical comparison, it is necessary to report and analyze the statistical variability of the</p>	<p>vegetation biomass as a function of salinity for existing and future conditions with the Project and their implications for the assessment of effects on marine vegetation.</p> <p>Update Table 11-19 to reflect the statistical confidence predicted for changes in salinity of the biofilm area corresponding to existing conditions and conditions with the proposed Project for freshet and non-freshet periods, including:</p> <ul style="list-style-type: none"> <li>the standard deviations for the two columns reporting differences in salinity in Table 11-19; and</li> <li>standard deviations for the differences between the means in salinity predictions.</li> </ul> <p>Provide a discussion of the implications of incorporating statistical variability in the evaluation of the potential for reduced productivity for marine and freshwater biofilm assemblages as a function of salinity differences during freshet and non-freshet periods.</p>	<p>The proponent has explained, the data presented in EIS Tables 11-14, 11-15, 11-16, and 11-18 are representations of proportions of existing vegetated biomass that will be exposed to the future salinity condition and, as such, there are no outliers.</p> <p>The 'difference' column in the mentioned tables does not reflect a statistical prediction between existing and future conditions and the values presented therefore do not represent the level of precision associated with a prediction.</p> <p>Biomass estimates as a function of salinity are not provided, as explained.</p> <p><b>Sufficient.</b> The proponent reworked the dataset, in order to determine the mean salinity change and associated variability calculated for each zone and temporal period. In some instances, this procedure resulted in slight changes in the difference values presented in EIS Table 11-19 compared to those reported in their response.</p> <p>Similar to information reported in the EIS, the greatest difference in salinity between conditions is predicted to occur in the Lower intertidal zone, experiencing a mean salinity approximately -3 PSU lower than existing conditions.</p> <p>In light of new information collected since submission of the EIS, and due to the small statistical variability in mean difference estimates reported in Table IR8-02-1 compared to salinity levels (and associated estimates of variability) predicted with the project in place, potential changes to biofilm productivity described in the EIS are considered conservative and are not affected by the mean salinity difference requested as part of this information request.</p>

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			differences.		
IR8-03	Marine Vegetation - Biomass Estimates, Existing Conditions	EIS Volume 3: Section 11.5 Figure 11-2	<p>In Section 11.5 of the EIS, the Proponent provided biomass estimates under existing conditions for each marine vegetation sub-component within the local assessment area during the summer. The biomass values reported were:</p> <ul style="list-style-type: none"> <li>• Native eelgrass - 407 tonnes</li> <li>• Non-native eelgrass - 17 tonnes</li> <li>• Intertidal marsh - 2,220 tonnes</li> <li>• <i>Ulva</i> - 17,268 tonnes</li> <li>• Kelp - 373 tonnes</li> <li>• Rockweed - 300 tonnes</li> <li>• Biomat - 12,019 tonnes</li> <li>• Biofilm - 19,486 tonnes</li> </ul> <p>It is unclear what the source of these estimates is, and how this information contributed to the assessment of the effects of the proposed Project on marine vegetation.</p>	<p>Provide the source of the biomass estimates under existing conditions for each marine vegetation sub-component and an explanation of the method used to calculate these estimates.</p> <p>Provide an explanation of how the biomass values for existing conditions contribute to the assessment of effects on marine vegetation.</p>	<p><b>Sufficient.</b> The biomass value estimates under existing conditions were estimated using a combination of Roberts Bank field data and scientific literature. The data and/or scientific literature used, as well as the method, are described below in Table IR8-03-1 for each marine vegetation sub-component.</p> <p>The biomass values for existing conditions were used in the lines of evidence for the assessment of effects on marine vegetation. The biomass values represent empirical estimates of existing biomass within the LAA and were used as reference points to quantitatively assess changes in productivity due to the Project. The biomass values were also used as inputs to the Roberts Bank ecosystem model reflecting estimates of existing biomass undercurrent conditions. A sensitivity analysis of the ecosystem model biomass input values was performed to see what effect variability or uncertainty in these input values had on the results of the ecosystem model.</p>
IR8-04	Marine Vegetation - Biofilm	EIS Volume 3: Section 11 ECCC response to Information Request ECCC IR-02 (CEAR Doc#960)	<p>In its response to Review Panel information request ECCC IR-02, Environment and Climate Change Canada stated that a multi-year baseline sampling program could provide the spatial and temporal variability in biofilm composition and abundance at Brunswick Point. This sampling could be used to characterize biofilm taxonomy; essential fatty acid profiles; and to correlate to salinity, sediment grain size, currents and wave action. It was the view of Environment and Climate Change Canada that these information gaps</p>	<p>Confirm whether the Proponent has collected samples that were not reported in the EIS that could be available for analysis to provide information regarding the spatial and temporal variability in biofilm composition, biofilm taxonomy; essential fatty acid profiles or other factors.</p> <p>Indicate whether further analyses of</p>	<p><b>Sufficient.</b> The VFPA confirmed that additional biofilm sampling and analysis have been completed since the submission of the EIS. Sampling was undertaken in both 2016 and 2017. The results and analysis of the 2016 program are presented in this response. The results from the 2017 sampling program are currently being analysed and will be submitted to the Panel registry once reporting is complete.</p>

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IR11-01	<p><b>Accidents and Malfunctions by, Methods, Incidence, Probabilities</b></p>	<p>EIS Volume 1: Section 4 EIS Volume 5: Section 30 Appendix 30-A Marine Shipping Addendum: Section 10 Appendix 10-A CEAR Doc#509 CEAR Doc#982 CEAR Doc#1067 Proponent Responses to IR1-05 (CEAR Doc#897) and IR4-03 to IR4-09 (CEAR Doc#1051)</p>	<p>identified could be addressed through new studies conducted over a minimum of three years. Although the Department advised that this information could not be generated within the timeline of the environmental assessment of the proposed Project, information is required to determine whether there are additional samples that are being or could be utilized for further analyses on biofilm.</p> <p>Appendix 30-A of the EIS and in Appendix 10-A of the Marine Shipping Addendum, the Proponent reported marine vessel incidence predictions that informed its assessment of marine vessel accidents or malfunctions. The local data reported incidents in the Vancouver Region from 1995 to 2013 for vessels over 300 gross tonnage. The Proponent and participants have since submitted additional information on ship incidents and vessel movements. This new information includes:  <ul style="list-style-type: none"> <li>container ship incident information for Roberts Bank from 2004 to 2016 submitted by Transport Canada (CEAR Doc#509), which reported incidents that occurred after 2013 and three incidents that did not appear in Appendix 30-A of the EIS (e.g. Hanjin Express on November 11, 2011);</li> <li>information on anchorage sites submitted by Transport Canada and sourced from the Pacific Pilotage Authority (CEAR Doc#982),</li> <li>environmental study for the potential anchorage sites off Gabriola Island provided by the Pacific Pilotage Authority (CEAR Doc#1067); and</li> <li>updated vessel movement projections included in the Proponent's responses to Review Panel information requests IRI-05 and IR4-03 to IR4-09.</li> </ul> <p>Furthermore, although some information on anchorage sites has been provided, it is not clear whether the additional vessel movements related to the use of anchorages were considered in the Proponent's analyses. Additionally, the Proponent identified certain periods</p> </p>	<p>these samples are underway or contemplated by the Proponent.</p> <p>Provide updated incidence probabilities, where applicable, by incorporating the new information into the calculations of marine vessel incidence probabilities for the assessment of accidents or malfunctions in the EIS and the Marine Shipping Addendum. Discuss whether the assessment of accidents or malfunctions in the EIS and the Marine Shipping Addendum would change as a result of these updates.</p>	<p><b>Sufficient.</b> The proponent provided information on subsequent incidents included in the Transport Canada documentation for the period of June 2013 to 2016 were as follows:  <ul style="list-style-type: none"> <li>In May 2015, a container ship bound for Deltaport Terminal, under the control of a pilot, reported a loss of propulsion due to fuel oil issues. The vessel was towed to English Bay anchorage to effect repairs;</li> <li>In February 2016, a mooring bit was torn of the deck by an assist tug; and</li> <li>In April 2016, an auxiliary engine was disabled on a container ship during the voyage and after arriving at Deltaport.</li> </ul> <p>The proponent stated that calculations of probabilities will not change from those presented in EIS Appendix 30-A and MSA Appendix 10-A based on the information provided in the responses to IR4-04 and IR4-07 of CEAR Document #1051.</p> </p>

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			<p>as peak and non-peak, such as sailing and whale watching season (responses to IR4-05 and IR4-07) and Christmas season (EIS Section 4). In response to IR4-07, the Proponent reported changes in peak (June to September) and non-peak (October to March) weekly ship movements of BC Ferries' vessels. Appendix 30-A of the EIS and Marine Shipping Addendum Appendix 10-A did not specify how peak periods in ship movements were accounted for in the incidence probabilities and subsequent analyses in the accidents or malfunctions assessment in the EIS or Marine Shipping Addendum.</p> <p>Updates and clarifications are required to ensure that marine vessel incidence probabilities reflect the best available information to date.</p>		
IR11-02	Accidents and Malfunctions - Methodology, Quantitative Risk Assessment	<p>EIS Volume 5: Section 30.1 Appendix 30-A: Section 1.2 Figures 1-1 and 1-2 Marine Shipping Addendum: Section 10 Appendix 10-A Appendix 10-B</p>	<p>In Section 30.1 of the EIS, the Proponent stated that it commissioned a Qualitative Risk Assessment (QRA) during Project planning for vessel-related accidents or malfunctions during Project operations, and that this QRA was provided in EIS Appendix 30-A and 30-B. In Section 1.2 of Appendix 30-A of the EIS, the Proponent provided an overview of the components included in a QRA. As illustrated in Figures 1-1 and 1-2, a QRA for accidents or malfunctions would include hazard identification, a frequency assessment, a consequence assessment, a risk analysis, and risk management conclusions.</p> <p>It is stated in Section 1.2 of EIS Appendix 30-A that this appendix solely presents the probability component of the QRA for marine vessels, while EIS Appendix 30-B focuses only on the assessment of the fate of estuarine and marine spill-type accidents. As for the Marine Shipping Addendum, Appendix 10-A and 10-B were provided as supplemental reports to EIS Appendix 30-A and 30-B, but specifically for the marine shipping area. Although the appendices to EIS Section 30 and Marine Shipping Addendum Section 10 provided components of a QRA for marine vessels, it is unclear whether other components of a QRA, such as a consequence assessment and a risk analysis, were produced for all types of accidents or malfunctions, and if they were produced, how they were considered</p>	<p>Provide a summary of all the components included in the QRA that were completed for the assessment of accidents or malfunctions in connection with the proposed Project and marine shipping activities. Include a description of the risk level of potential accidents or malfunctions based on an assessment of frequency and consequence for both the marine and land-based Project and marine shipping activities. Provide a description of the risk management options that would be applied during the life of the Project.</p>	<p><b>Sufficient.</b> The five components referred to in the context to the information request (hazard identification, frequency assessment, consequence assessment, risk analysis, and risk management) are the components of an overall accidents or malfunctions assessment, which differs from the components appropriately included in a quantitative risk assessment (QRA).</p> <p>The selection of the three plausible worst-case scenarios documented in the EIS, were based on an examination of the risk associated with 27 candidate scenarios. This risk evaluation was based on both the frequency (assessed quantitatively as return periods and categorised as probability levels), as well as the likely consequences of such an incident, documented qualitatively in the EIS.</p> <p>As requested, a summary of the risk evaluation for the 27 candidate scenarios in the EIS was provided in Table IR11-02-2, including the probability levels for marine- and land-based incidents, listed in EIS Tables 30-4 and 30-5, and the consequences documented in EIS Sections 30.4 and 30.5. The information on probability and consequence were evaluated and presented in</p>

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IR11-03	<p><b>Accidents and Malfunctions - Effects Assessment, Potential Contaminant Release</b></p>	<p>EIS Guidelines Section 10.1.4 EIS Volume 5: Section 30 Appendix 30-A Appendix 30 B Marine Shipping Addendum: Section 10 Appendix 10-A Appendix 10-B CEAR Doc#231</p>	<p>in the assessment of potential accidents or malfunctions in connection with the proposed Project and marine shipping associated with the Project. It appears that the assessment of accidents or malfunctions in the EIS and the Marine Shipping Addendum was based primarily on the probability component of the QRA, rather than on a complete risk analysis, which would include an assessment of consequences such as potential environmental effects. Given that the environmental assessment of the Project and marine shipping associated with the Project focuses on potential environmental effects and the measures that can mitigate them, a complete risk analysis and risk management approach of potential consequences is required.</p>	<p>In a tabular format, summarize the following aspects of a potential spill of hazardous and noxious substances on land and in the marine environment from potential accidents or malfunctions that could occur in relation to the proposed Project and marine shipping associated with the Project:</p> <ul style="list-style-type: none"> <li>• _potential quantity of material released (such as the maximum credible discharge volume);</li> <li>• _mechanism of release (such as container handling accidents or malfunctions of refuelling equipment);</li> <li>• _rate of release, if applicable;</li> <li>• _state of material released; and,</li> <li>• _characteristics of material released, including the types of pathways of effect to environmental components and the potential effects.</li> </ul> <p>In the table, identify the probability of occurrence for the applicable accident</p>	<p>Table IR11-02-2.</p> <p>The risk management options that would apply during the life of the Project are described in EIS Section 30.3, and include regulatory requirements, regional risk mitigation related to marine traffic, VFPA-specific practices and procedures, and Project-specific design, management, and emergency response. As indicated in EIS Section 30.3, the VFPA's Port Information Guide contains port-wide procedures and practices that apply to all vessels using the port, including information on safety and emergency response. Existing risk mitigation practices applicable to marine traffic in southern B.C. are described in EIS Appendix 30-A, Section 3.2.</p> <p><b>Insufficient.</b> The potential quantity of material released (such as the maximum credible discharge volume) were not supplied.</p> <p>The rate of release, if applicable were not given. General indications of state of material released were given. In a very general sense, classes of HNS chemicals characteristics of material released, were given as well as general indications to the types of pathways. Effects to environmental components and the potential effects were given in Figure 11-03-3. This chart insufficiently describes spills, for example of HNS as having medium impacts to a variety of groups of organisms. This is not reflective of true impact. Some chemicals may have high impact to some groups and not to others, depending on a number of factors. The Figure does not adequately yield any useful information.</p> <p>The proponent does not provide a table, identifying the probability of occurrence for the applicable accident or malfunction scenarios associated with the potential mechanisms of release.</p>

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IR11-04	Accidents and Malfunctions - Effects Assessment, Potential Spill of Light Fuel Oil	EIS Volume 5: Section 30.6.1 Marine Shipping Addendum: Section 10.3.3.1 Table 10-1 Appendix 10-B CEAR Doc#641	<p>appendices, the detail regarding the quantity, mechanism, rate, state of material released and characteristics of these contaminants is not consistently available in the EIS and the Marine Shipping Addendum.</p> <p>In Section 30.6.1 of the EIS and Section 10.3.3.1 of the Marine Shipping Addendum, the Proponent provided a description of plausible worst-case scenarios that could result in a spill. Spills of heavy fuel oils such as bunker fuel, residual fuel oil and intermediate fuel oil were discussed separately from spills of light fuel oils such as diesel and distillate-derived fuels (Glossary, Appendix 10-B of the Marine Shipping Addendum). In Table 10-1 of the Marine Shipping Addendum, the Proponent indicated that although container ships typically carry both light fuel oil and heavy fuel oil, when spilled to the environment, heavy fuel oil is more persistent; evaporates less; is more likely to travel farther; and, is more likely to wash ashore. Due to its toxic properties, behaviour, and persistence in the marine environment, the plausible worst-case scenarios presented in the EIS and Marine Shipping Addendum is a spill involving heavy fuel oil. However, a submission (CEAR Doc#641) to the Review Panel stated that:</p> <ul style="list-style-type: none"> <li>• light fuel oil, while being less persistent and likely to spread less than a more persistent heavy oil, is much more acutely toxic;</li> <li>• components of light oil can contain much higher proportions of compounds such as benzene, toluene, xylene and ethyl benzene and lower molecular weight polycyclic aromatic hydrocarbons such as the naphthalenes; and</li> </ul>	<p>or malfunction scenarios associated with the potential mechanisms of release.</p> <p>Include all types of materials discussed in Appendix B (Table B-4) and Appendix G of EIS Appendix 30-A, as well as operational pollutants referred to in Appendix F of EIS Appendix 30-A. Identify and discuss any other materials of concern that may be imported or exported in the reasonably foreseeable future at Roberts Bank Terminal 2.</p> <p>Provide a characterization of the potential acute and chronic effects on all relevant environmental components of light fuel oil spills that differ from the potential environmental effects from heavy fuel oil spills and, predict the potential significance of those effects.</p> <p>Identify additional mitigation measures that would be considered to mitigate the potential environmental effects on environmental components from a spill of light fuel oil. Identify follow-up measures that would be put in place in the short and long-term to verify the effectiveness of these mitigation measures and to assess potential residual environmental effects on environmental components.</p>	<p>The proponents inability to provide the requested information is explained by given the wide variety of HNS transported by container vessels, it is difficult to define an HNS spill hypothetical scenario for RBT2 and RBT2-associated vessels. Instead types of HNS and some other groups of chemicals are discussed very generally.</p> <p><b>Insufficient.</b> The proponent states that environmental impacts will vary considerably and primarily by the sensitivity of the environment oiled and the density of vulnerable organisms in those locations oiled. What is not stated but implied in the toxicity data given in Table IR11-04-1 is that the toxicity of lighter oils and gasoline is much higher than heavy oil.</p> <p>The proponent summarizes impact in Table IR11-04-2: a spill of heavy oil has a higher potential impact during all seasons relative to a light fuel oil spill according to 2 sources (DoE 2015; French-McCay et al. 2009), as shown in Relative Impact Risk Scores by Oil Type and Season; potential impacts are highest in the spring when considering the composite of all resources averaged over all WCS estuarine and marine zones in the marine shipping area. The composite over all water types may be misleading. The data and impacts need to be given for marine, estuarine and freshwater to show that this is the case for each water type.</p> <p>Additional information on seasonal impacts for individual organism groups is provided in the response to IR11-10. In summary, based on the findings above, the potential acute and chronic</p>



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IR11-05	<p><b>Accidents and Malfunctions - Effects Assessment, Ultra Large Container Ship Scenario</b></p>	<p>EIS Volume 5: Section 30 Marine Shipping Addendum: Section 10 Proponent Response to IR4-01 (CEAR Doc#1051)</p>	<p>• although exposure scenarios and toxicity from mixtures of light fuel oils are different than that of heavy fuel oils, they could cause effects of a greater magnitude even if the exposures are of shorter duration.</p> <p>In Section 10.3.3.1 of the Marine Shipping Addendum, the Proponent also indicated that the solubility of light fuel oils can increase exposure and toxicity to organisms.</p> <p>Further information is required to determine the potential effects of a spill of light fuel oils on environmental components and how environmental effects could be mitigated.</p>	<p>Provide a description of the types of accidents or malfunctions that could occur for vessels greater than 18,000 TEUs.</p> <p>Clarify whether vessels greater than 18,000 TEUs carry specific types and quantities of potential contaminants - including fuel types and volumes - that were not assessed in the EIS and Marine Shipping Addendum for vessels of smaller sizes. If so, identify how the effects could differ and the</p>	<p>effects on fish and fish habitat, marine birds, and marine mammals of a light fuel oil spill are anticipated to be similar to the potential environmental effects from a heavy fuel oil spill, which has higher persistence and mechanical injury potential. Therefore, the hypothetical spill scenarios involving heavy fuel that were assessed previously are representative of the potential significance of effects from a light oil spill on environmental components.</p> <p>This may be disputed, as each spill scenario presents different exposure scenarios and toxic effects. If light oils are more toxic, this cannot always be balanced out by more persistently heavy oils. In some scenarios light oils may cause more damage than heavy oils depending on the spill scenario.</p> <p>The proponent did not identify additional mitigation measures that would be considered to mitigate the potential environmental effects on environmental components from a spill of light fuel oil or identify follow-up measures that would be put in place in the short and long-term to verify the effectiveness of these mitigation measures and to assess potential residual environmental effects on environmental components.</p> <p><b>Insufficient.</b> To answer the request, the proponent simply states that the number of weekly services and vessel calls is anticipated to decrease as ship sizes increase. A decrease in the number of vessel calls will reduce the probability of the accidents or malfunction incident occurring, but the types of accidents or malfunctions that could occur are not anticipated to change.</p> <p>The proponent states that the EIS and MSA assessments are applicable to vessels greater than 18,000 TEUs, with respect to fuel types and</p>

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IR11-06	Accidents and Malfunctions - Effects Assessment, Discharge at Sea	EIS Volume 5: Section 30.4.7 CEAR Doc#989 CEAR Doc#1054	<p>In Section 30.4.7 of the EIS, the Proponent provided a qualitative assessment of the potential effects and mitigation related to a break in the disposal at sea (DAS) pipeline or a non-compliant DAS discharge. The Proponent discussed the DAS pipeline primarily in relation to activities connected to the Intermediate Transfer Pit (ITP) component of the proposed Project.</p> <p>The Proponent stated in CEAR Doc#989 that the ITP is no longer a component of the Project, and instead planned to incorporate the discharge of Fraser River sand directly into fill areas. The Proponent provided in CEAR Doc#1054 its plan to describe additional activities that would result from this change in the Project. However, it remains unclear whether the Proponent intends to assess accidents or malfunctions related to the direct discharge of Fraser River sand into fill areas.</p> <p>Further, as shown in Figure 4-14 of the EIS and described in CEAR Doc#989, there are three DAS pipelines in the Project construction design that would be used to discharge unsettled fines into the marine environment, with the outfall of the pipelines located at -45 m chart datum level. Section 30.4.7 of the EIS did not contain an explicit description of the accidents or malfunctions scenarios that could occur in relation to these pipelines, nor did it present an effects assessment on environmental components and additional mitigation measures that would be considered for a pipeline break or non-compliant discharge of the fines.</p> <p>Additional information is required on the potential effects from accidents or malfunctions related to</p>	<p>specific mitigations measures that would be applicable.</p> <p>Provide an assessment of the environmental effects related to accidents or malfunctions that could occur in connection with the supernatant discharge pipelines, including a description of potential effects on environmental components, applicable mitigation measures, and the significance of the predicted effects.</p> <p>Provide an assessment of the accidents or malfunctions that could occur in connection with the dredging, transport, and infilling of Fraser River sand into fill areas.</p> <p>Include a description of the scenarios that could lead to these types of accidents or malfunctions and their probability of occurrence.</p>	<p>volumes, therefore, potential effects are not anticipated to differ from those presented in EIS Section 30.0 and MSA Section 10.0. However, the proponent does not address other quantities of potential contaminants.</p> <p><b>Sufficient. The proponent states that the potential environmental effects on biophysical components and proposed mitigation measures are not expected to differ from those described in the EIS or PCU, and any residual effects related to productivity loss from supernatant discharge would not be significant.</b></p> <p>The proponent states that the probabilities associated with the grounding, foundering, allision or collision of a vessel involved in transporting Fraser River sand are identified in EIS Table 30-3 and remain unchanged, although construction-related changes documented in the PCU will decrease potential risks associated with sand transport.</p> <p>Potential scenarios of marine-based accidents or malfunctions involving a supernatant discharge pipeline or a construction-related vessel are described in EIS Section 30.4.7. EIS Table 30-3 provides the probability of such occurrences (i.e., moderate probability for a discharge or infilling pipeline break, low probability for a construction-related vessel grounding or allision, very low probability for a construction-related vessel collision, and moderate probability for a construction-related vessel foundering).</p>

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IR11-07	Accidents and Malfunctions - Environmental Management	EIS Volume 5: Section 30 Table 30-3 Table 30-4 Section 33 Appendix 33-A	<p>discharge at sea from existing Project components as well as from proposed new activities in connection with the dredging, transport and infilling of Fraser River sand into fill areas.</p> <p>In Section 30.3 of the EIS, the Proponent described the risk mitigation framework to mitigate environmental effects from accidents or malfunctions that may occur in relation to the proposed Project. The risk mitigation framework is comprised of applicable regulatory requirements, regional risk mitigation related to marine traffic, the Proponent's practices and procedures, Project-specific design, management, and emergency response. In Section 33 of the EIS, the Proponent further presented an outline of its emergency response plan for the construction and operation phases of the Project.</p> <p>The risk mitigation framework also described the various parties responsible for emergency response. However, the Proponent did not explain how environmental effects from accidents or malfunctions would be monitored in the long-term, after the implementation of mitigation measures, to determine whether recovery occurred or if additional mitigation measures may be required.</p> <p>In addition, in Sections 30.4 to 30.6 of the EIS, the Proponent elaborated on the environmental effects from accidents or malfunctions and stated that in certain instances environmental effects may depend on the speed and capacity of the emergency response, among other variables. For example, should a spill occur in the marine environment within the jurisdiction of the Proponent, it is unclear what would be done and who would be responsible to:</p> <ul style="list-style-type: none"> <li>• assess potential effects that occur on marine vegetation, invertebrates, fish, birds and marine</li> </ul>	<p>Provide a description of the measures that would be applied to assess, monitor and mitigate environmental effects following the occurrence of an accident or malfunction related to the proposed Project, as outlined in Sections 30.4 and 30.5 of the EIS (Tables 30-3 and 30-4).</p> <p>Explain whether the roles and responsibilities related to these measures would be assumed by the Proponent or by other parties.</p>	<p><b>Insufficient.</b> The proponent's response is not specific citing that the assessment and monitoring of environmental effects and implementation of additional mitigation requirements following the incident would vary by incident and depend on many factors, such as the following:</p> <ul style="list-style-type: none"> <li>☑ The specific location of incident and type, fate, and behaviour of substance released (if any), which will determine the environmental components that could be affected;</li> <li>☑ The climatic conditions under which the incident happens, which could influence extent of effects;</li> <li>☑ The initial response, containment, and clean-up activities, which could influence the extent of effects and requirements for additional measures;</li> <li>☑ The sensitivity of affected environment and uses (e.g., recreational use), which could inform the need for subsequent actions; and</li> <li>☑ The jurisdiction of the affected environment, which will dictate which responsible authorities are involved in post-incident requirements.</li> </ul> <p>They also state that, in general, the Responsible Party (i.e., the polluter, such as a trucking company, railway company, or vessel owner) would assume financial responsibility for the incident and would cooperate with the appropriate regulatory authorities to execute the response and implement additional requirements pertaining to assessing, monitoring, and mitigating environmental</p>

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IR11-08	<p>Accidents and Malfunctions - Effects Assessments, Other Vessels Scenario</p>	<p>Marine Shipping Addendum: Section 10 Appendix 10-A Proponent Response to IR4-03, IR4-04 and IR4-09 (CEAR Doc#1051)</p>	<p>mammals;                      • _monitor the persistence of oil and long-term effects to wildlife and human health; and                      • _conduct remediation activities if deemed necessary.</p> <p>A clarification of the roles and responsibilities for monitoring effects from accidents or malfunctions is required.</p> <p>Participants have expressed concerns that certain types of accidents with potentially severe consequences were not examined in detail by the Proponent in the Marine Shipping Addendum, such as an accident involving a container ship allision or collision with a ferry or a tanker. The Proponent instead focused its assessment on a plausible worst-case scenario, which involved a container ship grounding accident.</p> <p>The Proponent explained that an accident involving a ferry was not included on the basis of their high manoeuvrability and established risk avoidance and communication practices at Roberts Bank terminals (Marine Shipping Addendum Section 10.3.2.2). An accident involving a container ship with a tanker carrying crude oil was not considered based on an extremely low probability of occurrence. The probability of an accident involving a liquefied natural gas (LNG) tanker was not assessed based on the lack of evidence of LNG projects proceeding at the time the Marine Shipping Addendum was submitted.</p> <p>In response to Review Panel information request IR4-04, the Proponent provided updated vessel movement numbers for ferry movements, which were predicted to increase by 2030 in the marine shipping area. In response to IR4-03 and IR4-09, the Proponent updated vessel movement numbers for tanker movements for reasonably foreseeable projects by 2025 and 2030 in the marine shipping area, including crude oil and LNG tankers.</p>	<p>Provide an assessment of the potential environmental effects of the three following scenarios, regardless of the probability of occurrence, an accident resulting from a container ship allision or collision with:                      • _a passenger ferry;                      • _a tanker carrying crude oil; and                      • _a tanker carrying LNG</p> <p>Describe how the environmental effects and appropriate mitigation measures would differ from those in the plausible worst-case scenario described in Marine Shipping Addendum Section 10.3.3. Identify residual effects and discuss their significance.</p>	<p>effects.</p> <p><b>Insufficient.</b> For the collision with a passenger ferry, the proponent did not perform a worst case scenario and instead relied on the likelihood that the impact force from such a collision would be low and is not expected to result in hull penetration or a release of fuel oil due to regulatory requirements influencing ship construction.</p> <p>For the tanker carrying crude oil scenario the proponent states that differences between the container vessel grounding and container-tanker vessel collision scenarios, include the oil spill volume (7,500 m3 v. 40,000 m3) and cargo being released to the marine environment (i.e., crude oil and a HNS). They state, without any data or evidence that the larger spill (5x) would result in high consequences, regardless of the actual volume released. In addition, the extent of the spill, unmitigated, was assumed to be the same. The larger spill is likely to impact a wider area and affect more valued ecosystem components.</p>

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IR11-09	Accidents and Malfunctions - Effects Assessment, Structural Failure Scenario	Marine Shipping Addendum: Section 10 Appendix 10-A CEAR Doc#343	<p>An effects assessment of an accident involving a container ship and a ferry, as well as a container ship and a tanker, is required to determine the potential effects and additional mitigation measures required in the event of such accidents.</p> <p>A participant expressed concern that structural failure of container ships, due to structural fatigue, was not represented adequately in the Marine Shipping Addendum Section 10 and Appendix 10-A. Acknowledging that risk of structural failure could reasonably go undetected by the Proponent, further understanding is required regarding the potential consequences of such an event.</p>	<p>Provide a discussion that expands on Marine Shipping Addendum Appendix 10-A regarding the risk of structural failure in container ships, by identifying whether the effects of such a structural failure would differ from the worst-case scenario already examined in Marine Shipping Addendum Section 10. Explain whether there are risk management strategies that would be considered by the Proponent to prevent the occurrence of such an event.</p>	<p><b>Sufficient.</b> The proponent states that failure due to structural fatigue is accounted for in the incidence probabilities associated with the failure modes evaluated in the Marine Shipping Addendum (MSA), including foundering, collisions, allisions, and grounding. Structural fatigue failure can lead to these failure modes.</p>
IR11-10	Accidents and Malfunctions - Effects Assessment, Temporal and Spatial Aspects	Marine Shipping Addendum: Section 10.3.3.1 Section 10.5 Table 10-1 Environment and Climate Change Canada, Comment on the Completeness of the Marine Shipping Addendum (CEAR Doc#372)	<p>In Section 10.3.3.1 of the Marine Shipping Addendum, the Proponent indicated that one of the plausible worst-case scenarios involved the hard grounding of a container ship resulting in a spill. In Table 10-1 of the Marine Shipping Addendum, the Proponent presented the characteristics of this scenario, and Table 10-3 identified the components that would be affected. The Proponent indicated that the worst-case scenario would occur:</p> <ul style="list-style-type: none"> <li>in May since the freshest flows from the Fraser River would increase the likelihood of the spill's transport away from the incident site; and</li> <li>in Segment B at the south end of South Pender Island in Boundary Passage and Moresby Island since it is considered a higher collision or grounding risk area due to a narrow passage, navigational hazards, and prevailing wind directions.</li> </ul> <p>Although these characteristics represent the worst-case in certain aspects such as dispersion and</p>	<p>Provide a description of the effects on marine biophysical components (except for coastal birds – see IR11-11) resulting from a worst-case scenario heavy oil spill, assuming the spill would occur at the time of year and at the location in the marine shipping area when and where the marine biophysical components have the greatest sensitivities to such effects.</p> <p>Describe how the effects on marine biophysical components would vary across the marine shipping area at different times of the year. Discuss whether the residual effects would be considered significant.</p> <p>Describe how mitigation measures may need to be adapted to account</p>	<p><b>Insufficient.</b> The proponent describes various scenarios and effects in their response and the use of WCS vulnerability scores etc. The discussion does not directly address the request at all. Their predictions for the MSA's plausible worst-case spill scenario as reflecting maximum vulnerability of marine fish and Pacific salmon based on the information presented, and that a hypothetical spill in another area and/or during another season would experience similar or lesser effects relative to the worst-case scenario of a spill in the spring in Segment B is not supported at all. They concluded that the effect of a heavy fuel oil spill on marine fish and fish habitat is determined to be not significant over the long-term, as fuel oil concentrations in intertidal and subtidal waters and habitat will diminish and productivity will rebound due to natural recruitment and immigration processes is not scientifically supported. They state that</p>

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			<p>likelihood of grounding, the spatial and temporal constraints make it difficult to determine the potential effects on environmental components of a heavy oil spill that could occur elsewhere and during other times of the year.</p> <p>The Proponent acknowledged that an actual spill could have different characteristics from those presented in Table 10-1, and that changes to environmental components could vary from those described in Section 10.5 of the Marine Shipping Addendum. The Proponent indicated that these characteristics generally represent the worst-case consequences for most environmental components and sub-components and important differences are noted as appropriate in Section 10.5. However, in Section 10.5 the Proponent does not systematically describe these differences due to potential important variations in characteristics of the worst-case scenario.</p> <p>For example, in Section 10.5.6 of the Marine Shipping Addendum, the Proponent indicated that the plausible worst-case scenario is unlikely to further compromise at-risk salmon populations due to limited spatial (i.e. Sockeye and Chinook Salmon) or temporal (i.e. Coho Salmon) overlap. However, the Proponent did not elaborate on the potential effects to those species if the spill were to overlap their distribution in time and space. Similarly, Environment and Climate Change Canada indicated that many bird populations peak at times of the year other than May (CEAR Doc#372).</p> <p>Based on the large spatial and temporal distributions of environmental components within the marine shipping area, and the potential for a hard grounding and subsequent oil spill to occur anywhere along the marine shipping route, constraining the worst-case scenario to a place and time of year is inappropriate. The potential effects on environmental components within the entire marine shipping route of a worst-case heavy oil spill should be described, and adequate mitigation measures identified.</p>	<p>for seasonality and location of the spill.</p>	<p>based on the WCS rankings, their conclusions are representative of a hypothetical spill occurring in other areas in the marine shipping area and other seasons. These statements are not supported in any way by any type of qualitative or quantitative attempt any determining risk at all which is the means to address the request.</p>

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IR11-11	<p><b>Accidents and Malfunctions</b> Effects Assessment, Marine Birds</p>	<p>Marine Shipping Addendum Section 10 Environment and Climate Change Canada Sufficiency Review (CEAR Doc#581)</p>	<p>In Section 10 of the Marine Shipping Addendum, the Proponent assessed the environmental effects of accidents or malfunctions on biophysical components. For marine birds, the effects from the plausible worst-case scenario resulting in a heavy fuel oil spill were assessed for a spill occurring during the month of May in Boundary Passage (IR11-10). In section 10.5.8, the Proponent concluded that the residual effect on marine birds was determined to be not significant for the plausible worst-case spill scenario.</p> <p>In Section 10.3.3.1 of the EIS the Proponent acknowledged that an actual spill could have different characteristics than those defined for the plausible worst-case scenario, however the Proponent did not discuss variances in effects on marine birds assuming heavy fuel oil spills with different characteristics. Therefore, the potential effects of a heavy oil spill on marine birds have not been sufficiently assessed.</p> <p>In addition, Environment and Climate Change Canada (ECCC) noted in CEAR Doc#581 that the qualitative assessment conducted by the Proponent was not sufficient to determine the significance of heavy fuel spill effects on marine birds. ECCC stated that a quantitative assessment would be required to determine the significance of effects to marine birds arising from a heavy fuel spill. ECCC recommended the use of stochastic modeling to assess the behaviour and fate of a hypothetical oil spill under a range of environmental conditions, which would also serve to indicate the waters and shorelines most at risk from oiling and allow for the development of an oil spill response strategy.</p> <p>ECCC also recommended the Proponent incorporate information from a variety of detailed contemporary bird databases, including the BC Coastal Waterbird Survey, eBird, and the BC Marine Conservation Atlas in the assessment in order to account for how the spatial and temporal distribution of birds affects the</p>	<p>Provide an updated assessment on the effects on marine birds from a potential heavy fuel spill, considering that it may occur anywhere in the marine shipping area and at any point during the year, so as to reflect the worst-case scenario for marine birds. As recommended by ECCC, present a quantitative assessment for marine birds based on stochastic modeling of the behaviour and fate of hypothetical oil spills.</p> <p>Identify existing and proposed measures that would be included in an oil spill response strategy for marine birds.</p>	<p><b>Insufficient.</b> The proponent has not provided an updated assessment on the effects on marine birds from a potential heavy fuel spill, considering that it may occur anywhere in the marine shipping area and at any point during the year, so as to reflect the worst-case scenario for marine birds and state that effects to the shoreline from a spill elsewhere in the marine shipping area are not expected to largely differ from those presented in the MSA due to the extent of dispersion from an oil spill in Segment B and the types of habitats potentially affected. This statement does not address the request's intent.</p> <p>The proponent summarizes the request concern by stating that 'several ecologically important sites for marine birds could be affected by a spill at Site E in MSA Segment B, and prompt and effective response in the event of a spill would help reduce effects on these habitats.'</p>

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			<p>risk to the overall marine bird population.</p>		
<p><b>IR11-12</b></p>	<p><b>Accidents and Malfunctions - Pre-SCAT</b> survey and mapping information</p>	<p>Marine Shipping Addendum: Section 10 Figure 10-5 to 10-9 CEAR Doc#372 and #387</p>	<p>In CEAR Doc#387, Environment and Climate Change Canada (ECCC) proposed that a request for additional information should include the provision of Pre-SCAT survey and mapping information, as was initially requested in the EIS Guidelines. ECCC explained that this information is instrumental to inform spill response priorities and countermeasures at the time of an actual oil spill incident, and that it is important to ECCC's review pursuant to its various mandated areas of interest. ECCC recommended that if a Pre-Scat survey and mapping were not available the Proponent should:</p> <ul style="list-style-type: none"> <li>• Provide an update on the timeline for completion of the Geographic Response Plans (GRP) mapping for shorelines adjacent to and down-current from marine accidents and malfunctions associated with the proposed Project;</li> <li>• Discuss existing approaches which can be used to identify potential higher risk sites; and consider appropriate response measures in the event of an accident or malfunction.</li> </ul> <p>Information is required as to the status of the mapping exercise and the adequacy of the Proponent's maps provided in the Marine Shipping Addendum.</p>	<p>Provide an update on the timeline for completion of the Geographic Response Plans (GRP) mapping for shorelines adjacent to and down-current from marine accidents and malfunctions associated with the proposed Project.</p> <p>Provide examples of Pre-SCAT surveys, as is requested by ECCC in its review of the Marine Shipping Addendum.</p> <p>Present other existing approaches which can be used to identify potential high risk sites. Discuss the adequacy of the shoreline oil residency maps provided by the Proponent as Figure 10-5 to 10-9 of the Marine Shipping Addendum to inform spill response as compared with Pre-SCAT surveys information or other approaches. In the discussion, include appropriate response measures in the event of an accident or malfunction.</p>	<p><b>Sufficient.</b> Additional information on response planning, inventory, and mapping initiatives currently underway by agencies with jurisdictional authority in the marine shipping area are summarised.</p>



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IR11-23	Quality of Marine Sediment	<p>Proponent Response to Information Request Package 3 (CEAR Doc#984): Table IR3-25-1 Table IR3-27-1 CEAR Doc#1091</p>	<p>In Tables IR3-25-1 and IR3-27-1 of their response to Information Request Package 3 (CEAR Doc#984), the Proponent provided summary statistics for various chemical parameters measured in sediment at the dredge basin, existing tug basin, tug basin expansion area, Fraser River maintenance dredging sites and supernatant discharge area (formerly referred to as the candidate disposal at sea area). In their response to IR-04 (CEAR Doc#1091), Environment and Climate Change Canada (ECCC) indicated that the use of summary statistics as presented by the Proponent such as mean, minimum, and maximum, are insufficient to determine whether marine pollution could result from the use of the dredged material for construction of the proposed Project and resulting discharge of supernatant. ECCC indicated that the use of the 95 per cent upper confidence limit (UCL) of the mean concentration for a chemical parameter is a more conservative metric for evaluating whether contamination will cause marine pollution. The 95 per cent UCL of the mean concentration for each chemical parameter measured in sediment at the dredge basin, existing tug basin, tug basin expansion area, Fraser River maintenance dredging sites and supernatant discharge area is required to determine whether use of dredged material for construction of the Project and discharge of supernatant could result in adverse environmental effects to biophysical valued components.</p>	<p>Determine the 95 per cent UCL of the mean concentration for each chemical parameter measured in sediment at the dredge basin, existing tug basin, tug basin expansion area, Fraser River maintenance dredging sites and supernatant discharge area. Data from the 2011, 2013, 2016 and any more recent sampling campaigns should be used.</p> <p>Present the results in tabular format and provide a comparison with relevant Lower Action Levels and Canadian Council of Ministers of the Environment Interim Sediment Quality Guidelines.</p> <p>Provide a discussion of whether any of the chemical parameters measured, in any of the areas listed above, are likely to result in adverse effects to biophysical valued components.</p>	<p><b>Sufficient.</b> Table IR11-23-1 summarises the 95% UCLM concentrations for data presented in IR3-25 and IR3-27 (CEAR Document #984) for sediment chemical parameters measured at the dredge basin, existing tug basin, tug basin expansion area, Fraser River maintenance dredging sites, and supernatant discharge area.  Table provided.</p> <p>Discussion of whether any of the chemical parameters measured, in any of the areas listed above, are likely to result in adverse effects to biophysical valued components is provided.</p>
IR11-24	Mitigation Measures for Dredging and Sediment Discharge	<p>EIS Volume 5: Section 33.3.10 Proponent Response to Additional Information Requirements of July 31, 2015 (CEAR Doc#314): IR12 CEAR Doc#1091 CEAR Doc#1054</p>	<p>In Section 33.3.10 of the EIS, the Proponent stated that a Dredging and Sediment Discharge Plan would be developed to describe the management and timing of dredging activities and the discharge of sediment-laden water. The Proponent indicated that this plan would describe the mitigation efforts to be implemented. However, there are no further details provided regarding the mitigation measures that would be applied. Although there is additional information in the Proponent's response to information request 12 of CEAR Doc#314, there are no measures that could be</p>	<p>Provide a description of the mitigation measures that would be employed under the Dredging and Sediment Discharge Plan.  Provide information regarding:  <ul style="list-style-type: none"> <li>• _which measures are Vancouver Fraser Port Authority standard best practices for protecting the environment when dredging and for sediment discharge;</li> <li>• _other measures specifically designed to mitigate a potential</li> </ul> </p>	<p><b>Sufficient.</b> The VPPA's standard best practices for protection of the environment when dredging and for sediment discharge are reported.  A description of the mitigation measures that would be employed under the Dredging and Sediment Discharge Plan are provided.  Other measures specifically designed to mitigate a potential adverse effect of the Proposed Project to a particular environmental component are described.</p>

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			<p>construed as mitigation measures. For example, the Proponent indicated that compliance checking for water quality would occur, and that provisions for intervention in the case of non-compliance would be followed. However, these are measures that would be used as part of a follow-up program and, are not mitigation measures. As defined under the <i>Canadian Environmental Assessment Act, 2012</i>, mitigation measures are measures for the elimination, reduction or control of the adverse environmental effects of a designated project and, include restitution for any damage to the environment caused by those effects through replacement, restoration, compensation or any other means.</p> <p>In their submission to the Review Panel (CEAR Doc#1091), Environment and Climate Change Canada indicated that further information was required to determine whether marine pollution could result from the use of dredged material for Project construction and whether the resulting supernatant will result in marine pollution. Additional information regarding the mitigation measures that would be employed by the Proponent to mitigate adverse effects of dredging and sediment discharge is required.</p>	<p>adverse effect of the proposed Project to a particular environmental component; and</p> <ul style="list-style-type: none"> <li>the environmental components for which any of the above measures were designed.</li> </ul> <p>When responding to this information request, consider information that would be included in the Project Description Update as described in CEAR Doc#1054.</p>	
IR12-04	Human Health Risk Assessment Marine Resources and Contamination	EIS Volume 4: Revised Section 27 (CEAR Doc#412) Appendix 27-C: Roberts Bank 2 Technical Report - Shellfish Harvesting Potential and Contaminant-Related Consumption Risks at Roberts Bank Health Canada: Submission to the	<p>The Proponent, in Section 27 and Appendix 27-C, presented a human health risk assessment (HHRA) associated with the gathering and consumption of shellfish from the Roberts Bank area. The HHRA was focused on bivalve shellfish and Dungeness crabs which the Proponent stated have traditionally been an important marine resource for coastal indigenous communities. The Proponent concluded that the potential effects on human health from the construction and operation of the proposed Project were negligible. This conclusion was based on toxicological risks associated with existing contamination of marine shellfish; the Proponent's view that the source of contamination in the area is largely historical; and that sediment disturbance and resettlement during construction would not increase existing seabed levels of contamination.</p>	<p>Revise the assessment of the potential effects on human health from marine resource contamination for both Indigenous and non-Indigenous populations using the following conditions:</p> <ul style="list-style-type: none"> <li>Include the effects of resuspension and uptake of existing contaminants in marine resources due to construction of the proposed Project, based on the analysis presented in IR11-23. Include a full set of contaminants of potential concerns (COPCs) that could be discharged or mobilized from the Project.</li> <li>Include marine resources, in addition to those included in the</li> </ul>	<p><b>Insufficient.</b> The proponent stated that it was not possible to provide the information in order of relative reliance among traditional foods, as the information required for such an analysis is not available.</p> <p>No other data on other requests was supplied.</p>

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		<p>Review Panel (CEAR Doc#579) BC Ministry of Health: Submission to the Review Panel (CEAR Doc#629) CEAR Doc#1179, IR11-23 Environment Canada and Climate Change: Submission to the Review Panel (CEAR Doc#1091)</p>	<p>In IR11-23 of CEAR Doc#1179, the Panel requested additional information regarding the 95 percent upper confidence limit (UCL) of the mean concentrations for various chemical parameters in sediment and asked for information regarding the potential for adverse effects on biophysical components due to chemical concentrations in the sediment. Should the Proponent's analysis reveal exceedances in comparison to relevant guidelines (referred to by ECC in CEAR Doc#1091), or demonstrate potential adverse effects to biophysical components, the health effects from the consumption of marine foods would need to be re-evaluated to consider the resuspension and uptake of existing contaminants associated with Project construction. Further, Health Canada and the BC Ministry of Health commented that the HHRA should not be limited to bivalve shellfish and Dungeness crabs, but should consider all important traditional foods harvested in the Project area (i.e. full range of human populations harvesting in the area with a set of representative marine biota, vegetation and birds harvested). Both health authorities indicated that the HHRA should include all contaminants of potential concerns (COPCs) that could result from Project activities, not just contaminants associated with historical contamination. Additionally, the Proponent, in Section 27.5.4 of the EIS, indicated that health risks from exposure to inorganic arsenic from the consumption of crab leg muscle are acceptably low - assuming that 0.1% of the measured total arsenic is present in the form of the more toxic inorganic arsenic. Similarly, Appendix 27-C indicated that health risks from exposure to inorganic arsenic from the consumption of bivalves are acceptably low assuming that 1.8% of the measured total arsenic is present as inorganic arsenic. Health Canada was of the opinion that higher proportions of inorganic arsenic to total arsenic would be more appropriate for calculating health risks from</p>	<p>assessment (i.e., bivalves and crab), that are harvested by Indigenous and non-Indigenous populations within the Human Health Local Assessment Area (LAA):</p> <ul style="list-style-type: none"> <li>• Update shellfish consumption rates (g/day) (as per IR12-02) for Indigenous groups harvesting in the Human Health LAA and, in particular, the Lower Fraser River area and the southern Strait of Georgia; include groups such as the Tsawwassen First Nation, the Musqueam Indian Band, the Tseil-Waututh First Nation, Nations of the Cowichan Alliance, the Lyackson First Nation, the Lake Cowichan First Nation, the Hwlitsum First Nation and the Métis Nations of British Columbia); and</li> <li>• Include the exposure to arsenic in marine resources using a 3% inorganic arsenic to total arsenic ratio for crab (muscle and hepatopancreas), and a 5% ratio for bivalves (including oysters and mussels).</li> </ul> <p>Provide mitigation measures to address any new conclusions from the revised assessment, and details on their effectiveness. The results and assessment of effects should be presented in a manner that differentiates between Indigenous and non-Indigenous people. When responding to this IR, integrate any new information generated in Proponent Responses that would be relevant, such as from IR11-23.</p>	

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IR12-09	<p><b>Biofilm Salinity Measurements</b></p>	<p>CEAR Doc#1110: Appendix IR8-04-A: Figure 2-1 and Figure 4-2 EIS Volume 3: Section 11, Table 11-6</p>	<p>the consumption of bivalves and crab. In the absence of measured inorganic arsenic concentrations in the tissues of marine traditional foods in the vicinity of Roberts Bank, Health Canada advised the use of a more conservative 3% inorganic arsenic to total arsenic ratio for crab (muscle and hepatopancreas), and a 5% ratio for bivalves (including oysters and mussels). In consideration of the above, a revised HHRA for marine food contamination and updated mitigation measures are required.</p> <p>In order to understand the influence of abiotic factors on biofilm, the Proponent conducted statistical modelling of biofilm dependence on salinity and other measured variables using data collected at seven sampling stations on Roberts Bank (CEAR Doc#1110, Appendix IR8-04-A, Figure 2-1). Statistical model covariates included various percentiles of measured salinity, but the absolute salinity values associated with the reported percentiles were not reported in detail. The Proponent stated that zero salinity values plotted on Figure 4-2 of Appendix IR8-04-A are not real salinity concentrations, but indicative of low tide periods when water did not cover the salinity sensor. From the plot, it is unclear whether the zeroes were appropriately excluded in the salinity statistical analysis. Clarification is required regarding the salinity data to interpret the statistical models and the effects of abiotic factors on biofilm. This includes characterization of salinity differences across the sampling stations in order to better understand how the sampling network resolves spatial gradients of salinity and their effects on biofilm biomass.</p>	<p>For the salinity data set collected at the seven sampling stations in 2016, as well as any similar data sets collected in 2017, provide:  Time series plots of measured salinity in practical salinity units (psu), similar to Figure 4-2, but for all seven sampling stations, excluding any zero data points.</p> <ul style="list-style-type: none"> <li>• A station-resolved tabulation of measured salinity (in psu) at every 5th percentile value between the 5th and 95th percentiles as well as the 2nd and 98th percentile, excluding zeroes. Report the total number of data points and the number of zeroes at each station.</li> <li>• A tabulation of measured salinity (in psu) at every 5th percentile value between the 5th and 95th percentiles as well as the 2nd and 98th percentile, excluding zeroes, stratified as appropriate by tide level, tide direction and tide type (neap, spring, or intermediate).</li> <li>• Percentile-percentile plots of measured salinity (in psu) at every 5th percentile between the 5th and 95th percentiles as well as the 2nd and 98th percentile (excluding zeroes) for all</li> </ul>	<p><b>Sufficient.</b> Provided.</p>

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				<p>possible pairs of sampling stations.</p> <p>Provide a discussion on the variability of the salinity data across tidal stage, sampling dates within years, between stations and between years.</p>	
IR12-13	Marine Water Quality Organic Enrichment	<p>EIS Volume 2: Section 9.6 Section 9.7 CEAR Doc#900 CEAR Doc#1102 CEAR Doc#1124</p>	<p>The Proponent, in Section 9.6 of the EIS, stated that increased percent fines and organic-rich sediments are anticipated as a result of the proposed Project in the intertidal area immediately north of the causeway due to modified movement of the Fraser River plume carrying suspended fine sediments. A change in the distribution of Fraser River freshwater would also affect the delivery of natural and anthropogenic substances to different areas of the tide flats. The Proponent concluded that while minor localized changes in distribution may occur, a measurable change relative to existing conditions was unlikely. In Section 9.7 of the EIS, the Proponent further reported that excess concentrations of nitrogen or phosphorus can lead to increased primary production and a surplus of organic matter, which can lead to oxygen depletion and eutrophication. Eutrophic conditions were identified as a key indicator for monitoring as part of the Adaptive Management Strategy monitoring for the Deltaport Third Berth project (CEAR Doc#1124).</p> <p>Fisheries and Oceans Canada, in CEAR Doc#900 and #1102, indicated that anoxic events are known to be strong drivers of community composition and exclusion, regardless of substrate type, and that these conditions were not considered in the ecosystem model. Fisheries and Oceans Canada further observed that the proposed position of the new terminal at the seaward termination of the Deltaport causeway would produce a crescent-shaped feature in the wake of the Fraser River Plume, and that this feature may provide a silt trap that may promote organic enrichment.</p> <p>Fisheries and Oceans Canada proposed that</p>	<p>Provide a detailed description of the existing conditions relative to nutrient and organic matter enrichment and to the occurrence of anoxic events within the Marine Water Quality Study Area, including the area north of the existing causeway and the inter-causeway area of Roberts Bank.</p> <p>Provide an explanation for how the potential change in the distribution of organic-rich sediments due to the proposed Project may affect water quality at localized or larger scales within the Marine Water Quality Study Area.</p> <p>Provide a discussion on the potential environmental effects that could change water quality and lead to anoxic conditions for the environmental components assessed in the EIS and, clarify whether the potential for organic enrichment was considered in the design and evaluation of the proposed offsetting habitat concepts for the Project.</p> <p>The proponent has provided a description of the specific measures that would be included as part of the follow-up program to verify organic enrichment conditions and applicable mitigation measures in the event that organic enrichment is identified as a result of the Project placement.</p>	<p><b>Sufficient.</b> The proponent has provided a detailed description of the existing conditions relative to nutrient and organic matter enrichment and to the occurrence of anoxic events within the Marine Water Quality Study Area.</p> <p>The proponent has provided an explanation for how the potential change in the distribution of organic-rich sediments due to the proposed Project may affect water quality at localized or larger scales within the Marine Water Quality Study Area.</p> <p>The proponent has provided a discussion on the potential environmental effects that could change water quality and lead to anoxic conditions for the environmental components assessed in the EIS and, clarify whether the potential for organic enrichment was considered in the design and evaluation of the proposed offsetting habitat concepts for the Project.</p> <p>The proponent has provided a description of the specific measures that would be included as part of the follow-up program to verify organic enrichment conditions and applicable mitigation measures in the event that organic enrichment is identified as a result of the Project placement.</p>

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Additional Information Request Responses

IR #	Topic	Information Sources	Context	Information Request	Sufficiency of Information
IR13-26	<p><b>Accidents and Malfunctions</b> <b>Fate of Oil Spills</b></p>	<p>EIS Volume 5: Section 30 Appendix 30-B Marine Shipping Addendum: Section 10 Appendix 10-B Transport Canada Response to IR-14 (CEAR 1204) Review Panel Information Requests IR11-03 (CEAR 1179)</p>	<p>monitoring of sediments and indicators of nutrient and organic enrichment should be used in the Project's follow-up program, in order to verify the accuracy of the predictions pertaining to changes in marine water quality. The Proponent is required to provide additional information on the anticipated changes in distribution of organic-rich sediments due to the placement of the terminal, as a pathway of effects for environmental components assessed in the EIS.</p> <p>As part of Transport Canada's response to information request TC IR-14 (CEAR 1204), Natural Resources Canada provided the following observation with respect to its review of Appendix 30-B of the EIS and Appendix 10-B of the Marine Shipping Addendum: <i>'there was little discussion of how the variability of heavy oil properties (e.g. viscosity, density etc.) affect the variability of the fate and behaviour of the oils (e.g. sinking behaviour of bunker fuel or dispersion of diesel fuel etc.) over the range of water environments reported by the proponent.'</i> In Package 11 (CEAR 1179), IR11-03 "Accidents and Malfunctions - Effects Assessment, Potential Contaminant Release" requested additional information on the characteristics of contaminants potentially released, including the types of pathways of effect to environmental components and the potential effects associated to spills. IR11-03 was requested to consider how the range of water temperatures and salinities in the marine shipping area would influence the fate and behaviour of spills.</p>	<p>In response to IR11-03, include a discussion on the variability in the fate and behaviour of potentially released contaminants, including oils, in relation to the range of water temperatures and salinities in the marine shipping area.</p> <p>Clarify how variability in oil physical properties, and hence behaviour in the marine environment relates to response strategies for the water environments within the marine shipping area, as well as potential persistence in the environment.</p>	<p><b>Sufficient.</b> The descriptions in IR11-03 includes a discussion on the variability in the fate and behaviour of potentially released hazardous and noxious substances, as well as oils, in relation to the range of water temperatures and salinities in the marine shipping area but are very general in nature.</p> <p>Response to response strategies that would consider the type of oil spilled and expected behaviour based on environmental conditions at the time of the incident are also very limited and general.</p>
IR13-30	<p><b>Compilation of Environmental Management Plans, Mitigation Measures, and Follow-Up</b></p>	<p>Proponent Response to Additional Information Requirements of July 31, 2015 (CEAR 314): IR12 EIS Volume 5: Section 33 Appendix 33-A</p>	<p>The Proponent has provided information on environmental management plans, which often include mitigation measures as well as elements of follow-up programs. This information is found in numerous locations, including but not limited to, the mitigation sections of each chapter within the main text of the EIS, Section 33 and Appendix 33-A of the EIS, Table 35-1 and Table 35-2 of Section 35 of the EIS, and the response to information request IR12 of CEAR 314. Information was also provided in response to the</p>	<p>Using the attached templates, provide a compilation of the mitigation measures for each environmental component (both intermediate and valued components) affected by the proposed Project (Attachment #3) and marine shipping associated with the Project (Attachment #4). Include mitigation measures that reduced the adverse effect to a negligible residual</p>	<p><b>Sufficient.</b> Tables not final.</p>

Sufficiency Review of Terminal 2 Project's  
Additional Information Request Responses

IR #	Topic	Information Sources	Context	Information Request	Sufficiency of Information
	<p>Programs</p>	<p>Section 35, Table 35-1 and Table 35-2 EIS, Mitigation Sections (various) Marine Shipping Addendum, Mitigation Sections (various) Proponent Responses to Panel Information Requests (various) Proponent further Commitment(s) during Public Hearing</p>	<p>Review Panel's information requests. A compilation of this information would assist the Review Panel and participants to the environmental assessment of the Project and marine shipping associated with the Project in having comprehensive information on mitigation and follow-up measures for the proposed Project. In many cases, the measures presented as part of the various environmental management plans were described as mitigation measures, however, they are often in actuality elements of a follow-up program. Under the <i>Canadian Environmental Assessment Act, 2012</i>, mitigation measures are defined as measures for the elimination, reduction or control of the adverse environmental effects of a designated project and include restitution for any damage to the environment caused by those effects through replacement, restoration, compensation or any other means. A follow-up program is a program for (a) verifying the accuracy of the environmental assessment of a designated project, and (b) determining the effectiveness of any mitigation measures. For example, although compliance monitoring was listed as a mitigation measure in Table IR12-A of the response to IR12 (CEAR 314), this would fall under a follow-up program. Therefore, mitigation measures and follow-up programs should be presented separately for each environmental component of the proposed Project and marine shipping associated with the Project to facilitate the Review Panel's analysis of potential environmental effects. Where mitigation measures and elements of a follow-up program were tied to an environmental management plan or other plans, such as the Offsetting Plan, the Proponent should specify in which environmental management plan they are anticipated to be found.</p>	<p>adverse effect. Using the attached templates, provide a compilation of the elements of a follow-up program that are to be applied for each environmental component affected by the proposed Project (Attachment #5) and marine shipping associated with the Project (Attachment #6).</p>	

# TAB F





**Addressing *Species at Risk Act*  
Considerations Under the *Canadian  
Environmental Assessment Act* for  
Species Under the Responsibility of  
the Minister responsible for  
Environment Canada and Parks  
Canada**

Environment Canada and Parks Canada

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## Note to Readers

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### Document information

This guide may be reviewed and updated periodically. To ensure that you have the most up-to-date version, please consult:

- the [Species at Risk Public Registry](#); or
- the Canadian Environmental Assessment Agency's guidance material Web page at [Canadian Environmental Assessment Agency – Policy & Guidance – Guidance Materials](#).

This guide has been issued in French under the title: *Considérations relatives à la Loi sur les espèces en péril dans le contexte de la Loi canadienne sur les évaluations environnementales* concernant les espèces sous la responsabilité du ministre responsable d'Environnement Canada et de Parcs Canada.

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### Comments?

To submit comments in relation to this guide, please contact:

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Canadian Wildlife Service  
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Gatineau QC K1A 0H3  
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Fax: 819-997-2756  
Email: [cws-scf@ec.gc.ca](mailto:cws-scf@ec.gc.ca)

## Acronyms

<b>CEAA</b>	<i>Canadian Environmental Assessment Act</i>
<b>CESCC</b>	<b>Canadian Endangered Species Conservation Council</b>
<b>COSEWIC</b>	<b>Committee on the Status of Endangered Wildlife in Canada</b>
<b>NACOSAR</b>	<b>National Aboriginal Council on Species at Risk</b>
<b>SAR</b>	<b>Species at Risk</b>
<b>SARA</b>	<i>Species at Risk Act</i>
<b>SARA EA Checklist</b>	<i>Species at Risk Act</i> Environmental Assessment Checklist for Species Under the Responsibility of the Minister Responsible for Environment Canada and Parks Canada

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## Guide Overview

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### Purpose of guide

This document has been prepared to provide guidance on specific obligations under the *Species at Risk Act* (SARA) for species under the responsibility of the Minister responsible for Environment Canada and Parks Canada as they relate to federal environmental assessment. Specifically, the guide shows how certain SARA requirements may be addressed at each step of an environmental assessment conducted under the *Canadian Environmental Assessment Act* (CEAA).

---

### Contents

This publication contains the following topics:

Topic	Page
<a href="#">Part 1. SARA Provisions Relating to Project Review</a>	4
<a href="#">Part 2. Incorporating SARA Considerations into the CEAA Process</a>	21
<a href="#">Appendices: Background to the <i>Species at Risk Act</i></a>	60

Part 1 of this guide focuses on the SARA provisions that relate to federal environmental assessment project review and responsible authority (RA). It identifies the relevant SARA requirements for responsible authorities, as well as the federal policy associated with the requirements.

Part 2 of this guide examines how the SARA provisions can best be integrated into each step of the CEAA process. It presents guidance on the additional procedures that an environmental assessment practitioner or responsible authority may need to consider during an environmental assessment.

The appendices provide additional SARA background information that is of particular relevance to an environmental assessment practitioner. The appendices include an overview of SARA, definitions, responsibilities, key instruments, information sources and a template for notification.

In addition, SARA environmental assessment checklists for species under the responsibility of the Minister responsible for Environment Canada and Parks Canada developed as a complementary support tool for this guide provide the required information elements under SARA for environmental assessments conducted under CEAA.

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**Related guidance**

This guide complements related guidance available for both SARA and CEAA. For additional information on related topics, please refer to the following:

- SARA background material and guidance on the Species at Risk Public Registry website at [www.sararegistry.gc.ca](http://www.sararegistry.gc.ca); and
- CEAA guidance on the Canadian Environmental Assessment Agency's website at [www.ceaa-acee.gc.ca/default.asp?lang=En&n=DACB19EE-1](http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=DACB19EE-1).

**Note:** Additional guidance on integrating SARA considerations regarding species under the responsibility of the Minister responsible for Environment Canada and Parks Canada into other federal environmental assessments, such as environmental assessments conducted under the Mackenzie Valley Environmental Impact Review Board, the Nunavut Impact Review Board, and the *Yukon Environmental and Socio-economic Assessment Act* is currently under development.

---

**Intended users**

The guide is primarily intended for those who are already familiar with federal environmental assessment and would like to know how to incorporate SARA requirements regarding species under the responsibility of the Minister responsible for Environment Canada and Parks Canada into their project reviews under CEAA.

Various portions of this guide will be relevant for:

- responsible authorities and federal authorities under CEAA;
- environmental assessment practitioners responsible for conducting or contributing to environmental assessments involving the federal government;
- managers and project proponents responsible for projects that are subject to an environmental assessment under CEAA; and
- other jurisdictions that may have an interest in such projects.

**Note:** This guide is specific to species under the responsibility of the Minister responsible for Environment Canada and Parks Canada. For guidance regarding the incorporation of SARA requirements for species under the responsibility of the Minister of Fisheries and Oceans in the federal environmental assessment process, please contact Fisheries and Oceans Canada.

---



**Disclaimer**

This document has been prepared for information purposes only. It is not a substitute for CEAA, SARA or any regulations under these Acts. In the event of an inconsistency between this guide and these Acts or regulations, the Acts or regulations, as the case may be, would prevail.

Official or more detailed information can be found in the legal text of [SARA](#) and [CEAA](#) and any regulations made under these Acts, available on the Department of Justice website at <http://laws.justice.gc.ca/en/index.html>.

Individuals with specific questions about either Act are encouraged to seek legal advice.

**Note:** Regardless of whether an environmental assessment is triggered under CEAA, SARA compliance and prohibitions apply at all times. For further information on compliance responsibilities, see the [Species at Risk Public Registry](#).

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# Part 1. SARA Provisions Relating to Project Review

## Overview

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### Purpose of Part 1

SARA provides a framework for the protection and recovery of species at risk in Canada. The measures it provides for, and the information generated, will be highly relevant to the conduct of environmental assessments.

In addition, SARA contains four provisions that directly relate to federal project review.

Part 1 of this guide provides:

- an overview of the four SARA provisions that relate directly to federal environmental assessments; and
  - background for more detailed consideration of each of these provisions.
- 

### Contents

This part contains the following topics:

Topic	Page
<a href="#">1.1 SARA Notification Requirement</a>	7
<a href="#">1.2 SARA Project Review Requirements</a>	13
<a href="#">1.3 Amendment to the CEAA Definition of “Environmental Effect”</a>	18

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**Table 1: SARA provisions that relate directly to project review**

Three provisions in SARA directly relate to the conduct of environmental assessments. The following table summarizes these three provisions. Each provision is then considered in more detail in following sections.

<b>SARA provision</b>	<b>Description</b>	<b>For details see:</b>
s. 79(1)	Requires that every person who is required by or under an Act of Parliament to ensure that an assessment of the environmental effects of a project is conducted must, without delay, notify the competent minister or ministers in writing of the project if it is likely to affect a listed wildlife species or its critical habitat.	<a href="#">1.1 SARA Notification Requirement</a>
s. 79(2)	Requires that, where a federal environmental assessment is being carried out in relation to a project that may affect a listed wildlife species or its critical habitat, the person responsible for ensuring the assessment is conducted must: <ul style="list-style-type: none"> <li>• identify potential adverse effects on the listed wildlife species and its critical habitat; and</li> <li>• if the project is carried out: <ul style="list-style-type: none"> <li>› ensure that measures are taken to avoid or lessen those adverse effects and to monitor them, and</li> <li>› ensure that such measures are consistent with any applicable recovery strategy and action plans.</li> </ul> </li> </ul>	<a href="#">1.2 SARA Project Review Requirements</a>
s. 79(3)	Defines “person” as: <ul style="list-style-type: none"> <li>• including an association or organization, and a responsible authority as defined in subsection 2(1) of CEAA.</li> </ul> Defines “project” as: <ul style="list-style-type: none"> <li>• a project as defined in subsection 2(1) of CEAA.</li> </ul>	<a href="#">Definition of a person</a>  <a href="#">Definition of a project</a>

**Definition of responsible authority**

The expression “responsible authority” is defined in subsection 2(1) of CEAA.

It means, in relation to a project:

a federal authority that is required pursuant to subsection 11(1) to ensure that an environmental assessment of the project is conducted

---

**Definition of a project**

“Project” is defined in subsection 2(1) of CEAA as

- (a) in relation to a physical work, any proposed construction, operation, modification, decommissioning, abandonment or other undertaking in relation to that physical work, or
  - (b) any proposed physical activity not relating to a physical work that is prescribed or is within a class of physical activities that is prescribed pursuant to regulations made under paragraph 59(b)
- 

**Table 2:  
Amending provision of SARA**

The fourth provision in SARA that directly relates to federal project review also provides for a consequential amendment of the CEAA definition of “environmental effect,” summarized in the following table, that reinforces the obligation to consider potential environmental effects.

<b>Provision</b>	<b>Description</b>	<b>For details see:</b>
SARA s. 137	Amends the definition of “environmental effect” under CEAA to clarify, for greater certainty, that environmental effects include any change the project may cause in the environment, including to a listed wildlife species, its critical habitat or the residences of individuals of that species.	<a href="#">1.3 Amendment to the CEAA Definition of “Environmental Effect”</a>

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## 1.1 SARA Notification Requirement

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**SARA notification requirement for responsible authority**

Under subsection 79(1), SARA confers an obligation on a responsible authority to notify the competent minister or ministers of a project if the project is likely to affect a listed wildlife species or its critical habitat.

---

**Species or critical habitat to which the notification requirement applies**

The SARA notification requirement covers all species listed in Schedule 1 of SARA, regardless of whether they are found on lands managed by the federal, provincial or territorial governments.

“Listed species” refers to species listed in Schedule 1 of SARA and includes species designated as extirpated, endangered, threatened or of special concern. Listed species are identified on the Species at Risk Public Registry at [www.sararegistry.gc.ca/species/default\\_e.cfm](http://www.sararegistry.gc.ca/species/default_e.cfm).

The SARA notification requirement covers all listed species regardless of whether prohibitions apply to those species or not. Where prohibitions do apply, permits may be required.

Critical habitat is habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in the recovery strategy or action plan for the species. Recovery strategies and action plans are posted on the Species at Risk Public Registry.

---

**Notification for other species**

Notification of a project under subsection 79(1) is required for listed wildlife species only. However, the Species at Risk Public Registry also identifies COSEWIC species currently under consideration for listing. When any such species is likely to be affected by a project, a responsible authority is encouraged to send in a notification. While there is no legal requirement to do so, this would address the requirement for notification should listing occur before the environmental assessment is completed.

For the reasons stated above, a responsible authority may choose to provide notification if a project is likely to affect any COSEWIC-listed wildlife species.

---

**Who is responsible for notification?**

Under CEAA, the person who is required to ensure that an environmental assessment is conducted is the responsible authority. Thus, the onus is on the responsible authority to comply with subsection 79(1) of SARA.

If there is more than one responsible authority, then each has a responsibility to notify the competent minister(s). Their responsibilities may be met by coordinating a joint notification that each should sign, or alternatively, each sending in a separate notification.

For example, in a project with three responsible authorities, all three could sign a single notification or three separate notifications could be sent.

**Note:** Formal notification is required even if discussions have occurred between a responsible authority and the competent department offering advice on the species.

**Table 3: Who must be notified?**

A responsible authority must send a notification to the competent department reporting to the competent minister responsible for the listed wildlife species.

In other words:

<b>For...</b>	<b>Notification must be sent to...</b>
<ul style="list-style-type: none"> <li>• any species and their critical habitat found exclusively or partly in or on federal lands administered by Parks Canada</li> </ul>	<a href="#">Parks Canada</a>
<ul style="list-style-type: none"> <li>• for <a href="#">aquatic species</a> and their critical habitat</li> </ul>	<a href="#">Fisheries and Ocean Canada</a>
<ul style="list-style-type: none"> <li>• for migratory birds protected by the <i>Migratory Birds Convention Act, 1994</i> and their critical habitat, and</li> <li>• all other species and critical habitat</li> </ul>	<a href="#">Environment Canada</a> (see note)

**Note:** To find out whether more than one notification is required, please refer to the section entitled [Is more than one notification required?](#)

**How should notification be done?**

Notification should follow existing environmental assessment channels.

For example, notification letters should be sent to the regional environmental assessment department or agency contacts who would normally be contacted under the procedures of the *CEAA Regulations Respecting the Coordination by the Federal Authorities of Environmental Assessment Procedures and Requirements*, also known as the Federal Coordination Regulations.

Contact lists are available through department or agency members of the regional environmental assessment committees. For a list of contacts, please communicate with your Canadian Environmental Assessment Agency regional office. Contact information is also available on the Agency's website at [www.ceaa-acee.gc.ca/default.asp?lang=En&n=12D96EC7-1](http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=12D96EC7-1).

---

**Parks Canada contacts**

Parks Canada has 33 field units which are groupings of national parks, national historic sites and national marine conservation areas whose proximity to each other allows them to share management and administrative resources. There are four service centres: Halifax, Québec, Cornwall/Ottawa and Winnipeg/Calgary/Vancouver.

Most field units have an environmental assessment coordinator, and there are also environmental assessment specialists in each of the service centre offices. The environmental assessment coordinators and specialists are the primary contacts for environmental assessments.

Parks Canada contacts can be accessed at:  
[www.pc.gc.ca/eng/agen/courriel-email.aspx](http://www.pc.gc.ca/eng/agen/courriel-email.aspx)

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**Fisheries and Oceans contacts**

Fisheries and Oceans Canada contacts can be accessed at:  
[www.dfo-mpo.gc.ca/contact-eng.htm](http://www.dfo-mpo.gc.ca/contact-eng.htm)

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**Environment Canada contacts**

Environment Canada regional contacts can be accessed at:  
[www.ec.gc.ca/default.asp?lang=En&n=DA294545-1](http://www.ec.gc.ca/default.asp?lang=En&n=DA294545-1)

---

**Is more than one notification required?**

When more than one listed wildlife species or critical habitat may be affected, a single notification may cover all the species.

If there is more than one competent minister responsible for the listed wildlife species or critical habitat, notification must be sent to each competent department with responsibility for the species.

For example:

- If a project occurs or is proposed on both federal lands administered by Parks Canada and other lands, and could affect a species under the responsibility of the Minister responsible for Environment Canada and Parks Canada listed on Schedule 1 of SARA, both Parks Canada and Environment Canada regional contacts should be notified.
- Similarly, if a project occurs or is proposed on federal lands administered by Parks Canada and elsewhere, and could affect an aquatic species listed on Schedule 1 of SARA, both Parks Canada and Fisheries and Oceans Canada regional contacts should be notified.

Additional notification may be needed should it become known, later in the environmental assessment process, that additional listed wildlife species or their critical habitat are likely to be affected.

**When must notification be provided?**

Notification must be made as soon as a responsible authority identifies that a project is likely to affect one or more listed wildlife species or its critical habitat.

In practice, this could occur at any phase of the environmental assessment, such as very early during the review of a project description, during the scoping phase, as a result of field work, or later on during the analysis of environmental effects or even the follow-up. Notification is required at any of these stages if it is only then discovered that the project is likely to affect a listed wildlife species or its critical habitat.

The responsible authority should not delay notification until after the identification of mitigation measures. By informing the competent minister of the potential effect early in the process, discussions may be held or information or advice provided that will assist the responsible authority in avoiding or minimizing adverse effects. Early notification allows the competent department to provide advice in the development of mitigation measures, including alternatives that may not be possible at a later stage of planning.



**Must the effects be adverse or significant?** The notification requirement is independent of the significance of the effects. Notification is legally required even for minor effects, and notification is required regardless of whether effects are adverse or not.

---

**Information to be included in the notification** Subsection 79(1) of SARA does not specify what must be included in the notification. In keeping with the principle of notifying as early as possible in the environmental assessment process, it is recognized that some information, such as the nature or severity of the effect, may not be available at the time of notification.

The following information should be provided **as soon as it becomes available**:

- identification of the responsible authority(ies);
- name, location and a brief description of the project;
- federal environmental assessment process under which the project is being assessed;
- listed wildlife species and/or critical habitat that are likely to be affected by the project;
- information source (NatureServe Canada, sightings, recent surveys, etc.); and
- signature of the responsible authority(ies).

While notification should not be delayed until additional information can be produced, **where it is available**, the following could also be provided:

- Canadian Environmental Assessment Registry reference number;
- location data for the species or critical habitat, or any residences of individuals of those species, if known;
- nature of the potential effect;
- mitigation measures being considered or alternative means of carrying out the project, if known;
- need for confidentiality (for example, location data for some species vulnerable to poaching may be sensitive), if known.

A [notification template](#) for this information is provided in Appendix E.

---

**Related  
guidance**

For related information, see also, in this guide, sections:

- [2.2 Notification of the Competent Ministers](#)
  - [2.3 Responsibilities of the Competent Ministers](#)
- 

**SARA  
references**

- Notification of Minister: subsection 79(1)
  - Schedule 1 – List of Wildlife Species at Risk
- 

**CEAA  
references**

- *Regulations Respecting the Coordination by Federal Authorities of Environmental Assessment Procedures and Requirements*
-

## 1.2 SARA Project Review Requirements

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### SARA project review requirements

Under subsection 79(2), SARA confers obligations on a responsible authority to identify adverse effects of the project on a listed wildlife species and its critical habitat, and, if the project is carried out, to ensure that those effects are mitigated and monitored. These obligations are in addition to the requirements set out in CEAA for an assessment of the environmental effects of the project, including in particular any change it may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species as those terms are defined in subsection 2(1) of SARA.

---

### Identifying adverse effects

Identifying the adverse effects of a project on a listed wildlife species and its critical habitat is a requirement under subsection 79(2) of SARA. This is reinforced by the requirement of subsection 16(1) of CEAA for every environmental assessment to consider the “environmental effects” of a project. It is also supported by the CEAA definition of “environmental effect” that specifically includes any change that the project may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of SARA.

Thus, both Acts underscore the need to ensure that an environmental assessment fully considers how a project may affect species at risk and their habitats, including, but not limited to, effects on critical habitats and residences. For example, if using an approach based on valued ecosystem components, it would be best practice to ensure that any species at risk in the project area is identified as a valued ecosystem component.

The analysis should consider how a project affects the listed wildlife species or its critical habitat, including direct, indirect and cumulative effects. As well, effects on habitat that may adversely affect the species should be considered in the analysis. Special attention should be directed to habitat that has been identified as high quality or of special importance by the recovery team since adverse effects on such habitat may, in turn, adversely affect the species.

For species of special concern, critical habitat will not be identified under SARA, but management plans for those species may assist in determining when habitat may be of particular importance to the species.

Identifying potential adverse effects is discussed further in [section 2.6, Analysis of Potential Project Effects on Species at Risk](#).

---

**Mitigating adverse effects**

Under paragraph 16(1)(d) of CEAA, a responsible authority is required to identify “measures that are technically and economically feasible and that would mitigate any [significant](#) adverse environmental effect of the project”.

However, subsection 79(2) of SARA establishes a requirement to avoid or lessen **all** adverse effects of a project on listed wildlife species and critical habitat, regardless of the significance of those effects. Thus, in developing mitigation measures for listed wildlife species, the approach should be systematic and rigorous.

The following mitigation sequence should be followed (see note):

1. Avoidance of the adverse effect.
2. Minimization of the adverse effect.
3. Restitution for the adverse effect (e.g., replacement, restoration or compensation).

Mitigation is discussed further in [section 2.9, Mitigation Measures](#).

**Note:** While CEAA recognizes restitution for damage to the environment as a mitigation measure, restitution should be considered as a last resort. For species at risk, restitution may not be acceptable.

**Monitoring the adverse effects under SARA**

Subsection 79(2) of SARA also requires monitoring of the actual adverse effects of a project once it is carried out.

Subsection 79(2) requires a responsible authority to ensure that measures are taken to monitor the actual adverse effects on the listed wildlife species or its critical habitat. This implies a need to understand the actual on-the-ground effects once a project is implemented. This may involve verifying the accuracy of the predictions and determining the effectiveness of the mitigation measures; however, this requirement is independent of the significance of the predicted effects, the technology involved in the mitigation measures, or any other factors.

In an assessment under CEAA, the need for a follow-up program is discretionary for a screening, but is mandatory for a comprehensive study, mediation and an assessment by a review panel. As a result of SARA’s subsection 79(2) requirements, monitoring of adverse effects on listed wildlife species must occur regardless of whether a follow-up program under CEAA is initiated. Although there may be similarities between the objectives of the subsection 79(2) monitoring and the CEAA follow-up program, these are two distinct requirements.

When a follow-up program under CEAA is required or deemed to be appropriate, and SARA monitoring is also required, the two may be combined for greater efficiency where appropriate.

Monitoring is discussed further in [section 2.13, Monitoring and Follow-up Programs](#).

---

**Consistency with recovery strategies or action plans**

Subsection 79(2) of SARA also requires that measures taken to avoid or lessen the adverse effects, and to monitor those effects, are consistent with any applicable recovery strategy or action plan.

SARA requires that the competent minister prepare a recovery strategy for a wildlife species that is listed as [extirpated](#), [endangered](#) or [threatened](#). Where recovery is deemed to be technically and biologically feasible, the recovery strategy must address the threats to the survival of the species, including any loss of habitat, and must include specific elements as identified in section 41 of SARA. The competent minister may adopt a multi-species or an ecosystem approach when preparing the recovery strategy.

One or more action plans based on the recovery strategy must also be prepared by the competent minister. The contents of action plans are defined by SARA in section 49.

Proposed and finalized recovery strategies and action plans are posted on the Species at Risk Public Registry at:  
[www.sararegistry.gc.ca/sar/recovery/default\\_e.cfm](http://www.sararegistry.gc.ca/sar/recovery/default_e.cfm)

---

**If there is no recovery strategy or action plan**

In the absence of completed recovery strategies or action plans, the environmental assessment should use the best available information, such as:

- COSEWIC status reports (available on the Species at Risk Public Registry at [www.sararegistry.gc.ca/sar/assessment/status\\_e.cfm](http://www.sararegistry.gc.ca/sar/assessment/status_e.cfm));
- draft recovery strategies or action plans, where available;
- existing plans relating to the wildlife species (see note below); and
- specific advice from any jurisdiction that manages the species.

A jurisdiction that manages the species may also recommend consulting the recovery team or another expert. Any input from the recovery team into the environmental assessment should reflect the position of the team and not of individual members.

For species of special concern, it is best practice to ensure that measures, taken to avoid or lessen adverse effects and to monitor them, in the environmental assessment are consistent with the direction provided in SARA management plans prepared for these species, if available.

Advice regarding whether the measures are consistent with applicable recovery strategies, action plans or best available information may be provided by the competent department responsible for the species.

**Note:** Subsections 44(1), 51(1) and 69(1) of SARA state that existing plans relating to a wildlife species may be adopted as the proposed recovery strategy, action plan or management plan, under specified circumstances, when they meet the requirements of SARA.

### Compliance with SARA

In meeting the requirements of CEAA, the obligations under SARA are not necessarily met. For example:

- An environmental assessment under CEAA may conclude that a project will not result in significant adverse environmental effects. Nonetheless, that project could still involve certain activities that are prohibited under SARA, such as handling species at risk for scientific purposes. Such prohibited activities could not be carried out unless a permit is obtained under SARA. (Refer to guidance on permitting on the Species at Risk Public Registry at [www.sararegistry.gc.ca/sar/permit/default\\_e.cfm](http://www.sararegistry.gc.ca/sar/permit/default_e.cfm).)
- Similarly, a residual environmental effect cannot be considered insignificant just because the proposed activity is not prohibited under SARA. The process for determining significance under CEAA, and the related decisions, must still be respected.

### Related guidance

For related information, see also, in this guide, sections:

- [2.6 Analysis of Potential Project Effects on Species at Risk](#)
- [2.9 Mitigation Measures](#)
- [2.13 Monitoring and Follow-up Programs](#)
- [Appendix D: Key SARA Instruments](#)

### SARA references

- Required action: subsection 79(2)
- Recovery strategies and action plans: sections 41 and 49
- Existing plans: subsections 44(1), 51(1) and 69(1)
- Agreements and permits: sections 73–75

**CEAA  
references**

- Definitions: subsection 2(1)
  - Factors to be considered: subsection 16(1)
  - Follow-up programs: subsections 38(1)–(5)
-

## 1.3 Amendment to the CEAA Definition of “Environmental Effect”

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**Amended  
definition of  
environmental  
effect**

SARA amended the CEAA definition of “environmental effect” through a consequential amendment. This amendment reinforces the obligation to consider the potential environmental effects on listed wildlife species when conducting an environmental assessment under CEAA.

Pursuant to section 137 of SARA, the definition of “environmental effect” in subsection 2(1) of CEAA was amended as follows. The change explicitly states that “environmental effect” means, in respect of a project:

- (a) any change that the project may cause in the environment, including any change it may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of the *Species at Risk Act*,**
- (b) any effect of any change referred to in paragraph (a) on**
  - (i) health and socio-economic conditions,
  - (ii) physical and cultural heritage,
  - (iii) the current use of lands and resources for traditional purposes by aboriginal persons, or
  - (iv) any structure, site or thing that is of historical, archaeological, paleontological or architectural significance, or
- (c) any change to the project that may be caused by the environment, whether any such change or effect occurs within or outside Canada.**

---

**Implications of  
the amendment**

As per section 16 of CEAA, every environmental assessment conducted under CEAA is required to consider the environmental effects of a project and the significance of those environmental effects.

CEAA’s section 2 defines “environment” to mean the components of the Earth and to include: (a) land, water and air, including all layers of the atmosphere; (b) all organic and inorganic matter and living organisms; and (c) the interacting natural systems that include components referred to in paragraphs (a) and (b). The definition of “environmental effect” as amended by SARA does not change this, but rather reinforces the obligation to consider, in all environmental assessments conducted under CEAA, the potential adverse effects on listed wildlife species, residences of individuals of those species and critical habitats.

---



**Location of effects** Section 16 of CEAA requires that a responsible authority consider all environmental effects of a project, regardless of where those effects may occur.

Consequently, when a listed wildlife species will be affected by a project, the environmental assessment must consider all the environmental effects on these species, the residences of its individuals and its critical habitat even if that species or its habitat are also regulated under provincial law.

---

**Effects on other species at risk** The requirements of SARA apply to species that are listed on the List of Wildlife Species at Risk (Schedule 1 of SARA). Therefore, when a federal environmental assessment takes place, SARA requires that the potential effects of a proposed project on any wildlife species listed on Schedule 1 of SARA, on the critical habitat of such species or on the residences of individuals of such species be considered in that assessment.

In addition, CEAA requires consideration of the potential adverse effects of a project on *all* species as part of the consideration of environmental effects. This includes species that are not legally listed under SARA, but that are recognized as “at risk” by COSEWIC or by provincial or territorial agencies. This approach is in keeping with Canada’s commitments under the [Convention on Biological Diversity](#) and the [Accord for the Protection of Species at Risk](#) between the federal government and provinces/territories. Species that have been identified by provincial or territorial government are not necessary on the COSEWIC list.

Environmental assessment is a tool which, by allowing early consideration of the effects of projects on wildlife, may assist in preventing other wildlife species from becoming at risk; therefore it is best practice to consider the potential effects on all species.

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**Related guidance** For related information, see also, in this guide, section:

- [2.6 Analysis of Potential Project Effects on Species at Risk](#)

For more information, please see:

- *Environmental Assessment Best Practice Guide for Wildlife at Risk in Canada*
- *A Guide on Biodiversity and Environmental Assessment at:*  
[www.ceaa-acee.gc.ca/Content/D/A/C/DACB19EE-468E-422F-8EF6-29A6D84695FC/CEAA\\_19E.pdf](http://www.ceaa-acee.gc.ca/Content/D/A/C/DACB19EE-468E-422F-8EF6-29A6D84695FC/CEAA_19E.pdf)

---

**SARA references**

- Amendment to “environmental effect”: section 137

**CEAA  
references**

- Definitions: sections 2(1)
  - Factors to be considered: subsections 16(1) and 16(3)
-

## Part 2. Incorporating SARA Considerations into the CEAA Process

### Overview

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#### Purpose of Part 2

Part 2 of this guide:

- identifies considerations associated with SARA that may arise during specific steps of an environmental assessment conducted under CEAA;
- provides guidance for responsible authorities on addressing SARA considerations and incorporating them into an environmental assessment in a timely manner; and
- identifies, where appropriate, sources for more detailed guidance or information.

The guidance in this section is intended to complement and support best practices for environmental assessment practitioners.

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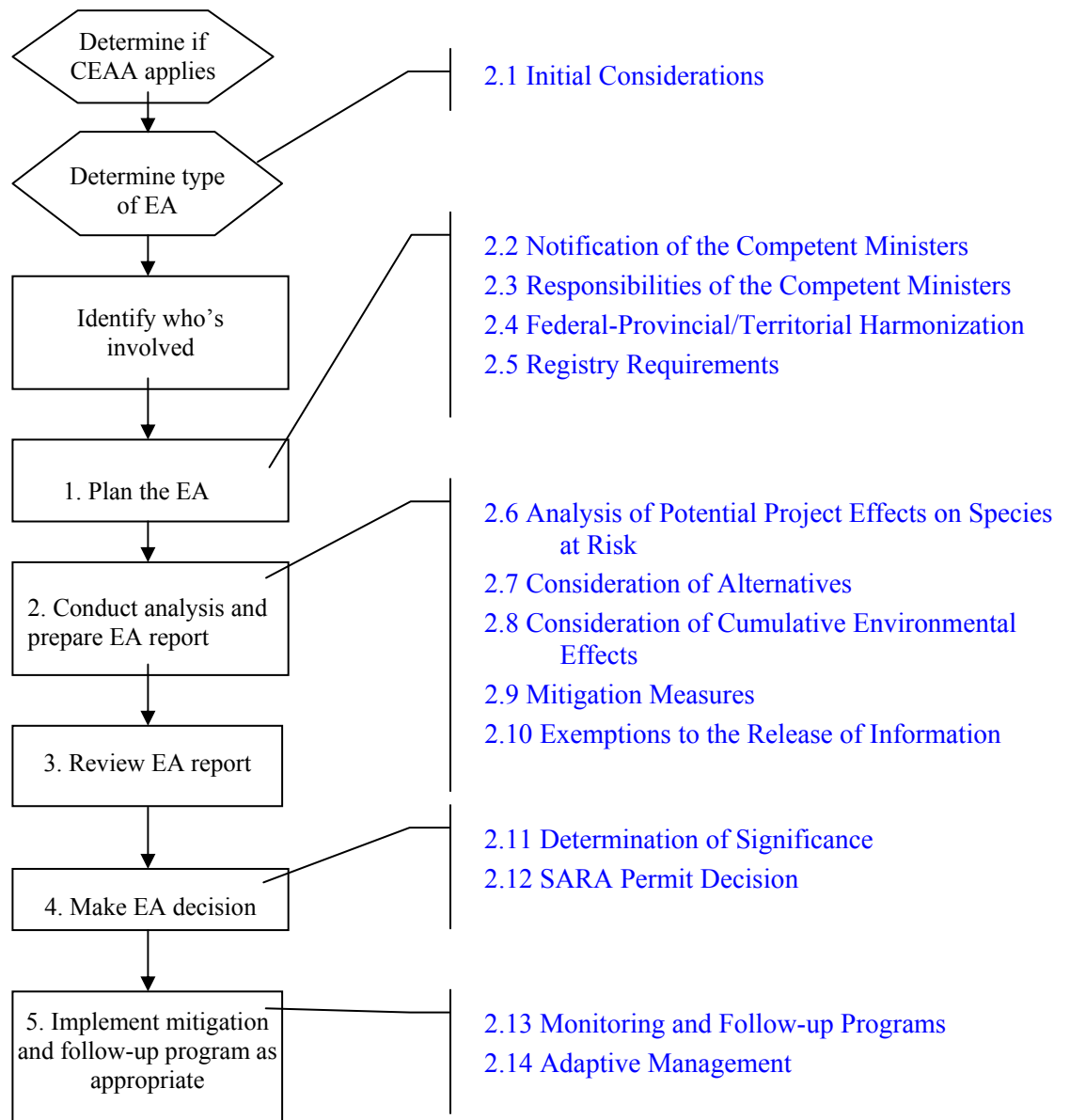
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**Figure 1:**  
SARA considerations during an EA

Figure 1 illustrates the major phases of an environmental assessment (EA) and identifies where the SARA-related considerations may typically arise.



**Additional information**

For more information on environmental assessment best practices related to species at risk, please refer to the Environment Canada's *Environmental Assessment Best Practices Guide for Wildlife at Risk in Canada*.

## 2.1 Initial Considerations

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<b>Determining if CEAA applies</b>	<p>Before initiating the federal environmental assessment process, the first step is to determine if CEAA applies and an environmental assessment for the project is required. SARA does not change this step.</p> <p>For detailed guidance on determining if an environmental assessment is required under CEAA, please refer to the Canadian Environmental Assessment Agency's <i>How to Determine if the Act Applies</i>.</p>
<b>SARA does not trigger CEAA</b>	<p>The presence of a listed wildlife species, a residence of individuals of the species or a critical habitat does not, in itself, trigger CEAA.</p> <p>Likewise, issuing a SARA permit does not, on its own, trigger the need for an environmental assessment under CEAA. Under section 74 of SARA, a permit can be issued by a competent minister, using existing laws and regulations, to authorize activities that may affect a listed wildlife species, any part of its critical habitat or the residences of its individuals, provided that the permitting requirements of SARA are met. Since SARA permits have not been added to the <i>Law List Regulations</i> under CEAA, they do not trigger an environmental assessment.</p>
<b>CEAA applies</b>	<p>If...</p> <ul style="list-style-type: none"> <li>• there is a project as defined by CEAA;</li> <li>• that project is not excluded from assessment under CEAA or its <i>Exclusion List Regulations</i>; and</li> <li>• a federal authority takes an action that enables a project to proceed, i.e., proposes a project as its proponent; grants money or other financial assistance to the proponent for the purpose of enabling a project to be carried out; sells, leases or otherwise disposes of land or any interest in land to enable a project to be carried out, or issues certain approvals as set out in the <i>Law List Regulations</i> under CEAA.</li> </ul> <p>then...</p> <ul style="list-style-type: none"> <li>• an environmental assessment will be required.</li> </ul> <p>Examples of such legislative or regulatory powers in the <i>Law List Regulations</i> include:</p> <ul style="list-style-type: none"> <li>• an authorization under subsection 35(2) of the <i>Fisheries Act</i>;</li> <li>• a permit issued under paragraph 15(1)(a) of the <i>National Parks Wildlife Regulations</i> made under the <i>Canada National Parks Act</i>;</li> </ul>

- a permit issued under subsection 12(1) of the *National Parks General Regulations* of the *Canada National Parks Act*;
- a permit issued under section 4 of the *Wildlife Area Regulations* of the *Canada Wildlife Act*; or
- a permit issued under subsection 19(1) of the *Migratory Birds Regulations* pursuant to the *Migratory Birds Convention Act, 1994*.

Activities that are projects undertaken under SARA recovery strategies or action plans, or through SARA funding, may also trigger an environmental assessment if they meet the criteria under CEAA, as described in the Canadian Environmental Assessment Agency's *How to Determine if the Act Applies*.

---

**Determining the type of environmental assessment**

As per CEAA subsection 18(1), if a project that requires an assessment under CEAA is not described in the comprehensive study list (which is set out in the *Comprehensive Study List Regulations*) or the exclusion list (which is set out in the *Exclusion List Regulations*), a screening of the project is required.

Under section 21 of CEAA, when a project is described in the comprehensive study list, the responsible authority must ensure that a comprehensive study of the project is conducted and that a comprehensive study report is prepared and submitted to the Minister of the Environment.

The potential of the project to cause adverse effects on a listed wildlife species at risk or its critical habitat may be a factor to consider when recommending the appropriate environmental assessment track.

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**Note:** As per legislative amendments made in the *Jobs and Economic Growth Act*, subsection 11.01 of CEAA provides that the Canadian Environmental Assessment Agency will perform the duties and functions of responsible authorities for most comprehensive studies, from the determination that a comprehensive study is needed until the Minister of the Environment is provided with the comprehensive study report.

---

**Starting the environmental assessment**

Once an environmental assessment has been triggered by a proposed federal decision or action, SARA requires that the potential effects on a listed wildlife species, its critical habitat or residences of individuals of that species be considered in that assessment.

Therefore, as early as possible in the environmental assessment process, a responsible authority should consider whether such species may be present or affected by the project.

---

**If no environmental assessment is required**

Regardless of whether an environmental assessment is triggered, compliance with SARA is required at all times and can entail other responsibilities such as taking measures to protect and recover species at risk, the residences of individuals of such species and their critical habitat.

See the [Species at Risk Public Registry](#) for further information on compliance responsibilities.

---

**Related guidance**

For related information, see also, in this guide, section:

- [2.12 SARA Permit Decision](#)

For guidance on determining if an environmental assessment is required under CEAA, please refer to the Canadian Environmental Assessment Agency's *How to Determine if the Act Applies*.

For guidance on how to determine if a species at risk may be present or affected by a project, please see the Canadian Wildlife Service's *Environmental Assessment Best Practice Guide for Species at Risk in Canada*.

---

**SARA references**

- Agreements and Permits: sections 73 and 74
- 

**CEAA references**

- Projects to be assessed: section 5
  - Excluded projects: section 7
  - Types of environmental assessment: sections 18 and 21
  - [Law List Regulations](#), [Exclusion List Regulations](#), [Comprehensive Study List Regulations](#) and [Inclusion List Regulations](#)
-

## 2.2 Notification of the Competent Ministers

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### SARA notification requirements

SARA establishes obligations to notify the competent minister(s). These obligations are independent of the requirements of CEAA or the *Regulations Respecting the Coordination by Federal Authorities of Environmental Assessment Procedures and Requirements*, commonly known as the *Federal Coordination Regulations*.

Under subsection 79(1) of SARA, the person required to ensure that a federal environmental assessment of a project is conducted (known under CEAA as the responsible authority) must notify the competent minister(s) without delay if the project is likely to affect a listed wildlife species or its critical habitat.

This notification must occur as soon as it becomes known that a listed wildlife species or its critical habitat is likely to be affected. This can happen at any time during the course of an environmental assessment.

---

### CEAA notification requirements

Under the *Federal Coordination Regulations*, when a federal authority receives a project description and determines that the project is likely to require an environmental assessment and the federal authority identifies itself as a likely responsible authority for that project, it must provide written notice to other federal authorities that are likely to:

- be a responsible authority; or
- be in possession of specialist or expert information or knowledge that is relevant to the conduct of the environmental assessment.

This notice must include a description of the proposed project and of the environment likely to be affected.

SARA does not change or replace the need to contact federal authorities under the *Federal Coordination Regulations*. Therefore, CEAA notification is required even if appropriate notification has been done under subsection 79(1) of SARA.

---

### Coordinating notification

To the extent that it is practical, notification under SARA may be facilitated through the coordination activities directed by the *Federal Coordination Regulations*.

This could occur when the description of the environment likely to be affected is sufficiently detailed to identify listed wildlife species or critical habitat likely to be affected by the project.



For example, a single letter of notification, signed by all responsible authorities, may be sent to a competent department, providing the information that is required under both the *Federal Coordination Regulations* and under subsection 79(1) of SARA. Alternatively, each responsible authority may send a separate letter of notification.

At any time, if further work reveals that other listed wildlife species or critical habitat may be affected, an additional SARA notification would be required later in the process, even if the competent department is already providing advice on the environmental assessment as an expert federal authority.

---

**Related guidance**

For related information, see also, in this guide, sections:

- [1.1 SARA Notification Requirement](#)
- [Appendix E: SARA Notification Template](#)

For additional information about notifications under the CEAA *Federal Coordination Regulations*, please see the Canadian Environmental Assessment Agency's guide entitled *Federal Coordination: Identifying Who's Involved* at:

[www.ceaa-acee.gc.ca/Content/D/A/C/DACB19EE-468E-422F-8EF6-29A6D84695FC/Federal-Coord-Identifying\\_e.pdf](http://www.ceaa-acee.gc.ca/Content/D/A/C/DACB19EE-468E-422F-8EF6-29A6D84695FC/Federal-Coord-Identifying_e.pdf)

---

**SARA references**

- Notification of Minister: subsection 79(1)
- 

**CEAA references**

- [\*Regulations Respecting the Coordination by Federal Authorities of Environmental Assessment Procedures and Requirements\*](#)
-

## 2.3 Responsibilities of the Competent Ministers

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### Response to SARA notification

In response to a notification, sent by a responsible authority under subsection 79(1) of SARA, the competent department representing the competent minister responsible for a species will indicate its involvement in the environmental assessment. The competent department will provide expert advice when the information or expertise is available within the competent department. Responsibility for some species may be shared with other jurisdictions.

---

### Nature of advice provided

Advice provided on species at risk by a competent minister constitutes specialist information and knowledge by an expert federal authority under CEAA.

Advice provided may include, but not be limited to:

- advice on the likely presence of a listed wildlife species or critical habitat in the project area;
- information on the ecology of the listed wildlife species;
- advice on how the project may affect the listed wildlife species, residences of individuals of the species, or its critical habitat and the potential significance of those effects;
- identification of measures to reduce or avoid adverse environmental effects;
- identification of monitoring requirements or follow-up recommendations; and
- advice on other applicable requirements under SARA (for example, relating to what is prohibited under SARA, permitting requirements, future regulations that may be developed, recovery strategies).

While the competent department will provide specialist or expert information in their possession, including possible contacts where further information can be obtained, it remains the responsibility of the responsible authority to ensure that the information acquired is sufficient to meet the requirements of CEAA.

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**Responding to  
CEAA federal  
coordination  
notices**

SARA does not change the need to notify, and coordinate the involvement of, federal authorities with an expertise in listed wildlife species (i.e., a competent department representing a competent minister).

Issues related to potential adverse effects on listed wildlife species may be coordinated through the work of the federal environmental assessment coordinator (and a federal project committee, if one has been established), in the same manner as any other issue requiring the involvement of other expert federal authorities.

---

**Related  
guidance**

For more information on coordination under CEAA, please see the Canadian Environmental Assessment Agency’s guide *Federal Coordination: An Overview*.

---

**SARA  
references**

- Notification of Minister: subsection 79(1)
- 

**CEAA  
references**

- Federal coordination: sections 12–12.5

## 2.4 Federal-Provincial/Territorial Harmonization

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### Shared responsibility for species at risk

Responsibility for species at risk is shared among federal and provincial/territorial jurisdictions. Thus, it is important to consider the importance of involving or cooperating with other jurisdictions when undertaking environmental assessments.

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### Harmonization under CEAA

Federal, provincial and territorial governments have moved towards greater harmonization of their environmental assessment procedures. In 1998, the Canadian Council of Ministers of the Environment signed the [Canada-Wide Accord on Environmental Harmonization](#) and the [Sub-agreement on Environmental Assessment](#).

The sub-agreement promotes the effective application of environmental assessment when two or more governments are required by law to assess the same proposed project. It includes provisions for shared principles, common information elements, a defined series of assessment stages and a provision for a single cooperative assessment.

Project-specific agreements are used to provide for a single assessment that meets the legal requirements of both jurisdictions.

---

### Integrating the two approaches to harmonization

The effectiveness of both SARA and CEAA is grounded in the cooperation of all governments.

Issues related to listed wildlife species should be an important part of the full range of issues that are addressed when establishing a cooperative environmental assessment between jurisdictions. In screenings and comprehensive studies, the federal environmental assessment coordinator typically would facilitate communication and cooperation among federal authorities and other participants. For joint review panels, the Canadian Environmental Assessment Agency would undertake this task.

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### Related guidance

For related information, see also the *Accord for the Protection of Species at Risk* at:  
[www.sararegistry.gc.ca/approach/strategy/accord\\_text\\_e.cfm](http://www.sararegistry.gc.ca/approach/strategy/accord_text_e.cfm)

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### SARA references

- Administrative agreements: section 10 and paragraph 123(b)
- Provincial and territorial classifications: section 36

**CEAA  
references**

- Other jurisdictions: subsections 12(4) and 12(5)
  - Federal coordination: subsection 12(3) and sections 12.1–12.5
-

## 2.5 Registry Requirements

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### Two distinct registries

A responsible authority must meet specific obligations with regards to the Canadian Environmental Assessment Registry established under CEAA.

The Species at Risk Public Registry plays a different role and does not establish new obligations for responsible authorities.

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### Canadian Environmental Assessment Registry

The Canadian Environmental Assessment Registry is a government-wide mechanism to facilitate public access to records related to environmental assessments conducted under CEAA. The Registry consists of two complementary components: an Internet site and a project file.

- The Internet site is an electronic registry administered by the Canadian Environmental Assessment Agency. A responsible authority or the Agency contributes specific records relating to an environmental assessment.
- The project file is a file maintained by a responsible authority or the Agency during an environmental assessment and made available to the public in a convenient manner. The project file includes all records produced, collected or submitted with respect to the environmental assessment of the project (including all records on the Internet site). Notifications required under subsection 79(1) of SARA would constitute records to be maintained in the project file.

The Internet site component of the Registry can be viewed on the Canadian Environmental Assessment Agency's website at:

[www.ceaa-acee.gc.ca/050/index\\_e.cfm](http://www.ceaa-acee.gc.ca/050/index_e.cfm)

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### Species at Risk Public Registry

The Species at Risk Public Registry is an online service that provides access to information and documents about SARA, including the list of species at risk (Schedule 1 of SARA), regulations, orders, agreements, status reports on species assessments, recovery strategies, action plans, management plans for species of special concern and information related to permits that were issued or agreements entered into. It supports public participation in decision making by providing the public opportunity to comment on SARA-related documents being developed by the Government of Canada.

The Species at Risk Public Registry can be viewed on the following website:  
[www.sararegistry.gc.ca/default\\_e.cfm](http://www.sararegistry.gc.ca/default_e.cfm)

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<b>Responsibility for the SAR Public Registry</b>	<p>The Species at Risk Public Registry is maintained by Environment Canada. Information on the public registry is provided by Environment Canada, Parks Canada, and Fisheries and Oceans Canada.</p> <p>A responsible authority conducting an environmental assessment under CEAA has no responsibilities to post records on the Species at Risk Public Registry.</p>
<b>Information source for responsible authority</b>	<p>Information in the Species at Risk Public Registry, such as status reports on species, recovery strategies, action plans and management plans for species of special concern, is an excellent source of information for environmental assessment practitioners about many listed wildlife species.</p>
<b>Related guidance</b>	<p>For more information on the operations and records of the Canadian Environmental Assessment Registry, please see the Canadian Environmental Assessment Agency’s <i>Guide to the Canadian Environmental Assessment Registry</i>.</p>
<b>SARA references</b>	<ul style="list-style-type: none"> <li>• Public Registry: sections 120–124</li> </ul>
<b>CEAA references</b>	<ul style="list-style-type: none"> <li>• Registry contents: sections 55, 55.1 and 55.4</li> </ul>

## 2.6 Analysis of Potential Project Effects on Species at Risk

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### **SARA obligations to address potential effects**

SARA establishes obligations to address potential effects on listed wildlife species in a federal environmental assessment. This obligation reinforces the requirements of CEAA.

Under subsection 79(2) of SARA, the person required to ensure that an assessment of the environmental effects is conducted (i.e., the responsible authority under CEAA) must identify the adverse effects of the project on the listed wildlife species and its critical habitat.

The obligation to identify adverse effects applies to all listed wildlife species, including species of special concern, and not only the extirpated, endangered or threatened species to which prohibitions apply.

This obligation to identify adverse effects on listed wildlife species is independent of the likely significance of the adverse effect.

---

### **CEAA obligations to address environmental effects**

Under subsection 16(1) of CEAA, every environmental assessment must include a consideration of the environmental effects of the project and the significance of these effects. As discussed in section 1.3 of this guide, the CEAA definition of “environmental effect” includes any change that the project may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species.

---

### **Required analysis**

From a practical perspective, the obligations under subsection 79(2) of SARA reinforce the need for federal environmental assessments to pay particular attention to listed wildlife species and their critical habitat.

The analysis in the environmental assessment must provide a basis on which to determine whether the project will adversely affect the listed wildlife species or its critical habitat. For example, when the analysis is based on the use of valued ecosystem components (VECs), all listed wildlife species found within the project area should be included as VECs. In addition, it is best practice to include, as VECs, other wildlife at risk found within the project area, such as species that are provincially listed but not listed under SARA.

The analysis should also consider those potential effects on habitat which may in turn adversely affect the species itself. Recovery strategies, action plans, management plans for species of special concern and status reports can all be helpful sources of information for the analysis. Even when critical habitat has not been identified, existing sources of information may assist in



identifying key habitat that, if adversely affected, may have repercussions on the species.

---

**SARA  
permitting  
analysis**

The SARA permitting analysis should, when possible, be coordinated with the environmental assessment analysis. The analysis should therefore address, among other considerations, the overall impact on the listed wildlife species in terms of its potential survival or recovery.

Certain activities may be authorized under SARA if a permit is issued. The activity must not only meet specified conditions as outlined in SARA but also not jeopardize the survival or recovery of the listed wildlife species.

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**Uncertainty in  
the analysis**

Where there is uncertainty regarding the likelihood or possible significance of adverse effects on wildlife species at risk, it is best practice to adopt a precautionary approach in the analysis, given their vulnerability.

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**Related  
guidance**

For related information, see also, in this guide, sections:

- [1.2 SARA Project Review Requirements](#)
- [2.12 SARA Permit Decision](#)
- [Precautionary approach](#)

Applicable status reports, recovery strategies, action plans and management plans for species of special concern may be able to provide direction to responsible authorities on the identification and analysis of potential effects on listed wildlife species.

Information on methods for assessing potential effects on species at risk is available in the *Environmental Assessment Best Practice Guide for Wildlife at Risk in Canada*.

---

**SARA  
references**

- Agreements and permits: section 73
  - Required action: subsection 79(2)
  - Amendment to “environmental effect”: section 137
- 

**CEAA  
references**

- Definition of environmental effect: subsection 2(1)
- Factors to be considered: subsection 16(1)

## 2.7 Consideration of Alternatives

### Avoiding adverse effects by considering alternatives

SARA requires mitigation of all adverse effects on listed wildlife species and their critical habitat, and the consideration of alternatives may provide the means of avoiding or minimizing adverse effects.

In addition, one of the pre-conditions to issuing permits under SARA is the consideration of alternatives. Accordingly, consideration of alternatives in an environmental assessment through a screening may be necessary in order to meet requirements under SARA when a permit or an agreement under the Act is necessary.

### Alternatives under CEAA

Under CEAA, there are two aspects to the consideration of alternatives: alternatives to the project and alternative means of carrying out the project.

**Alternatives to the project** are the functionally different ways to meet the project need and achieve the project purpose.

- For example, extending a bus route rather than widening a route to address traffic congestion.

**Alternative means of carrying out the project** are the various ways that the project or any of its activities or components can be implemented or carried out. The alternative means are to be technically and economically feasible, and the environmental assessment must consider the environmental effects of any such alternative means.

- For example, alternative locations, routes, and methods of development, implementation and mitigation.

### Table 4: Alternatives under CEAA

The consideration of alternatives is not always a requirement for environmental assessment under CEAA. The table below indicates when it is required under CEAA.

Consideration of...	in a screening is...	in a comprehensive study, mediation or an assessment by a review panel is...
alternatives to the project	at the discretion of the responsible authority	at the discretion of the Minister of the Environment, in consultation with the responsible authority
alternative means of carrying out the project	at the discretion of the responsible authority	mandatory

**Alternatives under SARA**

SARA establishes one obligation with respect to the consideration of alternatives. When a permit is requested under sections 73, 74 or 78, the permit can be issued only if the competent minister is of the opinion that “all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted.”

In addition, among other requirements, the competent minister must be of the opinion that all feasible measures will be taken to minimize the effect of the activity on the species, its critical habitat or residences of individuals of the species, and that the activity will not jeopardize the recovery or survival of the listed wildlife species.

Subsection 79(2) requires a responsible authority to identify measures to avoid or lessen the effects of a project on a listed wildlife species or its critical habitat. Fulfilling this obligation may require an examination of alternatives to the project or alternative means of carrying out the project. As such, the environmental assessment could consider alternative means or even alternatives to the project when there are adverse effects on a listed wildlife species or its critical habitat.

**Integrating SARA considerations into the environmental assessment**

A responsible authority conducting an environmental assessment of a project that has the potential to affect a listed wildlife species or its critical habitat should bear in mind the provisions of CEAA paragraphs 16(1)(e) and 16(2)(b) regarding the consideration of alternatives. The responsible authority should include consideration of the following in the assessment:

- alternatives to the project, or alternative means of undertaking the project, that would reduce the effect on the species; and
- a recommendation on the best solution to adopt.

Information on alternatives considered by the competent minister under the permitting process, and by the responsible authority in the environmental assessment process, should be shared to inform both processes, avoid duplication of effort and promote consistency.

**Related guidance**

For related information, see also, in this guide, sections:

- [2.9 Mitigation Measures](#)
- [2.11 Determination of Significance](#)
- [2.12 SARA Permit Decision](#)

Applicable recovery strategies, action plans or management plans for species of special concern may provide direction to responsible authorities on the consideration of alternatives.

For further guidance on addressing alternatives, please see the Canadian Environmental Assessment Agency's Operational Policy Statement: Addressing "Need for", "Purpose of", "Alternatives to", and "Alternative Means" under the *Canadian Environmental Assessment Act* at: [www.ceaa-acee.gc.ca/013/0002/addressing\\_e.htm](http://www.ceaa-acee.gc.ca/013/0002/addressing_e.htm)

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**SARA  
references**

- Agreements and permits: subsection 73(3)
  - Required action: subsection 79(2)
- 

**CEAA  
references**

- Factors to be considered: subsections 16(1) and 16(2)
-

## 2.8 Consideration of Cumulative Environmental Effects

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### **Importance of cumulative environmental effects**

Cumulative environmental effects are environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out.

The need to assess cumulative environmental effects stems from the very nature of species at risk. For the most part, such species have already been adversely affected by a combination of threats to the extent that their very survival is in question.

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### **Cumulative environmental effects under CEAA**

Under paragraph 16(1)(a) of CEAA, every environmental assessment must consider “the environmental effects of the project, including the environmental effects of malfunctions or accidents that may occur in connection with the project and any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out”.

Since the definition of “environmental effect” includes any change a project may cause to a listed wildlife species, its critical habitat or the residences of individuals of that species, it is important that cumulative environmental effects on listed wildlife species are considered in the environmental assessment process.

In addition, section 16.2 of CEAA recognizes the value of regional studies as a means of identifying possible future projects that may occur within a region and that may contribute to cumulative environmental effects. Regional studies could be an effective means of identifying and managing species at risk issues raised by multiple project proposals.

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### **Cumulative environmental effects under SARA**

SARA establishes no explicit obligations to address cumulative environmental effects on listed wildlife species. However, many listed wildlife species are at risk precisely because of cumulative environmental effects that have occurred in the past, such as gradual loss of habitat.

Thus, it is implicitly important in the cumulative environmental effects analysis that environmental assessments always consider the potential for cumulative environmental effects on listed wildlife species, the residences of their individuals and their critical habitat, in the context of the combined past threats the species have faced, as well as any additional present or future threats that can reasonably be expected to occur.

In addition, if an activity requires a permit under SARA, several requirements set out in section 73 of SARA must be met before the permit can be issued. In particular, a determination must be made as to whether the activity jeopardizes the survival or recovery of the species. Please refer to section 2.12 SARA Permit Decision.

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**A broad-scale approach**

The adoption of best practice approaches may include considering wildlife issues at broader planning levels, and avoiding the undertaking of projects in species at risk hotspots, thus contributing to the goals of preventing species from becoming at risk.

Regional studies may be valuable tools in this regard. Such studies may provide a venue for sharing information and effectively addressing cumulative environmental effects issues through a cooperative approach. Regional studies may also provide greater scope for mitigation after all project-specific impact avoidance and reduction opportunities have been exhausted. A proponent may address cumulative environmental effects by contributing to mitigation on a scale broader than the project study area (e.g., off-site issues within the species range).

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**Related guidance**

COSEWIC status reports provide information on threats facing species at risk. Recovery strategies, action plans and management plans for species of special concern also consider threats, as well as strategies and measures to deal with these threats, and they will also identify population and distribution objectives for the species. This information should assist in the evaluation of the cumulative environmental effects of projects. In the absence of such information, the assessment of cumulative environmental effects must be undertaken based on best available information. See the [Species at Risk Public Registry](#) for more information.

For related information, also refer to:

- Canadian Wildlife Service's *Environmental Assessment Best Practices Guide for Wildlife at Risk in Canada*.

For more information about cumulative environmental effects assessment, please refer to the Canadian Environmental Assessment Agency's:

- Operational Policy Statement: *Addressing Cumulative Environmental Effects under the Canadian Environmental Assessment Act* at: [www.ceaa-acee.gc.ca/013/0002/cea\\_ops\\_e.htm](http://www.ceaa-acee.gc.ca/013/0002/cea_ops_e.htm); and
  - *Cumulative Effects Assessment Practitioners Guide* at: [www.ceaa-acee.gc.ca/013/0001/0004/index\\_e.htm](http://www.ceaa-acee.gc.ca/013/0001/0004/index_e.htm)
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**SARA  
references**

- Recovery strategies and action plans: sections 41 and 49
  - Management plans: section 65
  - Agreements and permits: section 73
- 

**CEAA  
references**

- Factors to be considered: subsection 16(1)
-

## 2.9 Mitigation Measures

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### Obligations to mitigate

SARA establishes an obligation for responsible authorities to ensure that adverse effects on listed wildlife species or critical habitat are avoided or lessened if a project undergoing a federal environmental assessment is to be carried out. SARA also states that the mitigating measures must be taken in a way that is consistent with any applicable recovery strategy and action plans.

This confers additional obligations on the responsible authority, beyond the requirements of CEAA.

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### Mitigation under CEAA

Mitigation is defined in section 2 of CEAA to mean “in respect of a project, the elimination, reduction or control of the adverse environmental effects of the project, and includes restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means”.

Under subsection 16(1) of CEAA, every environmental assessment must include a consideration of the environmental effects of the project, of the significance of these effects, and of technically and economically feasible measures to mitigate any significant adverse environmental effects.

Under paragraphs 20(1.1)(b) and 37(2.1)(b) of CEAA, the responsible authority, when making decisions concerning proposed projects, may consider mitigation measures that the responsible authority can ensure will be implemented, and must ensure their implementation. The responsible authority can also consider mitigation measures that will be implemented by another person or body such as a provincial government. The responsible authority must be satisfied that those mitigation measures will be implemented by the other person or body.

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### Mitigation under SARA

Under subsection 79(2) of SARA, the responsible authority must ensure that measures are taken to avoid or lessen the adverse effects of the project on any listed wildlife species and its critical habitat and, if the project is carried out, must ensure that measures are taken to avoid or lessen those effects and to monitor them. These measures must be consistent with applicable species recovery strategies and action plans. It is best practice to ensure that measures taken to mitigate adverse effects on species of special concern be consistent with applicable management plans for those species.

SARA also establishes requirements that must be met before permits can be issued for activities that are otherwise prohibited. One of these requirements relates directly to mitigation measures: When a permit is requested under



sections 73, 74 or 78, the permit can be issued only if the competent minister is of the opinion that “all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals”.

A responsible authority could assist the competent minister in this regard by ensuring that commitments “to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals” are documented in the environmental assessment.

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**Preferred mitigation sequence**

SARA underscores the importance of mitigation. The preferred approach is to adopt measures that would avoid the adverse effect, followed however by measures that could minimize the impact.

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**Mitigation implemented by others**

SARA requires the responsible authority to ensure that mitigation measures are implemented for the adverse effects of the project on listed wildlife species or critical habitat.

In some cases the responsible authority may not have the regulatory tools to ensure the implementation of the mitigation measures. For example, in some cases species managed by a province may be affected and the provincial government may be in the best position to require mitigation through its legislation.

Subsections 20(1.1) and 37(2.1) of CEAA allow the responsible authority to consider such mitigation in the environmental assessment if the responsible authority is satisfied that the mitigation measures will be implemented.

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**Related guidance**

For related information, see also, in this guide, sections:

- [1.2 SARA Project Review Requirements](#)
- [2.12 SARA Permit Decision](#)

Applicable recovery strategies, action plans and management plans for species of special concern may provide direction to responsible authorities on mitigation.

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**SARA references**

- Agreements and permits: sections 73, 74 and 78
  - Required action: subsection 79(2)
-

**CEAA  
references**

- Factors to be considered: subsection 16(1)
- Mitigation measures: 20(1.1)–20(2.1) and 37(2)–(2.3)

## 2.10 Exemptions to the Release of Information

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### Sensitive information

Under certain circumstances, the release of information related to listed wildlife species could be harmful to the species.

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### Exempted information under CEAA

Under CEAA, all information related to the environmental assessment is publicly available, with a few exceptions, either in the Canadian Environmental Assessment Registry's Internet site or the project file.

The exceptions to public access relate to the withholding of certain information, including:

- documentation obtained in confidence from the government of a province or an institution, as per paragraph 13(1)(c) of the *Access to Information Act*;
- information related to the conduct of the Government of Canada relating to federal-provincial affairs, as per section 14 of the *Access to Information Act*;
- information relating to law enforcement and investigations, as per section 16 of the *Access to Information Act*;
- third party information as defined in section 20 of the *Access to Information Act*, such as, for example, trade secrets of a third party.

In addition, under section 35 of CEAA, a review panel may hold hearings *in-camera* and keep information confidential to prevent the release of information that might cause specific, direct and substantial harm to a witness or specific harm to the environment. In the latter case, for example, a review panel could withhold information that may be used by poachers to locate the residences of individuals of a listed wildlife species.

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### Exempted information under SARA

Under section 124 of SARA, the Minister of the Environment, on the advice of COSEWIC, may restrict the release of any information required to be included in the Species at Risk Public Registry if that information relates to the location of a wildlife species or its habitat and restricting its release would be in the best interests of the species.

For example, the precise location of a listed wildlife species, its residence or critical habitat could be withheld to prevent poachers from killing or stealing individuals of that species.

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**Integrating  
the SARA  
provision**

The responsible authority:

- should consider, at a very early stage of the environmental assessment, the potential for the environmental assessment to generate specific information that, if released, may be harmful to a listed wildlife species;
- should inform the federal environmental assessment coordinator and the appropriate competent department (i.e., Environment Canada, Parks Canada or Fisheries and Oceans Canada) of any such potential; and
- must take care not to make publicly available nor to include in the Canadian Environmental Assessment Registry any information that would not be disclosed under the *Access to Information Act*, including information that the Minister of the Environment has restricted under section 124 of SARA for the purposes of the Species at Risk Public Registry and that the responsible authority determines would not be disclosed to the public under the *Access to Information Act* (e.g., in technical studies or the environmental assessment report available through the Canadian Environmental Assessment Registry).

Environment Canada and/or Parks Canada should, as soon as possible upon receipt of a notification under subsection 79(1) of SARA, inform the responsible authority and expert federal authorities of any restrictions on the release of information under section 124 of SARA. If a project has been referred to a mediator or a review panel, then the competent department should notify the Canadian Environmental Assessment Agency of any such restrictions.

In a screening or comprehensive study, the responsible authority, in consultation with Environment Canada and/or Parks Canada, may need to consider approaches for providing information relevant to the technical studies and the environmental assessment report, without disclosing detailed, precise descriptions of locations that could pose a threat to the listed wildlife species. In the case of mediation or an assessment by a review panel, the Canadian Environmental Assessment Agency may need to work with Environment Canada and/or Parks Canada on the appropriate approach.

**SARA  
references**

- Public Registry restrictions: section 124

**CEAA  
references**

- Information to be made available: section 55.5

***Access to  
Information Act*  
references**

- Exemptions: paragraph 13(1)(c), sections 14, 16 and 20

## 2.11 Determination of Significance

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<b>Need for special attention</b>	The status of species at risk should be taken into consideration when determining the significance of adverse effects of a proposed project.
<b>Significance under CEAA</b>	<p>Under CEAA, the critical “test” in the environmental assessment decision is whether the project is likely to cause significant adverse environmental effects after taking into account the implementation of any mitigation measures that a responsible authority considers to be appropriate.</p> <p>The conclusion determines the next steps in the environmental assessment process (i.e., whether the responsible authority can provide federal support for the project).</p> <p>In addition, CEAA commits responsible authorities to “... exercise their powers in a manner that protects the environment and human health and applies the precautionary principle” (subsection 4(2)).</p>
<b>Significance with respect to species at risk</b>	SARA requires that the adverse effects of a project on listed wildlife species and their critical habitat be identified in a federal environmental assessment, and that, if the project is carried out, measures be taken to avoid or lessen such effects and to monitor them. SARA does not use the concept of significance, but provides principles that may assist in determining whether a project’s effects are significant under CEAA. These are outlined in the sections below.
<b>The purposes of SARA</b>	The purposes of SARA are to prevent wildlife species from being extirpated or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered and threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened.
<b>Survival and recovery of listed wildlife species</b>	SARA provides a framework for the survival and recovery of listed wildlife species. Such species have usually already been adversely affected by a combination of threats which cumulatively have resulted in their precarious status.

<b>Pre-conditions for issuing permits</b>	<p>SARA establishes requirements that must be met before activities that may affect listed extirpated, endangered and threatened species are authorized.</p> <p>This includes pre-conditions for issuing permits under sections 73, 74 or 78, to the effect that all adverse effects must be avoided or minimized wherever possible, and that residual effects must not jeopardize the survival or recovery of the species.</p>
<b>Objectives of recovery strategies</b>	<p>Recovery strategies for listed extirpated, endangered and threatened species must include a statement of the population and distribution objectives that will assist the recovery and survival of the species. These objectives should be considered when determining the significance of an adverse effect. Management plans for species of special concern will also provide relevant information for those species. In the absence of completed strategies or plans or of detailed population objectives, the responsible authority should use the best available information.</p>
<b>Protecting critical habitat and residences</b>	<p>Similarly, SARA has provisions to protect critical habitat and residences of individuals of listed wildlife species. Adverse effects on critical habitat and residences of individuals must also be considered in examining environmental impact.</p>
<b>SARA prohibitions</b>	<p>While certain activities are prohibited under SARA, some activities that are not prohibited may still have important adverse effects. For example, there are no prohibitions covering species of special concern; however, adverse effects on such species could exist (such as in certain cases there may be regional effects or the effect may cause the species to become threatened).</p> <p>Proponents should be aware of the permitting requirements of SARA. The following three conditions under which a permit may be issued are: 1) all reasonable alternatives to the activity to reduce the impact on the species have been considered and the best solution adopted; 2) all feasible measures will be taken to minimize the impact on the species or its critical habitat or the residences of its individuals; 3) the activity will not jeopardize the survival or recovery of the species.</p>
<b>Related guidance</b>	<p>For related information, see also, in this guide, section:</p> <ul style="list-style-type: none"> <li>• <a href="#">2.12 SARA Permit Decision</a></li> </ul>

Applicable recovery strategies, action plans and management plans for species of special concern (either posted on the Species at Risk Public Registry or published elsewhere) may provide direction to responsible authorities for the determination of environmental impact.

For information on the methodology of determining adverse effects on listed wildlife species, please see:

- *Environmental Assessment Best Practice Guide for Wildlife at Risk in Canada*
- *Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects* at:  
[www.ceaa.gc.ca/013/0001/0008/guide3\\_e.htm#Reference%20Guide](http://www.ceaa.gc.ca/013/0001/0008/guide3_e.htm#Reference%20Guide)

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**SARA  
references**

- Purposes: section 6
- Agreements and permits: sections 73, 74 and 78

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**CEAA  
references**

- Purposes: subsection 4(2)
  - Course of action decision: sections 20 and 37
-

## 2.12 SARA Permit Decision

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### **Prohibited activities**

A project undergoing a federal environmental assessment may involve an activity that is prohibited under SARA. In order to proceed, such a project will require a permit under SARA. The need to obtain a permit under SARA may give rise to additional considerations during the environmental assessment.

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### **Issuing permits under SARA**

Under sections 73, 74 and 78 of SARA, permits, agreements, licences, orders or other similar documents can be issued or made for activities that are otherwise prohibited, where:

- the activity is scientific research relating to the conservation of the species and conducted by qualified persons;
- the activity benefits the species or is required to enhance its chance of survival in the wild; or
- affecting the species is incidental to the carrying-out of the activity.

Three pre-conditions must be met before such permits can be issued or agreements made:

- all reasonable alternatives to the activity that would reduce the impact on the listed wildlife species have been considered and the best solution has been adopted;
- all feasible measures will be taken to minimize the impact of the activity on the listed wildlife species or its critical habitat or the residences of its individuals; and
- the activity will not jeopardize the survival or recovery of the listed wildlife species.

Permits may be issued for a period of up to three years, while agreements may be made for a maximum of five years. All permits or agreements must be accompanied by an explanation of why they were issued, and this explanation is to be posted in the Species at Risk Public Registry.

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**Prohibited activities vs. adverse effects**

There is no direct link between the SARA subsection 79(2) requirement to identify adverse effects on listed wildlife species and their critical habitat, and the prohibitions set out in the Act.

In other words, determining that an activity will lead to an adverse effect does not necessarily mean that the activity itself is prohibited. Prohibitions are set out in sections 32-36 and 58-61 of SARA and their applicability depends on a variety of circumstances. For information on the prohibitions, please refer to [Appendix D](#).

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**Exemptions to prohibitions under SARA**

In certain cases, activities are exempted from prohibitions where they are permitted by a recovery strategy, an action plan or a management plan for species of special concern and are authorized under an Act of Parliament (subsection 83(4) of SARA).

In such cases, a SARA permit would not be required; however, such activities would still need to be considered in the environmental assessment of a project where they are components and for which CEAA has been triggered.

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**Course of action decision under CEAA**

Following the environmental assessment conclusion regarding significance of environmental effects under CEAA, the responsible authority must make a decision regarding whether the project is likely to cause significant adverse effects and whether it can exercise any power, duty or function that would permit the project to proceed (e.g., to provide funding, lease land, issue a permit or grant a licence). This is called the responsible authority's course of action decision.

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**Coordinating the SARA permitting and environmental assessment decisions**

The SARA permitting decision and the environmental assessment process under CEAA address several similar issues. For example, an assessment under CEAA could consider alternatives and would identify mitigation measures to avoid or minimize adverse effects on the listed wildlife species, its residences or critical habitat. In considering environmental effects, the assessment would need to consider cumulative environmental effects and overall impacts on the survival or recovery of the listed wildlife species. Thus, the assessment would consider many, if not all, of the pre-conditions for permitting under SARA.

Steps taken to assure compliance with CEAA and SARA could be concurrent and mutually supportive. The environmental assessment could include a discussion on the proposed approach for compliance with SARA prohibitions, and if a permit is required, how permitting pre-conditions would be satisfied. That is, the CEAA and SARA compliance efforts could be aligned and made concurrent as much as reasonably possible.

At a minimum, there could be communication between the parties responsible for the two processes to ensure that information is shared, to avoid duplication of effort, and to ensure consistency between the two analyses.

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**Implications of a CEAA decision**

A decision under CEAA that permits a responsible authority to provide federal support for a project does not constitute an authorization to violate the SARA prohibitions which stand on their own and must still be respected. The environmental assessment can mention a proposed approach, but this cannot be substituted for an authorization by the competent minister under SARA.

In addition, the potential significance of an adverse environmental effect under CEAA is not necessarily an indication of whether an activity is prohibited under SARA, nor of whether the activity would meet the pre-conditions for a SARA permit.

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**Integrating the SARA permit and CEAA course of action decisions**

The need to directly integrate a SARA permit decision into a responsible authority's course of action decision will arise only in circumstances when a competent minister is acting under another Act of Parliament, pursuant to section 74 of SARA, to authorize activities that would otherwise be prohibited under SARA.

For example, this could occur when certain provisions of the *Fisheries Act* (Fisheries and Oceans Canada), the *Canada National Parks Act* (Parks Canada) or the *Migratory Birds Convention Act, 1994* (Environment Canada) are used to permit activities that would otherwise be prohibited under SARA.

The decision of a competent minister to permit activities affecting a listed wildlife species can be integrated with the responsible authority's course of action decision. Mitigation measures identified in the environmental assessment may be required to be added as terms or conditions to the SARA permit authorization to ensure that adverse effects are minimized, that the listed wildlife species are protected and also that any necessary mitigation measures required by CEAA are implemented.

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**Competent ministers as responsible authorities**

A competent minister can also be a responsible authority when it proposes a project as its proponent; grants money or other financial assistance to a proponent for the purpose of enabling a project to be carried out; sells, leases or otherwise disposes of land or any interest in land to enable a project to be carried out, or issues certain approvals as set out in the *Law List Regulations* under CEAA.

When the competent minister is a responsible authority, it cannot exercise any power, or perform any duty or function under any Act of Parliament that would allow the project to be carried out in whole or in part until an environmental assessment is conducted and a course of action decision has been made under CEAA that allows the project to go forward (see subsection 11(2) or paragraphs 20(1)(a) and 37(1)(a) of CEAA). Thus, when the responsible authority is also the competent minister, the environmental assessment must be completed before a permit under SARA (or under other legislation) can be issued.

**Note:** If a competent minister is a responsible authority and, as a result of the environmental assessment, will authorize a project to proceed as per sections 73 or 74 of the SARA which will affect a listed wildlife species as per the SARA prohibitions, an explanation must be posted in the Species at Risk Public Registry, as per subsection 73(3.1).

**Proponent compliance with SARA**

Regardless of whether a project is likely to result in significant adverse environmental effects under CEAA, the proponent must still comply with the requirements under SARA, such as applying for permits or avoiding actions that would constitute an offence under SARA.

That is, the proponent's obligations may differ from the responsible authority's and extend beyond completion of the environmental assessment.

**Related guidance**

For related information, see also, in this guide, sections:

- [2.1 Initial Considerations](#)
- [2.11 Determination of Significance](#)

For additional information, also refer to the SARA Permitting Policy posted on the [Species at Risk Public Registry](#).

**SARA references**

- Agreements and permits: sections 73–74
- Exemptions for permitted activities: subsection 83(4)

**CEAA  
references**

- Timing of assessment: subsection 11(2)
- Course of action decision: sections 20 and 37
- *Law List Regulations*

## 2.13 Monitoring and Follow-up Programs

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### **Obligations to monitor under SARA**

SARA establishes obligations to ensure that measures are taken to monitor the adverse effects of a project on listed wildlife species and their critical habitat after the environmental assessment decision has been taken.

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### **Effects monitoring under SARA**

Under subsection 79(2) of SARA, a responsible authority is required to ensure that measures are taken to monitor the adverse effects of the project on listed wildlife species and their critical habitat. This is required regardless of the significance of those adverse effects, and is required for all listed wildlife species.

Measures taken to monitor the adverse effects must be consistent with any applicable recovery strategy or action plan. In addition, it is best practice to ensure that measures taken to monitor adverse effects on species of special concern be consistent with relevant management plans for those species.

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### **Follow-up under CEAA**

Follow-up programs are recognized as an important tool for ensuring accountability in the environmental assessment process and for improving the quality of future environmental assessments. The results of a follow-up program can also be used for implementing adaptive management measures.

Following a decision to enable a project to be carried out under CEAA, a responsible authority must ensure implementation of all mitigation measures that it considers appropriate. In addition to this mitigation monitoring, a follow-up program may be undertaken to:

- verify the accuracy of the environmental assessment; and
- determine the effectiveness of any measures taken to mitigate the adverse environmental effects of the project.

Under CEAA, the need for a follow-up program in a screening is at the discretion of a responsible authority; however, a follow-up program is mandatory for a comprehensive study, an assessment by a review panel or mediation. Where a follow-up program is deemed to be required, the responsible authority ensures its implementation.

When a follow-up program under CEAA is initiated, the responsible authority has certain obligations in terms of informing the public and maintaining records on the Canadian Environmental Assessment Registry.

These obligations are not triggered by the subsection 79(2) monitoring requirement.

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**SARA  
monitoring  
and CEAA  
follow-up**

The SARA monitoring obligation is independent and distinct from any CEAA follow-up program responsibilities. That is, even if a follow-up program is not undertaken under CEAA, a responsible authority must ensure that SARA monitoring is implemented if the project is carried out and there are potential adverse effects on a listed wildlife species or its critical habitat.

Undertaking monitoring as a result of the obligation under SARA does not necessarily constitute a follow-up program under CEAA; however, it is good practice to integrate the two requirements wherever possible.

For example, integrating the two programs would make sense if a follow-up program is deemed necessary under CEAA, and the objectives of the SARA monitoring are identical to the objectives of the follow-up program with regards to species at risk. In some cases, the need to monitor the project's effects on a listed wildlife species may constitute sufficient justification for a follow-up program under CEAA.

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**Developing a  
monitoring  
plan**

If potential adverse effects on a listed wildlife species or its critical habitat are identified in an environmental assessment, to best comply with the SARA requirement for ensuring monitoring, it is best practice for the responsible authority to identify the objectives, scope, timelines and responsibilities for carrying out the monitoring activity. Where possible, this should be done in the early planning stages of the environmental assessment and may be described directly in the environmental assessment report or as part of a monitoring plan linked to the environmental assessment.

The monitoring plan should also identify the circumstances under which corrective measures may be needed to address any issue or problem identified through the monitoring, for example, if unanticipated effects occur or the importance of the effects is greater than anticipated.

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**Results of monitoring and follow-up**

Results of the monitoring under SARA should be provided to the competent minister(s).

It is best practice to include monitoring reports on the Canadian Environmental Assessment Registry and project file, even if they are not part of a CEAA follow-up program; however, confidentiality of information may need to be considered.

If the mitigation measures are found not to be effective and listed wildlife species are being adversely affected, then [adaptive management measures](#) under CEAA or under other legislation may be required. In some cases, these adaptive management measures may be considered conditions for the project approval.

**Related guidance**

For related information, see also, in this guide, sections:

- [1.2 SARA Project Review Requirements](#)
- [2.9 Mitigation Measures](#)
- [2.14 Adaptive Management](#)

Applicable recovery strategies, action plans and management plans for species of special concern may provide direction to responsible authorities on issues related to monitoring and follow-up programs.

For more information, please refer to the Canadian Environmental Assessment Agency's Operational Policy Statement entitled *Follow-up Programs under the Canadian Environmental Assessment Act* at: [www.ceaa.gc.ca/013/0002/followup\\_e.htm](http://www.ceaa.gc.ca/013/0002/followup_e.htm)

**SARA references**

- Required action: subsection 79(2)

**CEAA references**

- Mitigation measures: subsection 20(2)
- Follow-up programs: subsections 38(1)–(5)

## 2.14 Adaptive Management

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### Linking monitoring and adaptive management

The requirement for ensuring that measures are taken to monitor adverse effects on listed wildlife species and their critical habitat creates an opportunity to consider adaptive management measures.

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### What is adaptive management?

Unanticipated adverse environmental effects may arise during the life of a project calling for adaptive management. Adaptive management measures:

- involve the implementation of new or modified mitigation measures over the life of a project to address unanticipated environmental effects; and
- allow for the adoption of improved mitigation measures (e.g., due to technological advances) over the life of a project.

In other words, adaptive management measures are actions taken on the basis of new information, typically gathered from monitoring activities in a follow-up program, to avoid, reduce or compensate for the environmental effect of a project once a project is underway or completed.

Adaptive management may also involve the purposeful testing of alternative impact hypotheses and mitigation measures. For example, given uncertainty regarding the effectiveness of different mitigation measures, several such measures could be applied simultaneously to different portions of the affected [valued ecosystem component](#) to determine the best approach.

---

### Adaptive management under CEEA

The value of adaptive management is recognized in CEEA under subsection 38(5), which states that the results of follow-up programs may be used for implementing adaptive management measures or for improving the quality of future environmental assessments.

---

### Adaptive management under SARA

SARA establishes no specific obligations with respect to considering adaptive management measures; however, responsible authorities and project proponents may need to consider applying adaptive management measures to mitigate adverse effects on listed wildlife species.

Adaptive management is recognized as an important tool for mitigating effects on listed wildlife species and critical habitat that are identified during project implementation.



The environmental assessment report, for example, could note any potential need for adaptive management measures with respect to listed wildlife species or critical habitat that may be identified through the effects monitoring activity.

---

**Adaptive management as a compliance tool**

Notwithstanding the environmental assessment, a proponent will still have a legal responsibility to comply with SARA, and adaptive management can be a tool to help ensure that listed wildlife species, their critical habitat and residences of individuals of the species are not adversely affected.

In addition, adaptive management may be a means of ensuring that implementation of a project does not adversely affect new species that may be listed, or that measures advanced in new recovery strategies, action plans or management plans for species of special concern can be adopted when appropriate.

In the event that adaptive management is not appropriate or possible, or does not result in sufficient protection, provisions under section 80 of SARA allow for an emergency order to protect a listed wildlife species that is facing imminent threats to its survival or recovery.

---

**Related guidance**

Applicable recovery strategies, action plans and management plans for species of special concern may provide direction to responsible authorities on the issues related to adaptive management.

For more information, please refer to the Canadian Environmental Assessment Agency's Operational Policy Statements entitled *Adaptive Management Measures under the Canadian Environmental Assessment Act* at:  
[www.ceaa.gc.ca/default.asp?lang=En&n=50139251-1](http://www.ceaa.gc.ca/default.asp?lang=En&n=50139251-1)

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**SARA references**

- Emergency order: section 80

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**CEAA references**

- Adaptive management: subsection 38(5)
-

## Appendices: Background to the *Species at Risk Act*

### Overview

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**Purpose of appendices**

The appendices provide additional SARA background information of particular relevance to an environmental assessment practitioner. The appendices include an overview of SARA, definitions, responsibilities, key instruments, information sources and a template for notification.

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**Contents**

The appendices contain the following topics:

<b>Topic</b>	<b>Page</b>
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## Appendix A: Introduction to SARA

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### Purposes of SARA

The purposes of SARA are to:

- prevent wildlife species from being extirpated or becoming extinct;
  - provide for the recovery of wildlife species that are extirpated, endangered, or threatened as a result of human activity; and
  - manage species of special concern to prevent them from becoming endangered or threatened.
- 

### Scope of SARA

SARA applies to all extirpated, endangered or threatened species, and species of special concern that are listed on the List of Wildlife Species at Risk set out in Schedule 1 of SARA.

A number of provisions in SARA apply specifically to:

- all listed wildlife species on all federal lands in Canada (e.g., national parks and reserve lands);
- all listed aquatic species (a fish or a marine plant as defined in the *Fisheries Act*, including fish, shellfish, crustaceans, marine animals, algae and phytoplankton) whether on federal lands or not; and
- all listed migratory birds protected by the *Migratory Birds Convention Act, 1994* whether on federal lands or not.

SARA received Royal Assent in 2002, implemented in stages, and came into full force in 2004. When SARA received Royal Assent in 2002, there were 233 Wildlife Species at Risk listed in Schedule 1. Since that time an additional 192 species were added to the list. Schedule 1 now lists 425 species.

In addition, of the 117 species designated at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) prior to October 1999, all but 17 have been reassessed and added to the list in Schedule 1.

SARA sets out a process to add a species to the List of Wildlife Species at Risk or change its status on the List. The List, which will be updated regularly, can be viewed on the Species at Risk Public Registry.

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### Key features of SARA

The following are the key features of SARA.

- Strongly promotes the role of stewardship and voluntary measures in protecting species at risk.

- Promotes a cooperative approach among federal, provincial and territorial governments to protecting species at risk.
  - Establishes a process for legally listing wildlife species as extirpated, endangered, threatened or special concern, recognizing the role of COSEWIC in assessing and identifying species at risk.
  - Establishes a list of species at risk (Schedule 1).
  - Establishes a National Aboriginal Council on Species at Risk.
  - Provides legal protection for individuals of species, residences of individuals or critical habitats when those species are listed as extirpated, endangered or threatened.
  - Establishes a framework for the recovery of species listed as extirpated, endangered or threatened through the development of recovery strategies and action plans.
  - Establishes a framework for the management of species of special concern, through the development of management plans for those species, to prevent them from becoming further at risk and to promote their recovery.
  - Provides for the protection of critical habitat through a series of measures which may include prohibitions.
  - Creates a public registry to assist in making documents under the Act more accessible to the public and for consulting the public on them.
-

## Appendix B: SARA Definitions

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<b>Definitions in SARA</b>	The following sections provide definitions of some of the key terms from subsection 2(1) of SARA.
<b><i>Aquatic species</i></b>	A wildlife species that is a fish, as defined in section 2 of the <i>Fisheries Act</i> or a marine plant, as defined in section 47 of that Act.
<b><i>Competent Minister</i></b> <i>or</i> <b><i>Competent Department</i></b>	Throughout the guide, the terms “competent ministers” or “competent departments” are used to refer to the ministers or departments responsible for SARA: <ul style="list-style-type: none"> <li>(a) the Minister responsible for Parks Canada with respect to individuals in or on federal lands administered by that Agency. Since December 12, 2003, the Minister of the Environment has been designated as the Minister responsible for Parks Canada.</li> <li>(b) the Minister of Fisheries and Oceans with respect to aquatic species, other than individuals mentioned in paragraph (a); and</li> <li>(c) the Minister of the Environment with respect to all other individuals.</li> </ul>
<b>COSEWIC</b>	The Committee on the Status of Endangered Wildlife in Canada established by section 14 of SARA.
<b><i>Critical habitat</i></b>	Habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in the recovery strategy or in an action plan for the species.
<b><i>Endangered species</i></b>	A wildlife species that is facing imminent extirpation or extinction.
<b><i>Extirpated species</i></b>	A wildlife species that no longer exists in the wild in Canada, but exists elsewhere in the wild.

<b><i>Federal land</i></b>	<p>(a) land that belongs to Her Majesty in right of Canada, or that Her Majesty in right of Canada has the power to dispose of, and all waters on and airspace above that land;</p> <p>(b) the internal waters of Canada and the territorial sea of Canada; and</p> <p>(c) reserves and any other lands that are set apart for the use and benefit of a band under the <i>Indian Act</i>, and all waters on and airspace above those reserves and lands.</p>
<b><i>Habitat</i></b>	<p>(a) in respect of aquatic species, spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced; and</p> <p>(b) in respect of other wildlife species, the area or type of site where an individual or wildlife species naturally occurs or depends on directly or indirectly in order to carry out its life processes or formerly occurred and has the potential to be reintroduced.</p>
<b><i>Individual</i></b>	An individual of a wildlife species, whether living or dead, at any developmental stage and includes larvae, embryos, eggs, sperm, seeds, pollen, spores and asexual propagules.
<b><i>List</i></b>	Means the List of Wildlife Species at Risk set out in Schedule 1 of SARA.
<b><i>Listed</i></b>	Means listed on the List.
<b><i>Precautionary approach</i></b>	Consistent with SARA, if there are threats of serious or irreversible harm to a listed wildlife species, cost-effective measures to prevent the reduction or loss of a species will not be postponed for lack of full scientific certainty.
<b><i>Residence</i></b>	A dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating.
<b><i>Species at risk</i></b>	An extirpated, endangered or threatened species or a species of special concern.

---

<b><i>Species of special concern</i></b>	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
<b><i>Threatened species</i></b>	A wildlife species that is likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction.
<b><i>Wildlife species</i></b>	A species, subspecies, variety or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and <ul style="list-style-type: none"><li>(a) is native to Canada; or</li><li>(b) has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.</li></ul>

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## Appendix C: Summary of Responsibilities Under SARA

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**Responsibilities of key parties** The following sections summarize some of the major responsibilities of key parties under SARA:

---

***Minister of the Environment – Environment Canada***

- Overall administration of SARA.
  - Protection of all listed wildlife species, other than aquatic species, that occur anywhere in Canada other than on federal lands administered by Parks Canada.
  - Development of recovery strategies and action plans (for extirpated, threatened or endangered species) and management plans (for species of special concern) for all listed wildlife species, other than aquatic species, that occur anywhere in Canada other than on federal lands administered by Parks Canada.
  - Implementation of conservation and protection measures under SARA for listed wildlife species under the responsibility of Environment Canada, other than those in or on federal lands administered by Parks Canada.
- 

***Minister of the Environment – Parks Canada***

- Protection of all listed wildlife species in or on federal lands administered by Parks Canada.
  - Development of recovery strategies and action plans (for extirpated, threatened or endangered species) and management plans (for species of special concern) for aquatic and terrestrial listed wildlife species in or on federal lands administered by Parks Canada.
  - Implementation of conservation and protection measures under SARA for listed wildlife species in or on federal lands administered by Parks Canada.
- 

***Minister of Fisheries and Oceans – Fisheries and Oceans Canada***

- Protection of listed aquatic species that occur anywhere in Canada other than in or on federal lands administered by Parks Canada.
- Development of recovery strategies and action plans (for extirpated, threatened or endangered species) and management plans (for species of special concern) for all listed aquatic species other than aquatic species in or on federal lands administered by Parks Canada.
- Implementation of conservation and protection measures under SARA for listed aquatic species under the responsibility of the Minister of Fisheries and Oceans, other than those that occur in or on federal lands administered by Parks Canada.



***Canadian  
Endangered  
Species  
Conservation  
Council  
(CESCC)***

Members include: the Minister of the Environment, the Minister of Fisheries and Oceans, and ministers of the provincial and territorial governments responsible for the conservation and management of a wildlife species in the province or territory.

Responsibilities include:

- general direction on the activities of COSEWIC, the preparation of recovery strategies, and the preparation and implementation of action plans; and
- coordination of the activities of the various governments represented on the Council relating to the protection of a species at risk.

***Committee on  
the Status of  
Endangered  
Wildlife in  
Canada  
(COSEWIC)***

Members include: qualified wildlife experts drawn from the federal, provincial and territorial governments, wildlife management boards, Aboriginal groups, universities, national non-governmental organizations, museums, and others.

Responsibilities include:

- assessment and classification of the status of wildlife species using the best available information on the biological status of a species, including scientific knowledge, community knowledge and Aboriginal traditional knowledge; and
- provision of advice to the Minister and the CESCC.

***National  
Aboriginal  
Council on  
Species at Risk  
(NACOSAR)***

Members include: six representatives of the Aboriginal peoples of Canada selected by the Minister of the Environment based upon recommendations from Aboriginal organizations.

Responsibilities include:

- advising the Minister of the Environment on the administration of SARA; and
- provision of advice and recommendations to the CESCC.

## Appendix D: Key SARA Instruments

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### Summary of key instruments

The following sections summarize the key instruments that can be used to help achieve SARA's objectives.

**Note:** In the following sections, the numbers in parentheses reference the relevant provisions of SARA.

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### *Stewardship action plan (10.1–10.2)*

A stewardship action plan may be established to create incentives and other measures to support voluntary stewardship actions.

---

### *Conservation and contribution agreements (11–13)*

SARA provides competent ministers the authority to enter into conservation agreements and contribution agreements with any government in Canada, organization or person. A conservation agreement may benefit a species at risk or enhance its survival in the wild. A contribution agreement may support the conservation of wildlife species.

---

### *COSEWIC and the listing process (14–31)*

SARA creates a framework whereby:

- COSEWIC independently assesses the status of wildlife species;
  - government responds to COSEWIC assessment;
  - a process is established to add or remove species from Schedule 1; and
  - a List of Wildlife Species at Risk is set out in Schedule 1.
- 

### *General prohibitions (individuals and residences) (32–36)*

These provisions make it an offence:

1. to kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species;
2. to possess, collect, sell, buy or trade an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species, or any part or derivative of such an individual; and
3. to damage or destroy the residence of one or more individuals of a wildlife species that is listed as an endangered species or a threatened species, or that is listed as an extirpated species if a recovery strategy has recommended the reintroduction of that species into the wild in Canada.

These prohibitions apply without an order from the Governor in Council:

- on federal land, except in the territories;

- on land in the territories under the authority of the Minister of the Environment or Parks Canada;
- to listed extirpated, endangered or threatened migratory birds species that are protected by the *Migratory Birds Convention Act, 1994* wherever they are found; or
- to listed extirpated, endangered or threatened aquatic species wherever they are found.

The expression “federal land” under SARA means:

- land that belongs to Her Majesty in right of Canada, or that Her Majesty in right of Canada has the power to dispose of, and all waters on and airspace above that land;
- the internal waters of Canada and the territorial sea of Canada; and
- reserves and any other lands that are set apart for the use and benefit of a band under the *Indian Act*, and all waters on and airspace above those reserves and lands.

These prohibitions also can be applied, by order of the Governor in Council on the recommendation of the Minister of the Environment, following consultations with relevant provinces and territories as set out in SARA and public consultations as required by the Government of Canada regulatory policy:

- to a species that is not listed under SARA but that has been classified as threatened or endangered by a provincial or territorial minister, and that is found on federal land; or
- to a species on provincial or territorial land, where the laws of the province or territory do not effectively protect the species or the residence of its individuals (known as the “safety net” provision).

---

***Recovery strategies (37–46)***

The competent minister must prepare recovery strategies for listed endangered, extirpated and threatened species. A recovery strategy will, among other things:

- describe the species and its needs;
  - include a statement of the population and distribution objectives for the species;
  - identify threats to the survival of a species and its habitat, and outline a broad strategy to respond to those threats; and
  - identify the species’ critical habitat to the extent possible, based on best available information.
-

**Action plans  
(47–55)**

Action plans support the implementation of recovery strategies and will, among other things, include:

- a statement of measures to implement the recovery strategy, including those that address the threats to the species and those that help to achieve population and distribution objectives;
  - an identification of a species' critical habitat and examples of activities that could destroy the critical habitat;
  - a statement of measures proposed to protect the species' critical habitat; and
  - methods to monitor the recovery of the species and its long-term viability.
- 

**Protection of  
critical habitat  
(56–64)**

Critical habitat is identified in recovery strategies or action plans. Critical habitat will then be protected through a range of mechanisms that could include provisions in or mechanisms under SARA including agreements under s. 11 of SARA, other Acts of Parliaments or provincial or territorial legislation.

Where a critical habitat prohibition applies, SARA makes it an offence to destroy any part of the critical habitat of a species listed under SARA as extirpated (if a recovery strategy has recommended its reintroduction into the wild in Canada), endangered or threatened.

For critical habitat in a national park of Canada named and described in Schedule 1 of the *Canada National Parks Act*, a marine protected area under the *Oceans Act*, a migratory bird sanctuary under the *Migratory Birds Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* the prohibition applies 90 days after a description of the critical habitat is published in the *Canada Gazette* (such publication occurs 90 days after the critical habitat is identified in a recovery strategy or action plan).

For critical habitat of listed aquatic species located elsewhere, and for all critical habitat located on other federal lands, in the exclusive economic zone of Canada or on the continental shelf of Canada, the prohibition applies by way of an order from the competent minister. Otherwise, for the critical habitat prohibition to apply on lands that are not federal land, in the exclusive economic zone of Canada or on the continental shelf of Canada, an order from the Governor in Council upon the recommendation of the competent minister is required.

---

**Management  
plans (65–72)**

Management plans are developed for species of special concern, and will, among other things, set out measures for the conservation of a species and its habitat.

***Agreements and permits or other documents (73–78)***

Sections 73 to 78 of SARA allow agreements, permits, licences, orders or other similar documents to be issued or entered into for the following types of activities:

- the activity is scientific research relating to the conservation of the species and conducted by qualified persons;
- the activity benefits the species or is required to enhance its chance of survival in the wild; or
- affecting the species is incidental to the carrying-out of the activity.

Permits and agreements are subject to several requirements, including the following pre-conditions:

- all reasonable alternatives to the activity that would reduce the impact on the listed wildlife species have been considered and the best solution has been adopted;
- all feasible measures will be taken to minimize impact of the activity on the species, or its critical habitat or the residences of its individuals; and
- the activity will not jeopardize the survival or recovery of the listed wildlife species.

***Project review (79)***

A responsible authority must notify the competent minister(s) if the project is likely to affect a listed wildlife species or its critical habitat.

When a federal environmental assessment is required under an Act of Parliament, the person responsible for ensuring that assessment is conducted must identify the adverse effects of the project being assessed on the listed wildlife species and its critical habitat.

If the project is carried out, the responsible authority must ensure that measures are taken to avoid or lessen those effects and to monitor them. The measures must be taken in a way that is consistent with any applicable recovery strategy and action plans.

***Emergency orders (80–82)***

Emergency orders provide authority for the federal government to take emergency action to protect a listed wildlife species or the habitat that is necessary for the survival or recovery of the species, when the competent minister believes that a listed wildlife species is facing imminent threats to its survival or recovery.

***Exceptions (83)*** Several exceptions to the prohibitions and emergency orders are provided for in the Act, including exceptions for:

- activities related to public safety, health or national security that are authorized by or under any other Act of Parliament;
  - activities authorized under sections 73, 74 or 78 by an agreement, permit, licence, order or similar document;
  - a person who is engaging in activities in accordance with conservation measures for wildlife species under a land claims agreement; and
  - a person who is engaging in activities that are permitted by a recovery strategy, action plan or management plan and who is also authorized under an Act of Parliament to engage in that activity.
- 

***Enforcement (85–119)***

Sections 85 to 119 of SARA address a range of enforcement issues, including:

- public applications for investigation (sections 93–96);
  - offences and punishments (sections 97–107); and
  - alternative measures (sections 108–119).
-

## Appendix E: SARA Notification Template

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INSERT ADDRESS OF SENDER

INSERT DATE

INSERT ADDRESS OF RECIPIENT

Dear Mr./Ms.:

**RE:** Notification pursuant to the requirements of subsection 79(1) of the *Species at Risk Act*

Please be advised that (*name of competent department*), as responsible authority for the environmental assessment for (*name of project*), has determined that this proposed project is likely to affect the following listed wildlife species or its critical habitat: (*name of species and/or critical habitat*). This determination is based on information from (*information source, e.g., NatureServe Canada, sightings, recent surveys*).

The (*name of project*), located at (*location information*), is proposed to involve (*brief description of proposed project*). The nature of the potential effect is (*potential effect on species or its critical habitat*). At this point, the following mitigation measures and alternatives are being considered (*mitigation and/or alternative means of carrying out the project, if known*).

The proposed project is subject to a (*type of environmental assessment*) under the (*applicable legislation*). Additional information about the environmental assessment is available through the (*location, e.g., Canadian Environmental Assessment Registry*) at (*reference number*).

Additional information (*e.g., location data for species or critical habitat, or any known residences of individuals of those species*) is attached.

Please note that we are (*aware of / not aware of*) a need for confidentiality regarding the location data for the species.

If you have any questions, please feel free to call the contact for this environmental assessment: (*name of contact, address, email and telephone number*).

Sincerely,

*Department Representative (Signature of all responsible authorities if applicable)*

---

# TAB G





# POPULATION

As of January 11, 2019 the SRKW population totals 75 whales:  
J Pod=22, K Pod=18, L Pod=35



Photo: K14, K42 and K26 - Sept. 17, 2009

## Southern Resident Killer Whale POPULATION

The Southern Resident killer whales (also called orcas/Orcinus orca) are a large extended family, or clan, comprised of three pods: J, K, and L pods. Within each pod, families form into sub-pods centered around older females, usually grandmothers or great-grandmothers. Both male and female offspring remain in close association with their mothers for life.

Each Southern Resident pod uses a distinctive dialect of calls (sounds) to communicate. Certain calls are shared between all three pods. The calls used by the Southern Resident community are unlike the calls used by any other community of killer whales. These calls can travel ten miles or more underwater.

From spring through fall, the Southern Resident killer whales are most often seen in the protected inshore waters of the Salish Sea. The Salish Sea includes the Strait of Juan de Fuca, Strait of Georgia, and Puget Sound, and all their connecting channels and adjoining waters, and the waters around and between the San Juan Islands in Washington State and the Gulf Islands in British Columbia.

**As of July 1, 2018, the SRKW population totals 75 whales:  
J Pod=23, K Pod=18, L Pod=34.**

The size of all three Southern Resident pods was reduced in number from 1965-75 as a result of whale captures for marine park exhibition. At least 13 whales were killed during these captures, while 45 whales were delivered to marine parks around the world. Today, only Lolita (Tokitae) remains alive in captivity at the Miami Seaquarium. Annual SRKW population updates occur on July 1 and December 31 each year.

\* The SRKW population totals cited in this website are for the general public and are provided as estimates. The number of whales in this population is constantly changing. Please contact the Center for Whale Research directly to receive the most current information, prior to any publication of this population estimate. The information on this page is updated on July 1 and December 31 each year. Any published or broadcast reference to this population estimate must include credit to the CWR.



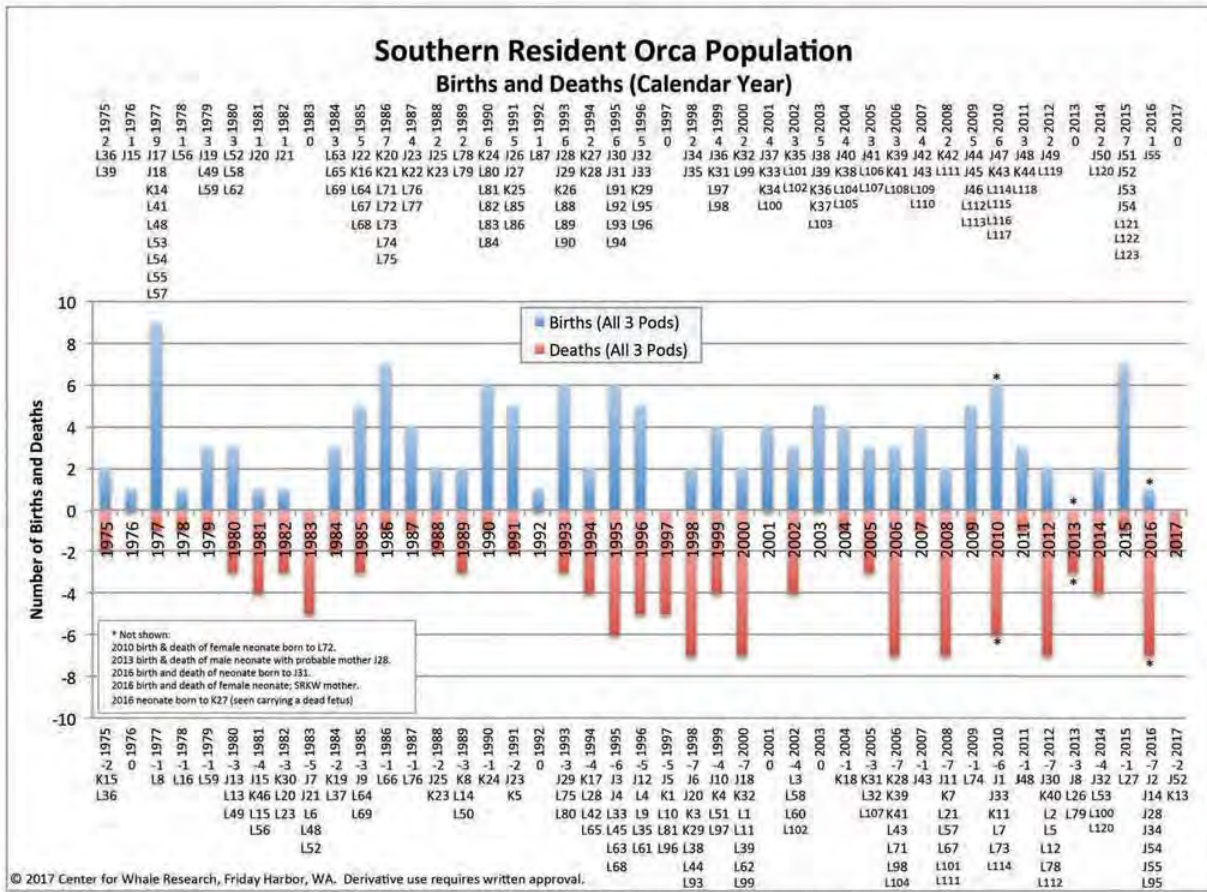
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- Recent ENCOUNTERS
- Outreach & Education

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# TAB H



11/14/17

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 J. Cogan for Center for Whale Research. DFO Workshop Nov. 15-17, 2017

# TAB I



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Photo from June 25, 2017 by Robyn Cartwright. Left to right: J16 Slick (mother), J50 Scarlet (at 2 1/2 years old), J26 Mike (big brother), and J42 Echo (older sister).



[Saving Luna DVD](#)

### Southern Resident Orca Community Demographics, Composition of Pods, Births and Deaths since 1998

Updated January 11, 2019

All data provided by the [Center for Whale Research](#), San Juan Island.

As of January 11, 2019, the Southern Resident Killer Whale (Orca) population was comprised of **74** individuals ( **76** including Lolita/Tokitae, the L pod orca confined at the Miami Seaquarium). **J pod has 22** members; **K pod has 18**; and **L pod has 35**, including (approximately):

- J pod: 9 Adult females with three reproducing - 3 young females; 7 young males.
- K pod: 6 Adult females, all non-reproducing except K27 - 1 young female; 7 young males.
- L pod: 6 of 11 Adult females non-reproducing - 4 young females; 10 young males.

Go here for [Complete list and photos of babies born since 2001](#)

And here for The Whale Museum's [Adoption names and stories for each whale](#).

Donate to Orca Network

[Please click HERE to help](#)

Supporters

Gary E. Milgard Family Foundation

J pod		
ID	M/F	DOB
J16	F	1972*
J17	F	1977
J19	F	1979
J22	F	1985
J26	M	1991
J27	M	1991
J31	F	1995
J35	F	1998
J36	F	1999
J37	F	2001
J38	M	2003
J39	M	2003
J40	F	2004
J41	F	2005
J42	F	2007
J44	M	2009
J45	M	2009
J46	F	2009
J47	M	2010

K pod		
ID	M/F	DOB
K12	F	1972*
K14	F	1977
K16	F	1985
K20	F	1986
K21	M	1986
K22	F	1987
K25	M	1991
K26	M	1993
K27	F	1994
K33	M	2001
K34	M	2001
K35	M	2002
K36	F	2003
K37	M	2004
K38	M	2004
K42	M	2008
K43	F	2010
K44	M	2011

L pod (1)		
ID	M/F	DOB
L22	F	1971*
L25	F	1928*
L41	M	1977
L47	F	1974
L54	F	1977
L55	F	1977
L72	F	1986
L77	F	1987
L82	F	1990
L83	F	1990
L84	M	1990
L85	M	1991
L86	F	1991
L87	M	1992
L88	M	1993
L89	M	1993
L90	F	1993
L91	F	1995

L pod (2)		
ID	M/F	DOB
L94	F	1995
L103	F	2003
L105	M	2004
L106	M	2005
L108	M	2006
L109	M	2007
L110	M	2007
L113	F	2009
L115	M	2010
L116	M	2010
L117	M	2010
L118	F	2011
L119	F	2012
L121	M	2015
L122	M	2015
L123	M	2015
L124	U	2019



J49	M	2012
J51	M	2015
J53	F	2015

Dates of births marked with an asterisk (\*) are estimated based on actuarial tables of mortality rates combined with observed association patterns to determine family relationships, from [Life history and population dynamics of resident killer whales \(\*Orcinus orca\*\) in the coastal waters of British Columbia and Washington State](#), Olesiuk, P.F., M.A. Bigg and G.M. Ellis (Dept. of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C., Canada V9R 5K6) (1990). *In*: P.S. Hammond, S.A. Mizroch and G.P. Donovan (eds.): Individual recognition of cetaceans: Use of photo-identification and other techniques to estimate population parameters. Special Report #12, International Whaling Commission, Cambridge, p. 209-243.

Since 1998, 41 orcas have been born and survived:

- L124 (Unnamed) Unknown gender, born to L77 (Matia), her third calf, January, 2019
- L123 (Lazuli) Male born to L103 (Lapis), her first calf, November, 2015
- J53 (Kiki) Female born to J17 (Princess Angeline), her fourth calf, October, 2015
- L122 (Magic) Male born to L91 (Muncher), her first calf, September, 2015
- L121 (Windsong) Male born to L94 (Calypso), her second calf, February, 2015
  
- J51 (Nova) Male born to J41 (Eclipse), her first calf, February, 2015
- J49 (Tilem l'nges) Male born to J37 (Hy'shqa), her first calf, August, 2012
- L119 (Joy) Female born to L77 (Matia), her first calf, May, 2012
- K44 (Ripple) Male born to K27 (Deadhead), her first calf, July, 2011
- L118 (Jade) Female born to L55 (Nugget), her fourth calf, January, 2011
  
- L117 (Keta) Male born to L54 (Ino), her second calf, December, 2010
- L116 (Finn) Male born to L82 (Kasatka), her first calf, October, 2010
- L115 (Mystic) Male born to L47 (Marina), her third calf, August, 2010
- K43 (Saturna) Female born to K12 (Sequim), her third calf, February, 2010
- J47 (Notch) Male born to J35 (Tahlequah), her first calf, January, 2010
  
- J46 (Star) Female born to J28 (Polaris), her first calf, November, 2009
- L113 (Cousteau) Female born to L94 (Calypso), her first calf, October, 2009
- J45 (Se yi chn) Male born to J14 (Samish), her third calf, February/March, 2009
- J44 (Moby) Male born to J17 (Princess Angeline), her third calf, February, 2009
- K42 (Kelp) Male born to K14 (Lea) her fourth calf, June, 2008
  
- L110 (Midnight) Male born to L83 (Moonlight), her first calf, summer, 2007
- J42 (Echo) Female born to J16 (Slick), her third calf, spring, 2007
- L109 (Takoda) Male born to L55 (Nugget), her third calf, winter or spring, 2007
- L108 (Coho) Male born to L54 (Ino), her second calf, June, 2006
- J41 (Eclipse) Female born to J19 (Shachi), her second calf, July, 2005
  
- L106 (Pooka) Male born to L86 (Surprise), her first calf, first seen June, 2005
- K38 (Comet) Male born to K20 (Spock), her first calf, December, 2004
- J40 (Suttles) Female born to J14 (Samish), her fourth calf, December, 2004
- L105 (Fluke) Male born to L72 (Racer), her first calf, October, 2004
- K37 (Rainshadow) Male born to K12 (Sequim), her fourth calf, January, 2004
  
- K36 (Yoda) Female born to K14 (Lea), her fourth calf, September, 2003
- L103 (Lapis) Female born to L55 (Nugget), her third calf, first seen June, 2003
- J39 (Mako) Male born to J11 (Blossom), her fourth calf, Spring, 2003
- J38 (Cookie) Male born to J22 (Oreo), her second calf, Spring, 2003
- K35 (Sonata) Male born to K16 (Opus), her first calf, Fall, 2002
  
- K34 (Cali) Male born to K13 (Skagit), her fourth calf, Oct./Nov. 2001
- J37 (Hy'Shqa) Female born to J14 (Samish), her third calf, early Jan. 2001
- K33 (Tika) Male born to K22 (Sekiu), her first calf, early Jan. 2001
- J36 (Alki) Female born to J16 (Slick), her third calf, early 1999
- J35 (Talequah) Female born to J17 (Princess Angeline), her second calf, 1998

Since 1998, 73 orcas have gone missing or have died:

- J50 (Scarlet) Female born December, 2014 to J16 (Slick), her fourth calf, declared missing Sept 13, 2018 (age 3)
- L92 (Crewser) Male born 1995 to L60 (Rascal)(who washed up on outer WA coast May 2002 at age 30), declared missing June, 2018 (age 23)
- J52 (Sonic) Male born late March, 2015 to J36 (Alki), declared missing Sept. 2017 (age 2)
- K13 (Skagit) Female born est. 1972 (mother unknown), missing Winter, 2017 (age 45)
  
- J2 (Granny) Female born approx. 1911, declared missing Jan. 2017 (age est. 105)
- J34 (Doublestuf), Male born to J22 (Oreo), her first calf, born 1998, found deceased Dec. 20, 2016 (age 18)
- J54 (Dipper) Male born to J28 (Polaris) in December, 2015, her second calf, missing Oct. 2016 (age 10 months)
- J28 (Polaris) Female born to J17 (Princess Angeline) in 1993, her first calf, missing Oct. 2016 (age 23)
- J14 (Samish) Female born 1974 to J12, missing August, 2016 (age 42)



- L95 (Nigel) Male born 1996 to L43 (Jellyroll), found deceased March 30, 2016 (age 20)
- J55 unk., born Jan., 2016 to either J14, J37 or J40, missing January 19, 2016 (newborn)
- L27 (Ophelia) Female born 1965 (est.), mother unk., missing Summer, 2015 (age est. 50)
- J32 (Rhapsody) Female born to J20, 1996; found deceased with fetus Dec. 4, 2014 (age 18)
- L120 unk., born to L86, (Surprise!), her second calf, early Sept., 2014, missing Oct. 17, 2014 (age 1 mo.)
- L53 (Lulu) Female born 1977 to L7 (Canuck), missing Summer, 2014 (age 37)
- L100 (Indigo) Male born 2001 to L54 (Ino), missing Summer, 2014 (age 13)
- J8 (Speiden) Female born est. 1933 to ?, missing Fall, 2013 (age est. 80)
- L79 (Skana) Male born 1979 to L22 (Spirit), missing Summer, 2013 (age 34)
- L26 (Baba) Female born est. 1956 to ?, missing Spring, 2013 (age est. 57)
- L2 (Grace) Female born est. 1960 to ?, missing Fall, 2012 (age est. 52)
- L78 (Gaia) Male born 1989 to L2 (Grace), missing Summer, 2012 (age 23)
- K40 (Raggedy) Female born est. 1963 to suspected K18 (Kiska), missing Spring, 2012 (age est. 49)
- L5 (Tanya) Female born est. 1964 to ?, missing Spring, 2012 (age est. 48)
- L12 (Alexis) Female born est. 1933 to ?, missing Spring, 2012 (age est. 79)
- J30 (Riptide) Male born to J14 (Samish), missing 2012 (age 16)
- L112 (Victoria/Sooke) Female born to L86, Feb. 2009; found deceased Feb. 11, 2012 on shoreline of Long Beach, WA (age 3)
- J48 unk., born Dec. 2011 to J16 Slick her fifth calf, missing Jan. 2012 (age 1 month)
- J1 male (Ruffles) born est. 1951, missing Nov. 2010 (age est. 59)
- L7 (Canuck) Female born +/- 1961; missing Sept. 2010 (age est. 49)
- J33 (Keet) Male born 1996 to J16 (Slick), missing August 2010 (age 14)
- K11 (Georgia) Female born est. 1933; missing June 2010 (age est. 77)
- L114 unk., born to L77 (Matia) her second calf, missing June 2010, (age 4 months)
- L73 (Flash) Male born 1986 to L5 (Tanya), missing May 2010 (age 24)
- L74 (Saanich) Male born 1986 to L3 (Oreana), missing late 2009/early 2010 (age 23)
- L57 (Faith) Male born 1977 to L45 (Asterix), missing Nov. 2008 (age 31)
- L67 (Splash) Female born 1985 to L2 (Grace), missing Sept. 2008 (age 23)
- L111 Female born to L47 (Marina) her fifth calf Aug. 12, 2008, missing late Aug. 2008 (age <1 mo)
- J11 (Blossom) Female born +/- 1972 est. to J4 missing July 2008 (age est. 36)
- L21 (Ankh) Female born +/- 1950; missing summer 2008 (age est. 58)
- L101 (Aurora) Male born 2002 to L67 (Splash), her fourth calf; missing summer 2008 (age 6)
- K7 (Lummi) Female born +/- 1910, missing spring, 2008. (age est. 98)
- J43 unk., born to J14 (Samish), her fifth calf, in 11/07; missing April 2008 (age 5 months)
- L104 unk., born Oct. 2004 to L43 (Jelly Roll) her third calf, missing June 2007 (age 2)
- K41 unk., born Nov. 2006 to K22 (Sekiu), her second calf, missing Dec. 2006 (age 4 months)
- K39 unk., born Sept. 2006 to K28 (Raven) her first calf, missing Oct. 21, 2006 (age 4 months)
- K28 (Raven) Female born to K12 (Sequim), last seen Sept. 19, 2006 (age 12)
- L43 (Jellyroll) Female born ca. 1972, last seen Sept. 2, 2006, (age est. 34)
- L71 (Hugo) Male born to L26 (Baba), missing summer 2006 (age 20)
- L98 (Luna) Male born 1999 to L67 (Splash) died, March 10, 2006 in Nootka Sound, BC after being separated from pod at 18 months old (age 7)
- K31 (Tatoosh) Male born 1999 to K12 (Sequim) her third calf, missing Oct. 2006 (age 7)
- L32 (Olympia) Female born est. 1955, missing summer 2005 (age est. 50)
- L107 unk., born to L47 (Marina) June, 2005, her fifth calf, missing summer 2005 (infant)
- K18 (Kiska) Female born +/-1948, missing December, 2003 (age est. 55)
- L58 (Sparky) born 1980 to L5 (Tanya), missing June 2003 (age 23)
- L3 (Oreana) Female born +/-1950, missing 2002 (age est. 53)
- L102 unk. born to L47 (Marina), her fourth calf, missing Dec. 3, 2002 (age 1 month)
- L60 (Rascal) Female born 1972, washed up on outer WA coast May 2002 (age 30)
- K32 born 2000 to K16 (Opus), last seen 2001 (infant)
- L99 unk. born 2000, to L47 (Marina), last seen 2001 (infant)
- L62 (Cetus) Male born 1980 to L27 (Ophelia), last seen 2000 (age 20)
- L39 (Orcan) Male, born 1975 to L2 (Grace), last seen 2000 (age 25)
- L11 (Squirty) Female born 1957, last seen 2000 (age 43)
- L1 (Oskar) Male born est. 1959, last seen 2000 (age est. 41)
- J18 (Everett) Male born 1977 to J10 (Tahoma), found deceased at Tsawassen, Canada March 2000 (age 23)
- J10 (Tahoma) Female born est. 1962, last seen 1999 (age est. 37)
- K4 (Morgan) Female born est. 1933, last seen 1999 (age est. 66)
- L97 unk. born 1999 to L51 (Nootka), died Oct. 1999 (infant)
- L51 (Nootka) Female born 1973, found deceased at Race Rocks, Canada in Sept 1999 (age 26)
- J11's calf, unk. born to J11 (Blossom) 1998, died Dec. 1998 (infant)
- L93 (Nerka) Female born 1995 to L27 (Ophelia), last seen 1998 (age 3)
- L38 (Dylan) Male born est. 1965, last seen 1998 (age est. 33)
- L44 (Leo) Male born 1974 to L32 (Olympia), last seen 1998 (age 24)
- K3 (Sounder) Female born est. 1954, last seen 1998 (age est. 44)

- J20 (Ewok) Female born 1981 to J10 (Tahoma), last seen 1998 (age 17)



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# TAB J

Environment

## New orca calf seen among Puget Sound's critically endangered killer whales



Originally published January 11, 2019 at 12:25 pm | Updated January 14, 2019 at 8:35 am



Meet the newest southern resident orca whale, born to L77 (Center for Whale Research)

survive, meeting the same fate as other recent calves.

By [Lynda V. Mapes](#) 

*Seattle Times environment reporter*

A new calf has been born to the critically endangered southern resident killer whales, researchers confirmed.

The calf was born to L77, said Ken Balcomb, founding director of the [Center for Whale Research](#). He confirmed the birth in a text to The Seattle Times on Friday. He estimated the calf is several weeks old. The calf, which Balcomb named Lucky, is designated L124. The whale's sex is not yet confirmed.

Center staff first saw the calf Friday morning at the eastern end of the Strait of Juan de Fuca.

"It's great news," Balcomb said, adding the calf looks healthy.

**Hostile Waters: Orcas in Peril**



**PART I** | Orcas thrive in a land to the north. Why are Puget Sound's dying?

**PART II** | How a generation of killer whales was taken from Puget Sound

**PART III** | The decline of salmon adds to the struggle of Puget Sound's orcas

**FAQ:** A primer on the endangered killer whales

**ABOUT THIS SERIES** *In the weeks and months ahead, The Seattle Times' "Hostile Waters" series will continue to explore and expose the plight of the southern resident killer whales, among the most-enduring symbols of our region and most-endangered animals. We'll examine the role humans have played in their decline, what can be done about it and why it matters.*

It is the first known birth to the southern residents since Tahlequah, or J35, gave birth to a calf in July that lived only a half-hour.

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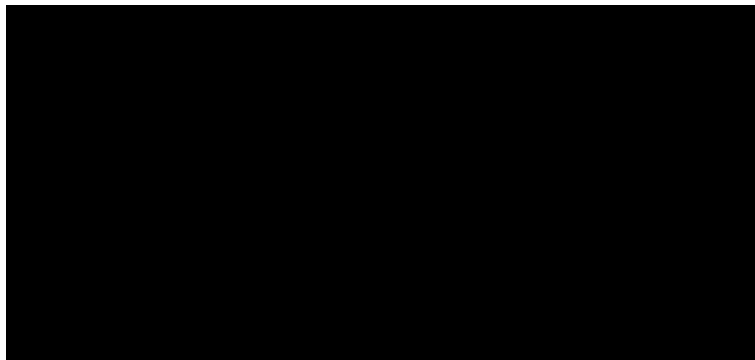
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Tahlequah [drew worldwide attention](#) when she carried the dead infant for 17 days and more than 1,000 miles, refusing to let it go.

Any birth in the southern resident population is big news because the orcas that frequent Puget Sound in the J, K and L pods are critically endangered. There are only 74 left, with three whales lost last year.

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The center on Friday also was observing K25, a southern resident whale known to be in poor body condition. If conditions allow, the center is attempting to get an update on that whale's status.

[K25 is doing poorly after the death of his mother K13 in 2017](#). Mother orcas preferentially feed their sons and K25 has been getting thinner and thinner — so thin that Balcomb has said he is concerned he may not last the summer.

J17, Tahlequah's mother, is also so thin as to cause similar concern.

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Balcomb cautioned about getting too attached to the baby whale, as survival rates are about 50 percent. The southern residents have not successfully reproduced in three years.

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**Lynda V. Mapes:** 206-464-2515 or [lmapes@seattletimes.com](mailto:lmapes@seattletimes.com); on Twitter: [@LyndaVMapes](https://twitter.com/LyndaVMapes). Lynda specializes in coverage of the environment, natural history, and Native American tribes.

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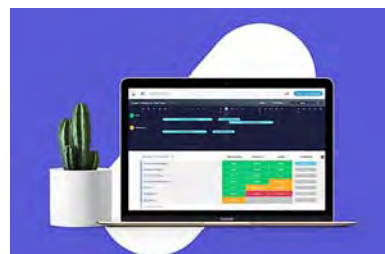
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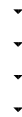
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# TAB K



British Columbia

## Orca 'Granny' missing and presumed dead



Death of oldest killer whale is seen as more bad news for endangered population

Mike Laanela · CBC News · Posted: Jan 03, 2017 7:00 AM PT | Last Updated: January 3, 2017



J-2 — also known affectionately as Granny — is estimated to have been born around 1911. (Erin Heydenreich/Centre for Whale Research)

One of the oldest known killer whales in the West Coast's southern resident population is missing and presumed dead, according to researchers.

The whale identified as J-2 — and known more affectionately as Granny — hasn't been spotted since Oct. 12, Ken Balcomb of the Centre for Whale Research in Washington state, said in a

[statement issued earlier this week](#). That was when Balcomb last saw Granny leading her pod north through Haro Strait.

"Perhaps other dedicated whale-watchers have seen her since then, but by year's end she is officially missing from the SRKW population, and with regret we now consider her deceased."

The matriarch of J-pod was one of the first identified by researchers in the 1970s. Based on studies of her family group, it was estimated she was born as early as 1911 — making her [up to 105 years old](#).

"She is one of only a few 'resident' whales for which we do not know the precise age, because she was born long before our study began," said Balcomb in the statement.

"In 1987, we estimated that she was at least 45 years old and was more likely to have been 76 years old," he said.

The pod is the most studied population of killer whales in the world and the lifespan of a wild orca is generally 60 to 90 years.

## Population in decline

The death is a blow to the [endangered population of southern residents](#), which lost several members in 2016, after a [baby boom of eight calves in 2015](#) pushed the population up to 85 whales.

"The population is now estimated to be 78 as of 31 December 2016, and J-pod contains only 24 individuals plus the wandering L-87," said Balcomb.





J-2, on the left, is with a large male in the waters between Point Roberts and Saturna Island. (Simon Pidcock/Ocean Ecoventures)

The other known deaths and disappearances in 2016 include:

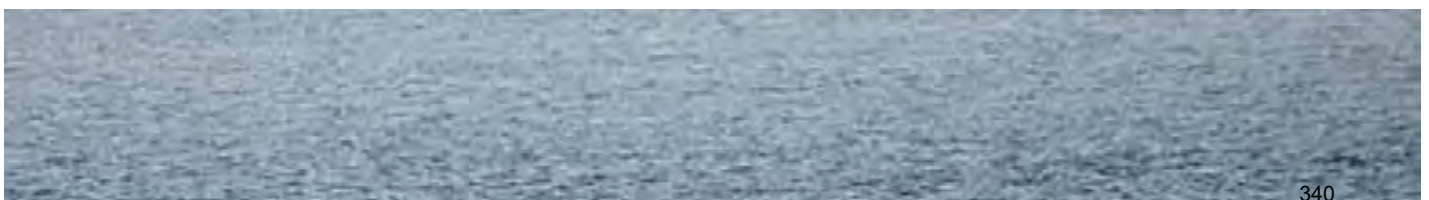
- [Calf J-55 was reported missing and presumed dead](#) in February.
- An unnamed [calf was found dead near Sooke in March](#).
- [L-95 was found dead in Nootka Sound in March](#) of a suspected infection from a satellite tracking dart.
- [Another female J-14 was also reported missing](#) and presumed dead in August.
- [In October, J-28, a female, was found dead](#).
- [In December, J-34, a male, was found dead](#) from what appeared to be a collision with a vessel.

While the individual causes of death vary, [researchers blame the overall decline](#) of the population on a shortage of their primary food — Chinook salmon — and high levels of toxins in the blubber, the result of pollutants in the water and food.

Balcomb said in years in which Chinook and other fish stocks are poor, the orcas are forced to metabolize their blubber, subsequently releasing toxins into their blood and organs.

Despite her age, Granny's death will be a blow to J-pod and the rest of the southern resident population, he said.

"She kept on going like the Energizer Bunny," said Balcomb. "Who will lead the pod into the future? Is there a future without food? What will the human leaders do?"





The last known sighting of J-2 was on Oct. 12, 2016. The killer whale matriarch of J-pod is now presumed dead. (Ken Balcomb/Centre for Whale Research)

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# TAB L





British Columbia

## Orca found on Sunshine Coast died of blunt force trauma, DFO says



J-34 was a male born in 1998 and nicknamed Double Stuf

CBC News · Posted: Dec 22, 2016 7:00 PM PT | Last Updated: December 22, 2016



Researcher examines the dead whale near Sechelt, B.C. Three other southern resident killer whales have died this year. (Fisheries and Oceans Canada)

Fisheries and Oceans Canada says early signs point to blunt force trauma killing a whale that washed up on the Sunshine Coast Wednesday.

The DFO's marine mammal coordinator, Paul Cottrell, said it appears the animal was struck while alive and died some time after, according to results from a necropsy.

"It's consistent with a vessel strike, but sometimes animal-animal aggression can cause trauma as well," Cottrell told [On The Coast](#) guest host Chris Brown.

"We'll be looking at the extent of the trauma in terms of the surface area of the body and we're also doing a CAT scan of the skull of the animal to look for any fractures as well to get a sense of the intensity of the blunt force trauma."

- [Dead orca found off B.C.'s Sunshine Coast](#)
- [2nd humpback death in 2 weeks worries experts, farmed salmon industry](#)
- [Southern resident orca matriarch missing, possibly dead](#)

Cottrell said vessel strikes usually kill larger whales, like humpbacks and fins, but they kill orcas as well.

The whale was J-34, a male born in 1998 and nicknamed Double Stuf.

J-34 was part of J-pod, which experienced a baby boom of eight calves in 2015.

It's one of three pods that make up the southern resident killer whale population, and it is comprised of approximately 80 members.

The southern resident killer whales have lost at least five members this year, and Cottrell said DFO is looking at what can be done to reduce human-caused whale deaths.

*With files from CBC Radio One's [On The Coast](#)*

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***To hear the full story, click the audio labelled: [Orca found on Sunshine Coast died of blunt force trauma, DFO says](#)***





# TAB M





L92 spyhop - Photo by Dave Ellifrit, Center for Whale Research



L92 - Photo by Dave Ellifrit, Center for Whale Research

# L92 1995-2018

With the loss of L92, the total number of Southern Resident killer whales is now 75 whales.

Press Release – June 15, 2018

## L92 - Missing Southern Resident killer whale is presumed dead

On Monday, June 11, more than 50 Southern Resident killer whales returned to inland waters, including J pod, L87, and most but not all of L pod. It has been nearly 2 months since J pod whales and L87 have been seen in local waters, an unusually long break but not unexpected based on trends in the past decade. In recent years, encounter data and sighting data compiled by the Center for Research show that the Southern Residents have been spending fewer days in inland waters in the April-May time frame. This trend parallels a decline in the abundance of the Fraser River spring Chinook salmon runs. Based on data from the Albion Test Chinook Test Fishery on the Fraser River, the number of Chinook salmon returning to the Fraser River has been unusually low so far in 2018.

Research has shown that Fraser River Chinook salmon comprise a significant portion of their diet when these whales are foraging in their "core summer habitat" or in the Strait of Juan de Fuca south of Vancouver Island. In one study, research conducted during the months of May through September, 2004-2008, revealed that 80-90% of the Chinook salmon consumed by Southern Resident killer whales near the San Juan Islands and off the southern end of Vancouver Island originated from the Fraser River, with only 6-14% originating from Puget Sound rivers (Reference 1). Research documented in a more recent publication also led to similar conclusions (Reference 2). It should be noted that of the wild Chinook salmon populations associated with Puget Sound rivers, 16 are classified as extinct and the remaining 22 populations are listed as threatened.

### Current Southern Resident population census:

**J pod:** All of the J pod whales and L87 were confirmed to be present by CWR staff members. At this time, there are 23 whales in J pod.

**L pod:** Both L25, the oldest female in all three pods, and L41, the oldest male in all three pods, were confirmed to be present by CWR staff members. Genetic testing has revealed that L41 is the father of at least 20 of the Southern Resident killer whales (Reference 3).

However, L92 was not present. L92 was last sighted by CWR staff in November of 2017, but conspicuously absent from several coastal sighting reports from colleagues and the public earlier in 2018.

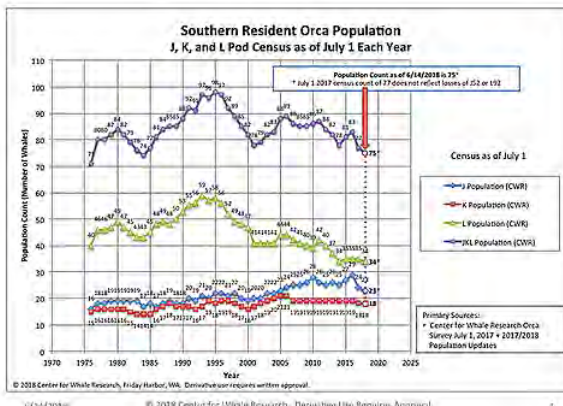
L92 is missing and presumed dead. L92, an adult male, was a member of the L26 matriline. With his death, the only surviving member of the L26 matriline is his aunt, L90.

The L54s, L84, and L88 have not yet returned to inland waters in 2018.

L pod currently has 34 members, down from nearly 60 members in the early 1990's.

**K pod:** All of K pod was seen by CWR staff in March of 2018. K pod currently has 18 members.

**With the loss of L92, the total number of Southern Resident killer whales is now 75 whales.**



L92 - Photo by Dave Ellifrit, Center for Whale Research

References

- (1) M. Bradley Hanson, Robin W. Baird, John K. B. Ford, Jennifer Hempelmann-Halos, Donald M. Van Doornik, John R. Candy Candice K. Emmons, Gregory S. Schorr, Brian Gisborne, Katherine L. Ayres, Samuel K. Wasser, Kenneth C. Balcomb, Kelley Balcomb-Bartok, John G. Snea, Michael J. Ford. 2010. Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. *Endang. Species Res.* 11: 69–82
- (2) Ford, M. J., Hempelmann J., Hanson, M. B., Ayres, K. L., Baird, R. W., Emmons, C. K., et al. (2016) Estimation of a Killer Whale (*Orcinus orca*) Population's Diet Using Sequencing Analysis of DNA from Feces. *PLoS ONE* 11(11): e0144956. doi:10.1371/journal.pone.0144956
- (3) J. Ford. M & Parsons. K & J. Ward. E & Hempelmann. Jennifer & Emmons. Candice & Hanson. M & C. Balcomb. K & K. Park. L. (2018). Inbreeding in an

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## Updates on Southern Resident Killer Whales J50 archive

**September 15:** After dedicated search efforts for J50 over the last two days, J50 was still unaccounted for. The team ended its act search last night (9/14), but the West Coast Marine Mammal Stranding Network remains on alert, and this is a time of year with many researchers on the water. We remain grateful to our many partners and everyone who has lent support to the response and search. J35 have emphasized the urgency of recovering Southern Resident killer whales.

**September 14:** The response team continues to search the air and water extensively today near where J50 was last seen. The U.S. Guard and the Washington Department of Fish and Wildlife are providing dedicated assets to the search. Contingency planning to support J50 is continuing in the event she is found and rescue operations are appropriate.

**September 13:** Unfortunately J50 has not been seen in several days of favorable conditions and sightings of her pod and family group including J16, her mother. Teams were on the water searching yesterday and are increasing a broad transboundary search today with on-water partners and counterparts in Canada. We have alerted the [West Coast Marine Mammal Stranding Network](#), which is a tremendous resource in such situations. Airlines flying in and out of the San Juan Islands are also on the lookout. The hotline for stranding reports is 1-866-767-6114.

**September 11:** NOAA Fisheries and our partners have been exploring and taking action to save J50 because of her importance as a contributing member of this population, and particularly to J Pod. The public has a stake in the J50 response and the recovery of Southern Resident killer whales and we understand many people are concerned. We want to know what people in the region think about this and potential steps so we are holding two public meetings in Washington State to hear the public's views:

- Saturday, Sept. 15, at 7 p.m. in Friday Harbor at Friday Harbor High School
- Sunday, Sept. 16, at 1 p.m. in Seattle at University of Washington, Haggett Hall Cascade Room

**September 10:** New aerial images collected through a collaboration between SR3 and NOAA Fisheries' Southwest Fisheries Science Center has given us new insight into the condition of J50 and her mother, J16. These images will help the teams assess further on support J50. See the images at [SR3's website](#).

**September 8:** J50 was seen lagging a half-mile to a mile behind the rest of her family group at times on Friday (9/7), and her body is not improving. She appeared to have lost more weight and looked very thin. With growing concern, we are working with Fisheries Oceans Canada (DFO) to evaluate options. Our highest priorities are to do all we can to ensure J50 remains a contributing part of Southern Resident killer whale population and to prevent any harm to her and her family under any potential response scenario. This is our bottom line.

**September 6:** Results are back from fecal and breath samples the team collected from a small group of J Pod whales, including J16 on genetic analysis, we determined that the fecal sample (collected 8/17) likely came from J16, J50's mother. This sample showed evidence of parasitic worms. Since J16 catches fish that she then shares with J50, the veterinary team prioritized treating J50 with a dewormer following antibiotics. A second fecal sample was identified as coming from J27, an adult male. Researchers at our Northwest Fisheries Science Center extracted DNA from the breath sample collected on 8/9. While the sample was small and yielded little DNA, researchers are adapting their analysis to make the most of the available material.

**September 4:** Biologists observing J50 on Monday (9/3) noted she was remarkably active and engaged with J Pod despite her sex

emaciated condition. J50 stayed close to her mother, J16, and continued the longer dives expected of healthy whales. Veterinarian Dr. Martin Haulena of the Vancouver Aquarium provided J50 another dose of antibiotics through a dart, following up the initial dose administered on 8/9. The treatment priority has now shifted to administering a dewormer, also through a dart, to reduce any parasitic burden on J50's system.

**September 3, 11:45 a.m.:** Good news! Multiple organizations are reporting that J50 has been spotted with J Pod in the Salish Sea this morning. We will continue efforts to assess the health of J50 and treat her according to the priorities outlined by the team of veterinarians and scientists.

**September 3:** J50 was not seen returning from open waters off the West Coast of Vancouver Island to the Salish Sea with J Pod this weekend (9/1-2). Biologists from The Center for Whale Research, Soundwatch, and the University of Washington spent much of the day Sunday with other members of J Pod, including J16, her mother, and J50 was not seen with them. The team has several boats on the water today to look for her. One of the last sightings by DFO on Thursday (8/30) reported that J16 and J26, J50's brother, were lagging behind most of J Pod by about three nautical miles, and J50 was lagging about a half-mile behind them. Sometimes she got closer, but she looked to be struggling to keep up. The standard for determining the loss of any of the Southern Residents is to spot a whale's family group multiple times without them. This rule may be relevant for J50 in order to confirm her status given how far behind the other whales she had followed at times.

**August 27:** J50 spotted with her family near Jordan River, B.C., on Friday (8/24).

**August 20:** Response teams spent about three hours on Saturday (8/18) monitoring J50/Scarlet as J Pod returned to the Salish Sea on the way towards San Juan Island. Biologists aboard a SeaDoc Society vessel reported J50/Scarlet actively socializing with the rest of the pod, a hint that her condition may be improving slightly. She fell behind the pod as the whales swam east, but a University of Washington (UW) team saw her rejoin her mother (J16/Slick) and sister (J42/Echo) to forage near Hannah Heights on the west side of San Juan Island. The UW team also collected two fecal samples from the group. On Sunday (8/19) J Pod was seen heading west, back toward open ocean. The plan going forward is to administer another dose of antibiotic through a dart and, if possible, a second dart with dewormer to reduce parasitic worms, known to be harmful in emaciated marine mammals like J50/Scarlet, and that were found in the recent fecal samples from a group of three whales including J50. The veterinary team believes another dose of antibiotic remains the priority to treat potential infection since the first dart on 8/9 delivered only half a dose. Darting a swimming killer whale that has thick skin, particularly on fins and flukes, from a rocking boat is challenging. To ensure that J50/Scarlet receives the medication, veterinarians may switch to a collared needle with a ridge that holds it in place long enough to deliver the full dose. This type of dart is commonly used to treat wildlife, such as elephants, and will fall out in time. See new photos from Saturday (8/18) at [flic.kr/s/aHsmpvmT1o](http://flic.kr/s/aHsmpvmT1o).

**August 17:** Test results from the health samples collected from J50/Scarlet are starting to come in from several top laboratories around the country. A fecal sample collected last weekend from a group of three J Pod whales (J16/Slick, J42/Echo, and J50/Scarlet), showed high levels of *Contraecium*, a nematode parasite that is commonly found in killer whales and other marine mammals. The worm is not usually a problem in healthy animals. However, in animals that are emaciated or are otherwise compromised, the parasite can penetrate the stomach lining, introducing bacterial infection to the bloodstream, or it can bore into internal organs. While we cannot be sure the sample came from J50/Scarlet, the veterinary team has updated her treatment priorities to include antibiotics and a dewormer. Both have proven successful and safe in other cetaceans. The treatment should help J50/Scarlet by reducing bacterial and parasitic burdens on her system so she can start regaining the weight she has lost. The whales remain in open waters off the west side of Vancouver Island, beyond the reach of the response teams.

**August 14:** Now that the response team has met its initial goals for J50 / Scarlet's health assessment and treatment, and J Pod has headed out to open waters, biologists and veterinarians are taking stock of what they have learned so far. They are reviewing video footage and photos and processing samples to gain further insights into her health and behavior. Teams continue to monitor the whales and collect fecal and prey samples (e.g., fish scales) when possible. They will also review the results of Sunday's (8/12) feeding trial while they determine next steps.

**August 13: Press Call transcript**

**Audio File: NMFS 08/13/2018 Press Call MP3 (7958 kb)**

**August 12:** Favorable conditions allowed the teams to proceed with an experimental live fish release off the west side of San Juan Island to evaluate the process as a way to treat J50 / Scarlet with medication and supplements. Under the direction of Jeff Foster with the Whale Sanctuary Program, a Lummi Nation vessel released eight live hatchery salmon about 75 to 150 yards in front of her, while teams observed from NOAA Fisheries and Washington Department of Fish and Wildlife (WDFW) vessels. While she appeared to react to the released fish by quickly diving, biologists could not confirm from the vessels whether she took the fish, and they are reviewing aerial footage for further clues. J50 / Scarlet socialized with members of J Pod but sometimes fell behind in the strong current. Researchers collected a fecal sample from the pod but could not confirm whether it was from J50 herself. Fecal samples can reveal whether the whales are eating, what they are eating, provide clues about their health, and gauge their stress levels by evaluating hormones such as cortisol.

**August 11:** The team spent several hours with J50 / Scarlet watching her behavior and interaction with members of J pod. Researchers from the Univ. of WA observed her swimming with the pod while trying to collect a fecal sample. Later the team watched her fall as much as 1 kilometer (~1/2 mile) behind against a strong tidal current. Biologists were concerned that they did not see her eat, even in a prime foraging area off San Juan Island. A charter company reported seeing her catch a fish earlier in the day.

**August 10:** J pod moved into Canadian waters. The team spotted J50 / Scarlet and watched as she repeatedly dove and surfaced where the pod was feeding. Biologists could not tell whether she also fed, but they collected leftover scale samples that will help identify what kind of salmon or other fish the whales had eaten. She again appeared active and energetic.

**August 9:** Response teams reached J Pod in Canadian waters and followed them into U.S. waters near San Juan Island. While very skinny and small, J50 / Scarlet kept up well with her mother and siblings. Vancouver Aquarium's veterinarian and the team conducted a visual assessment, obtained a breath sample that will help assess any infection, and administered antibiotics through a dart. Next steps are to



continue observations and consider trial feeding as a future route for delivering medications.

**August 8:** DFO spotted Jpod in U.S. waters off the Olympic Peninsula northwest of Neah Bay, Wash. J50/Scarlet was with her mother, J16, known as Slick. Teams are prepared to attempt a response tomorrow, if there is opportunity.

**August 7:** J50 was spotted by Dept. of Fisheries and Oceans Canada with her pod off Port Renfrew, near the west entrance to the Strait of Juan de Fuca. Throughout the day, as some teams searched for J50, other partners in the effort continued making important preparations to be ready for an opportunity to assess J50's health.

**Audio file: NMFS 08/07/18 Press Call MP3 (8.26 MB)**

**August 6:** Responders continued searching for J pod today without success. The whales have not been seen since Saturday night, when spotted in open waters on the west side of Vancouver Island. Veterinarians are on standby to conduct a health assessment of J50.

**Audio file: NMFS 08/06/18 Press Call MP3 (6.44 MB)**

**August 4:** J50 was seen with her pod (J pod) around the west side of Vancouver Island, beyond the reach of most response vessels. We are awaiting an opportunity to complete a veterinary medical assessment.

**August 3:** Analysis of a small sample of her breath did not definitively indicate an infection or illness, although it does not rule one out either. SR3, a response partner, posted [photos of J50 taken in May 2017 and August 2018](#) for comparison.

**August 2:** Experts agreed to focus efforts over the next few days on obtaining better photographs of J50 and conducting a veterinary health assessment to inform options for a decision on whether and how they might be able to respond. More: [Biologists assess condition of Southern Resident killer whale J50](#).

## J35 Updates

**August 11:** The [Center for Whale Research](#) confirmed J35/Tahlequah is no longer carrying the calf and appears to be in good condition.

**August 10:** The team sighted J35 / Tahlequah with J pod in Canadian waters, but could not confirm if she was still carrying her calf due to poor visibility.

**August 8:** Teams spotted J35/Tahlequah today and the heartbreaking sight of her still carrying her dead calf. It has been almost two weeks since she gave birth.

**Week of July 27:** Biologists last observed J35 the week of July 27. They are concerned about her health.

**July 24:** J35 gave birth to a female calf. The calf died about a half hour after birth. J35 has been seen carrying her dead calf since then. She is part of the J pod.

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# TAB O

# Oil spills in the critical habitat of Southern Resident killer whales (*Orcinus orca*)

Fall 2018 submission

Prepared for the National Energy Board hearings reviewing  
the marine shipping component of the  
Trans Mountain Expansion Project

by

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## Introduction

This report considers the importance of critical habitat to Southern Resident killer whales (“Southern Residents”) and the risk posed by an oil spill within that critical habitat. It further examines availability of Chinook salmon as an aspect of critical habitat, the existing degradation of that aspect of Southern Resident critical habitat, and the effect that an oil spill in the Fraser River estuary could have for the Southern Residents and their critical habitat. This report provides new information and updates information submitted in Raincoast’s 2015 submissions to the NEB including Logan *et al.* NEB filing ID A4L9F4 (“Logan *et al.* 2015”) and Lacy *et al.* Filing ID A4L9G2 (“Lacy *et al.* 2105”) on oil spill implications to salmon and Southern Resident killer whales.

The Southern Resident population is assessed as endangered due to its small and declining population and the expected continuance of this decline (COSEWIC 2008; 2001). The Committee on the Status of Endangered Wildlife in Canada’s (COSEWIC) 2008 re-assessment of their status states that Southern Residents are limited by the availability of their principal prey, Chinook salmon. They identify forecasts of continued low abundance of Chinook Salmon. In 2008, COSEWIC also identified that Southern Residents are threatened by increasing physical and acoustical disturbance, oil spills and contaminants. The Resident Killer Whale Recovery Strategy further identifies the serious risks that catastrophic events such as oil spills present to killer whales and their prey (DFO 2011). Southern Residents are also assessed as endangered under the *Endangered Species Act* in the United States on the grounds of their small population size, vulnerability to “demographic stochasticity”,<sup>1</sup> and catastrophic events such as oil spills (NMFS 2008). The Logan *et al.* 2015 Report, concluded that the Project increases the threat of an oil spill that could affect prey availability for Southern Residents. As set out further below, Project Related Shipping also increases the risk of an oil spill in critical habitat that could both affect both the whales and their primary prey, Chinook salmon.

### 1.0 Vulnerability of Southern Resident killer whales to an oil spill in critical habitat

There is no evidence that killer whales detect or avoid oil slicks (Matkin *et al.* 2008). As obligate surface breathers, Southern Resident killer whales are inherently vulnerable to oil spills and at acute risk of exposure through inhalation and contact during their normal behaviours of breathing, resting, socializing, feeding, and travelling. After an oil spill, the highest concentrations of volatile monoaromatic hydrocarbons<sup>2</sup> are typically found at the air-water interface (Colegrove *et al.* 2013). Thus, because killer whales breathe at the air-water interface, encountering spilled oil means they are likely to inhale toxic hydrocarbons as they evaporate from the surface slick (Matkin *et al.* 2008; Neff 1990).

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<sup>1</sup> Random variation in sex ratios that can have population level implications.

<sup>2</sup> A compound made of hydrogen and carbon, and important components of petroleum products.

Inhalation and aspiration of oil and its primary and secondary aerosol products can have a range of adverse effects on killer whales. Evaporating oil can result in a “narcosis” response (similar to over-anaesthesia) which can cause drowning (Matkin *et al.* 2008). Inhaled fumes can also cause inflammation and lesions in respiratory membranes. These can lead to lung disease and bacterial pneumonia, adrenal disease, absorption of hydrocarbons into the bloodstream, neurological damage, and liver disorders (Venn-Watson *et al.* 2015; Geraci and St. Aubin 1990). Ultimately, these can cause organ failure, reproductive failure, and mortality (Venn-Watson *et al.* 2015).

Oil spill vulnerability for BC marine mammals was examined by Jarvella- Rosenberger *et al.* (2017)<sup>3</sup> and was determined by considering 1) the likelihood of species- based oil exposure, 2) the likelihood of population-level effects given exposure, and 3) a combined vulnerability based on 1 and 2. Criteria and considerations used in these ranking are shown in Tables 1.1 and 1.2, and expanded on in Appendix Tables A2 and A3. Species-specific vulnerabilities were used to identify the likelihood of population- level effects occurring from oil exposure. Southern Residents were ranked in the highest vulnerability category due to their long lives, limited reproductive turnover, very small population sizes, complex social structure, identified critical habitat, and high dietary specialization.

**Table 1.1.** Likelihood of oil exposure for Southern Resident killer whales based on their biological and ecological characteristics. Five oil exposure pathways were examined and the likelihood of oil exposure through each pathway was scored as low, medium, or high. See Appendix II, Table A2 for scoring criteria. Source: AJR *et al.* 2017

Contact	Adhesion	Inhalation	Direct ingestion	Ingestion through contaminated prey
HIGH Extended time spent at surface	LOW smooth skin	HIGH Extended time near surface; Blowhole	LOW do not ingest large quantities of seawater	MEDIUM Salmon specialists, non salmon and squid also documented

**Table 1.2a & 1.2b.** Likelihood of population level effects from oil exposure based on Southern Resident killer whale biological and ecological characteristics. Life history traits were scored as having a low, medium, or high likelihood. See Appendix III Table A3 for scoring criteria. Source: AJR *et al.* 2017

<sup>3</sup> Herein, AJR *et al.* 2017

1.2a)

Population	Distribution	Group size	Habitat
HIGH Extremely small, declining population < 80 individuals	HIGH Sighted year round in BC coastal waters including Salish Sea	HIGH Large groups and complex social structure	HIGH Critical habitat defined in Salish Sea, small areas of pod specific high density

1.2b)

Reproduction	Life history	Diversity of diet	Prey susceptibility to decline
HIGH Calving takes place in BC waters	HIGH Long-lived, slow reproducing, 12-18 yrs before first mating, 5-6 yrs between offspring	HIGH Salmon specialists, diet predominantly Chinook, small percentage of non- salmonids	HIGH Prey vulnerable to abundance decrease

The heightened vulnerability of killer whales to population-level effects from oil spills was documented in Alaska's *Exxon Valdez* spill. Alaska's AB Resident killer whale population remained depressed for more than 20 years following the loss of 13 individuals (33% of the population), and the AT1 Transient group lost 9 individuals (41% of the population), including its remaining reproductive females (Matkin *et al.* 2008) and is now considered functionally extinct.

### 1.1 Applying a risk framework to critical habitat of Southern Resident killer whales

Conventionally risk is assessed as a product of consequence times probability i.e. the risk to the Southern Residents and their critical habitat from an oil spill should be determined by combining the likelihood of the spill occurring with the biological consequences of that event. Given that Southern Residents are ranked in the highest vulnerability category in the event of a spill, this "consequence" component can be combined with a separate probability for spill occurrence to provide a more complete assessment of oil spill 'risk' in the conventional sense. Site and incident specific factors, such as the type of oil product spilled, spill size, meteorological and oceanographic conditions, and the effectiveness of spill response, will all be factors that affect the exposure and consequence to whales.

To consider the concerns for critical habitat and Southern Residents, AJR *et al.* (2017) examined Trans Mountain’s hypothetical episodic oil spill in northern Haro Strait BC (EBA 2013). They combined the modeled probability of oil presence from a 15,000 m<sup>3</sup> oil spill originating near Turn Point in Northern Haro Strait (EBA 2013) with their calculation for the potential overlap of this spill within critical habitat (Table 1.3, Figure 1.1). Their analysis shows that 22% to 80% of designated Southern Resident Critical Habitat would be affected by a spill in northern Haro Strait.

**Table 1.3.** The overlap between a 15,000 m<sup>3</sup> modelled oil spill that originated at Arachne Reef, near Turn Point, in northern Haro Strait (BC and WA) and the designated Critical Habitat in Canada and the United States for the transboundary Southern Resident killer whales.

Probability of oil presence (source: EBA 2013)	Overlap between modelled spill and SRKW critical habitat (km <sup>2</sup> )	Percent of SRKW critical habitat affected
0.1	7107	80%
0.10	6652	75%
0.20	5985	67%
0.40	4831	54%
0.60	3785	43%
0.80	2687	30%
0.90	2205	25%
0.95	1962	22%

Modeling of biological consequences of oil spills and the probability of occurrence is generally required in major project applications to assess risk. Such a biological risk assessment was not undertaken by Trans Mountain. Trans Mountain modeled the likelihood of oil presence from a tanker spill at a single location within critical habitat. They also provided probabilities for oil tanker accidents. However they did not combine the biological consequence of oil spill exposure on Southern Residents with the probability of its occurrence in accordance with the standard generally used in risk assessments. A proper risk assessment would have combined the probability of the accident with the biological consequence to Southern Resident killer whales. Trans Mountain assumed that if the probability of an accident was low, then risk was low and this conclusion was flawed.

Equally, Trans Mountain generally relied on methods to assess consequence from oil spills that use “indicator” species to represent groups of animals (TERA 2013; Stantec 2010), and simplify biological risk assessments. Following an indicator species approach, marine mammals are examined as a group when assessing oil spill risk, but the findings of AJR *et al.* (2017) indicate variable outcomes based on the different biological and ecological characteristics of species. Their findings show that cetaceans and other marine mammals, and even different populations of cetaceans, are not equal in terms of their vulnerabilities. ARJ *et al.* (2017) also recommend that species and populations at higher risk of adverse effects warrant more detailed examinations or modeling exercises.

**Figure 1.1** Black to grey shading indicates the probability of oil presence 15 days following a 15,000 m<sup>3</sup> fall spill of diluted bitumen at Arachne Reef in northern Haro Strait, BC. The modelled probabilities of oil presence (EBA 2013) are overlaid with the Critical Habitat of Southern Resident killer whales in Canada and the United States. Source: AJR *et al.* 2017



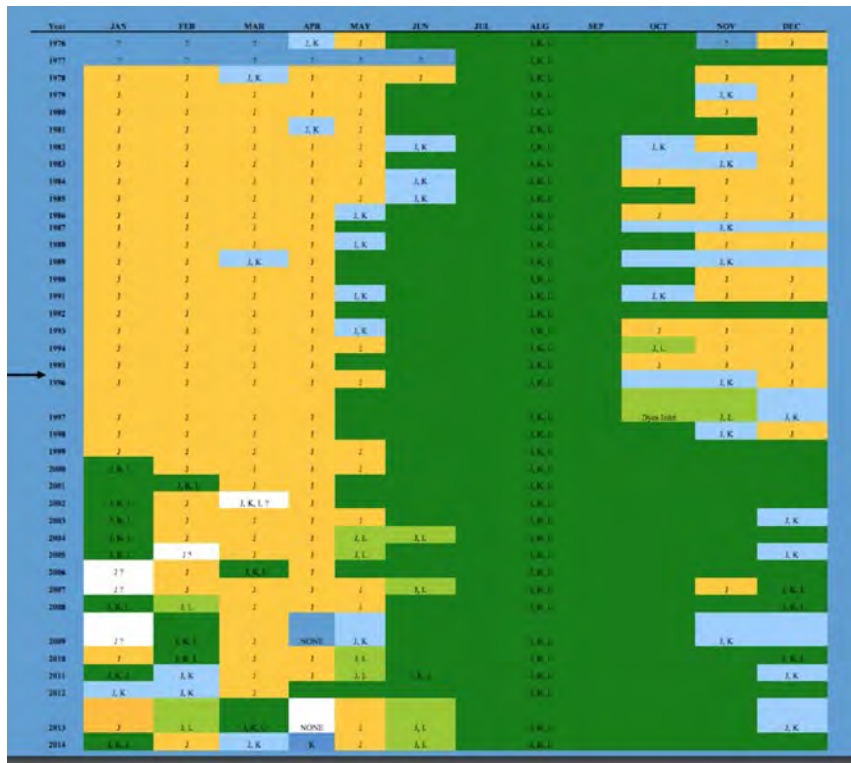
Trans Mountain suggests the spill probabilities for an on-route oil tanker incident are between 16-67% over the 50-year life span of the project, depending on the mitigation measures adopted (DNV 2013, Gunton and Broadhead 2015). However, Gunton and Broadhead (2015) evaluated Trans Mountain’s conclusions using international risk assessment guidelines and found that their assessment met none of the best practices criteria and failed to comply with a robust spill analysis. They identify the lower 16% estimate to be an outlier significantly below the estimates generated by other methodologies. They identify major deficiencies in the tanker spill risk analysis that compromise the credibility of the results. Using the U.S. Oil Spill Risk Analysis model and the Vessel



Traffic Risk Assessment methodology, they estimate that the likelihood of a tanker spill is 58% to 98% over the 50-year period of the project (Gunton and Broadhead, 2015).

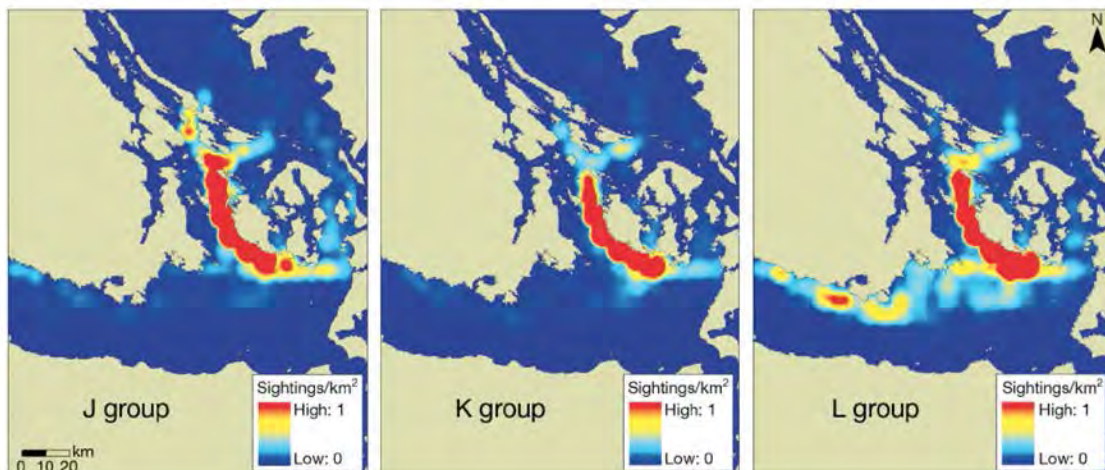
The U.S. based Whale Museum has examined the presence and distribution of Southern Resident pods (J, K, L) in the inside waters of the Salish Sea. Between 1976 and 2014, Southern Residents were in their critical habitat an average of 193.1 days/ year with a low of 139 whale days in 1977 and a high of 266 whale days in 2001 (Larson *et al.* 2018). While the presence of all three pods in the Salish Sea is highest from June to September, members of at least one pod are generally in their critical habitat every month of the year (Figure 2), with winter presence dominated by J pod. The Whale Museum notes that non-summer presence of K and L pods increased after 1996.

**Figure 1.2** The monthly presence of J, K, and L pods in their critical habitat between 1976 and 2014. The Whale Museum notes the increased presence of K and L pods in the non-summer months after 1996. Source: Larson *et al.* 2018.



Hauser *et al.* (2007) examined summer use of central critical habitat (excluding Puget Sound) by all three Southern Resident pods (and groupings of pods) between 1996 and 2001. Southern Residents were in their core critical habitat an average of 79.25% of their whale search days, with a range from 64.5% in 2000 to 96.7% in 2001. All pod groups heavily used critical habitat throughout Haro Strait, but in Swanson Channel and into Active Pass, Boundary Pass, Lopez Islands and into Rosario Strait, and the Strait of Juan de Fuca off southern Vancouver Island (Figure 1.3) different pod groups relied on these areas of critical habitat at different densities.

**Figure 1.3.** Kernel densities<sup>4</sup> for J, K, and L pod grouping within the core area of SRKW critical habitat in the summer months (June -September) between 1996-2001. Haro Strait is frequented by all three pods, but summer core use extends through Boundary Pass, Southern Georgia Strait, Rosario Strait, and the Southern shore of Vancouver Island through the Juan de Fuca. Source: Hauser *et al.* 2007



The near year-round use of critical habitat by some or all members of the Southern Resident pods has been documented since 1976 and identified as a population level vulnerability by NOAA (2014) because of their exposure to catastrophic events such as oil spills. Only one, month-long period was identified over almost four decades when Southern Residents were believed absent from their critical habitat. While the duration of time spent in critical habitat in the spring has declined in the last few years (Shields *et al.* 2018), whales still enter their critical habitat almost every month of the year.

Trans Mountain’s Turn Point spill trajectories show the dispersal of oil through Southern Resident critical habitat after the first 15 days following the spill. Spilled oil would likely persist at the water’s surface and travel for longer than 15 days.<sup>5</sup> Given the modelled extent of coverage and duration of oil presence, there is a high likelihood that some or all Southern Residents would encounter the oil slick.

Lacy *et al.* (2017, 2015) examined the population-level consequences of exposure to a large (>16,500 m<sup>3</sup>) and smaller (>8,250 m<sup>3</sup>) oil spill. Based on the percent overlap of oil coverage in critical habitat, Lacy *et al.* concluded that in a scenario where all members of the Southern Resident population were in their critical habitat, exposure to a large spill could result in mortality of 50%. A loss of such magnitude would bring the population to 37 whales, just above quasi-extinction (<30). It is highly probable this would lead to their full extinction within the following decades.

<sup>4</sup> Kernel densities are a statistical approach to estimating population density; they are often used in spatial density assessments.

<sup>5</sup> For example, oil spread away from Bligh Reef (sight of *Exxon Valdez* oil spill) for 56 days covering a distance of more than 700 kilometres (<http://www.evostc.state.ak.us/index.cfm?FA=facts.map>)

If the population was exposed to a smaller spill, Lacy *et al.* (2017, 2015) estimated mortality at 12.5% of the population. Given the November 2018 population of 74 individuals, no calf recruitment since 2015, and only 27 reproductive females, anthropogenic stressors that lead to the further loss of individuals would compromise reproductive capacity. The loss of 9-10 individuals would leave 64 whales, a population level never observed in the 50 year census. Given the deteriorating quality of critical habitat (Williams *et al.* 2014, Shields *et al.* 2018) that is already limiting recovery, sub-lethal longer term health effects in remaining whales from oil exposure (such as those described above) could compromise reproductive success. When combined with implications of a spill for the abundance of their primary prey (discussed below in part 2) and a random, disproportionate loss of reproductive females (as occurred in Alaska's AT1 transients) within the three different pods, the loss of 12.5% of the population due to exposure to a smaller spill could equally be an event from which the SRKWs cannot recover, and that precipitates their extinction.

## **2.0 The effect of an oil spill in the habitat of Fraser River Chinook salmon (*Onchorhynchus tshawytscha*) - the primary prey of Southern Resident killer whales**

### **2.1 The importance and decline of South Coast Chinook salmon for Southern Residents**

Chinook salmon dominate (up to 80%) the salmon diet of Southern Residents. Southern Residents use the Salish Sea more frequently in the spring to fall when they target Chinook salmon migrating as spring, summer and fall aggregates to the Fraser River, Georgia Strait, Puget Sound, and other Salish Sea rivers (Ford *et al.* 1998; Ford and Ellis 2005, Ford *et al.* 2010a; Ford *et al.* 2010b, Hanson *et al.* 2010; Ford *et al.* 2017). The abundance of early timed (spring) Fraser River Chinook is also a predictor of the cumulative presence or absence of the whales in the Salish Sea in the spring (Shields *et al.* 2018).

Southern Resident birth, survival, and mortality rates are strongly correlated with coastwide and local abundances of Chinook salmon (Ward *et al.* 2009, Ford *et al.* 2010, Vélez-Espino *et al.* 2013, Vélez-Espino *et al.* 2014, Shields *et al.* 2018). Unusually high mortality has followed periods of reduced or low Chinook abundance. In addition, the probability of calving is 50% higher following years of higher Chinook abundance (Ward *et al.* 2009).

Nutritional stress associated with lack of prey is considered the prime causes of late pregnancy failure and a key stressor in 69% of the failed pregnancies that occurred between 2008 and 2014 (Ayres *et al.* 2012, Wasser *et al.* 2017). Levels of nutritional and physiological stress are also linked to local and regional stock abundance in the Fraser and the Columbia Rivers (Ayres *et al.* 2012, Wasser *et al.* 2017). Hormone stress levels in Southern Residents that correspond with early Fraser River and Columbia River Chinook abundance support prior relationships established between Southern Resident vital rates and the coast wide Chinook abundance index.

Because the loss of individual fetuses, calves, and mature whales to malnutrition has population-level consequences, the Southern Resident population can be characterized as ‘food stressed’. This finding was reinforced by the conclusions of Lacy *et al.* (2017) who identified consumption of Chinook salmon as the most important factor limiting the recovery of Southern Residents.

To better understand the importance of specific stocks to the diets of Southern Residents, NOAA Fisheries (2018) developed a conceptual model to identify and rank priority stocks. Table 2.1 shows the ranked importance of BC’s Chinook salmon populations as determined from 32 stock groups on a scale of 0.0 to 5.0. These rankings were determined based on: i) observation of Chinook in their diet; ii) consumption of specific Chinook stocks during reduced body condition; and iii) degree of spatial and temporal overlap between Chinook stocks present and Southern Residents. NOAA’s findings stress the importance of all three run timing groups (spring, summer and fall) of Fraser River Chinook to Southern Residents. Fall Fraser River Chinook (along with other Georgia Strait stocks) rank in the top 7%, Spring Fraser Chinook rank in the top 21%, and the Summer Fraser Chinook rank in the top 44%.

**Table 2.1.** The importance of British Columbia’s Fraser River, Georgia Strait and West Coast Vancouver Island Chinook populations to the diets of endangered Southern Resident killer whales based on observed Chinook stocks in diet, Chinook stock consumption during reduced body condition, and degree of spatial and temporal overlap between Chinook stocks and SRKWs. Source: NOAA Fisheries 2018

Stock Region	Run type	Rivers /Stock in Group	Total Score	Rank
Strait of Georgia	Fall, ocean type	Lower Georgia Strait (Cowichan, Nanaimo); Upper Strait (Klinaklini, Wakeman, others); Fraser (Harrison)	4.63/ 5.0	# 4/32
Fraser River	Spring, stream type	Spring 1.3 (Upper Pitt, Birkenhead; Mid & Upper Fraser; North and South Thompson) and Spring 1.2 (Lower Thompson, Louis Creek, Bessette Creek)	4.25/ 5.0	#6/32
Fraser River	Summer, ocean type and stream type	Summer 0.3 (South Thompson & Lower Fraser; Shuswap, Adams, Little River, S. Thompson mainstem, Maria Slough in Lower Fraser) and Summer 1.3 (Nechako, Chilko, Quesnel; Clearwater River in North Thompson)	3.31/ 5.0	#15/32

West Coast Vancouver Island	Fall Ocean type	Robertson Creek, WCVI Wild	1.38 /5.0	#25/32
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### 2.1.1 The status of Fraser River and Southern BC Chinook salmon

Any project or activity that threatens Chinook abundance by extension threatens Southern Residents and their critical habitat. As discussed further below, Project Related Shipping poses such a risk to Southern Residents. This is a particular concern because Chinook abundance is already in decline.

Throughout the range of Southern Residents, wild Chinook salmon abundance has declined, in some places substantially, over the last century. Although 20th century historic declines have been far better documented in the US (NRC 1996, Montgomery 2003), many of the wild Chinook salmon populations that Southern Residents rely on in BC have declined in recent decades (Riddell *et al.* 2013, DFO 2016).

In 2005, Canada’s Wild Salmon Policy set a goal of “restoring and maintaining healthy and diverse salmon populations and their habitat”. British Columbia’s diversity of Chinook salmon streams and populations were assembled into genetically unique and irreplaceable conservation units (“CU”). A CU is defined as a group of salmon, which if extirpated, would be unlikely to re-colonize within human time frames.

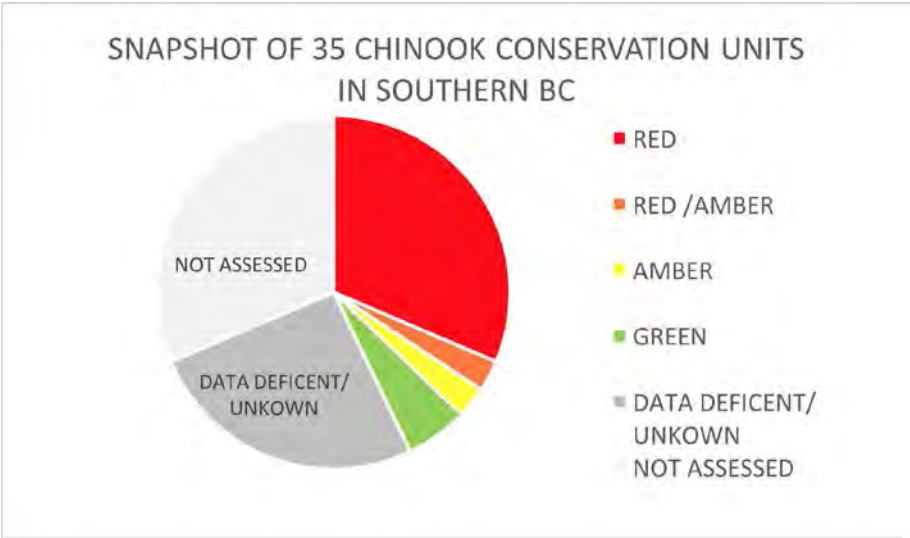
In southern BC, there are more than 400 spawning populations (Riddell *et al.* 2013, DFO 2017) grouped into 35 CUs that reflect the diverse freshwater and marine life histories and ocean migration patterns of Chinook. The health of these CUs was assessed in a DFO led process<sup>[1]</sup> in 2014 using criteria under the Wild Salmon Policy. Various metrics of CU health were integrated into a stoplight status of *Green* (not at risk), *Yellow* (management caution) and *Red* (a danger zone requiring more aggressive management action to prevent further decline).

Of the 35 CUs of Chinook salmon reviewed, only 15 were assigned a status (Figure 1). The remaining 20 CUs did not have enough data for assessment (9) and or could not be assessed due to the unknown contribution of hatchery salmon to the total abundance (11). These unknown CUs could range in status from Green to Red to extirpated.

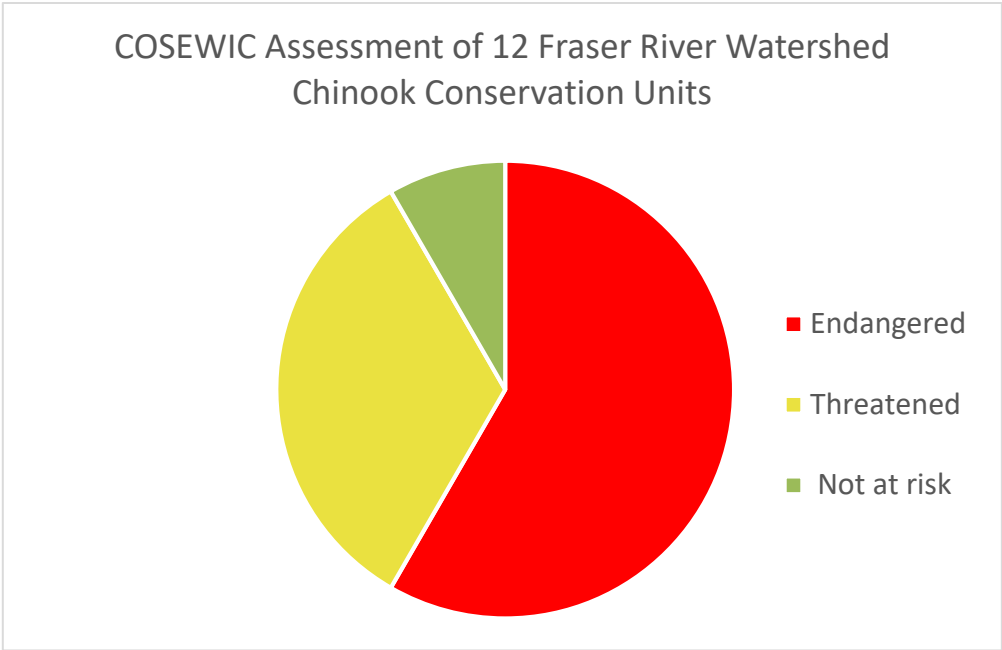
Of the 15 conservation units with a determined status, only two were considered not at risk. 87% were at levels of risk that require moderate to extensive management intervention to prevent them from further decline or extinction. Table 2.2 shows the status of the stocks identified as important to the Southern Residents based on reviews under the Wild Salmon Policy and more recently by COSEWIC.

<sup>[1]</sup> Canadian Science Advisory Secretariat workshop held in Feb 2014.

**Figure 2.1** A review of 35 conservation units in Southern BC shows 57% of units (20) could not be assessed. CUs with stop light designations show 80% are in risk zones that require proactive measures to prevent them from further decline (11 Red and 1 Red/Amber).



**Figure 2.2.** The status of 12 CUs from the Fraser watershed (including the Thompson watershed) as assessed by COSEWIC in 2018. The seven endangered CUs are early timed Chinook that return in the spring and early summer. The four threatened CUs include Chinook from spring and summer run timings and one lower Fraser fall run timing. One CU, South Thompson summer run ocean type, was assessed as not at risk.



**Table 2.2** The Wild Salmon Policy status of BC Chinook populations associated with the NOAA priority stocks to the diets of Southern Resident killer whales

Stock Group	Run type	Stock group with Rivers	Conservation Unit (CU)	Rank for stock group	WSP Status	COSEWIC Status
Strait of Georgia	Fall Ocean type	Lower Georgia Strait –Nanaimo	East VI -Nanaimo & Chemainus Fall 0.X	# 4/32	TBD/Not Assessed	Not Assessed
		Lower Georgia Strait –Cowichan	East VI - Cowichan & Koksilah Fall 0.X	# 4/32	TBD/Not Assessed	Not Assessed
		Lower Georgia Strait- others	East VI -Qualicum and Puntledge Fall	# 4/32	TBD/Not Assessed	Not Assessed
		Upper Georgia Strait - Wakeman	South Mainland-Southern Fjords Fall 0.X	#4/32	Data Deficient	Not Assessed
		Fraser (Harrison)	Lower Fraser Fall	#4/32	GREEN	Threatened
Fraser River	Spring, stream type	Spring 1.3 Birkenhead	Lower Fraser River springs 1.3	#6/32	TBD/Not assessed	Special Concern
		Spring 1.3 Middle Fraser	Middle Fraser River spring 1.3	#6/32	RED	Threatened
		Spring 1.3 Upper Fraser	Upper Fraser River spring 1.3	#6/32	RED	Endangered
		Spring 1.3 North Thompson	North Thompson Spring 1.3	#6/32	RED	Endangered
		Spring 1.2 Lower Thompson, Louis Creek	Lower Thompson Spring 1.2	#6/32	RED	Not assessed
Fraser River	Summer, Ocean type	Summer 0.3 South Thompson Little River,	South Thompson Summer 0.3	#15/32	GREEN	Not at Risk

		Summer 0.3 Adams River	Upper Adams River Summer x.x	#15/32	TBD/not assessed	Not Assessed
		Shuswap River	Shuswap River Summer 0.3	#15/32	TBD/not assessed	Not Assessed
		Maria Slough, Lower Fraser	Maria slough summer 0.3	#15/32	TBD/ not assessed	Not Assessed
	Summer, stream type	Summer 1.2 South Thompson - Bessette Cr	South Thompson - Bessette Cr Summer 1.2	#15/32	RED	Endangered
		Summer 1.3 North Thompson, Clearwater River	North Thompson Summer 1.3	#15/32	RED	Endangered
		Summer 1.3 South Thompson	South Thompson Summer 1.3	#15/32	RED/ AMBER	Endangered
		Summer 1.3 Upper Pitt	Lower Fraser Upper Pitt Summer 1.3	#15/32	RED	Endangered
		Summer 1.3 (Nechako, Chilko, Quesnel)	Middle Fraser River Summers 1.3	#15/32	AMBER	Threatened
Georgia Strait	Summer stream type	Upper Georgia Strait - Klinaklini	Klinaklini Summer 1.3	#15/32	Data Deficient	Data Deficient
West Coast Vancouver Island	Fall Ocean type	Robertson Creek	WCVI -North Fall	#25/32	TBD/ not assessed	Not Assessed
West Coast Vancouver Island		WCVI Wild	WCVI -South Fall 0.x	#25/32	RED	Not Assessed
West Coast Vancouver Island		WCVI Wild	WCVI -Nootka & Kyuquot Fall 0.x	#25/32	RED	Not Assessed



### 2.1.2 Fraser River Chinook

The Fraser River is Canada's most productive salmon watershed. It hosts 19 conservation units of Chinook salmon that return to spawn in the upper, middle and lower Fraser River and its sub basins, from spring to fall (historically from March - October) consisting of both stream type and ocean type life histories. Hanson *et al.* (2010) found that 80-90% of Southern Resident summer diet (May - September) consisted of Chinook from the Thompson watershed, the upper, middle and lower Fraser.

Within the 19 Fraser Chinook CUs, 8 (42%) do not have a status under the WSP due to either the lack of assessment data or their unknown percentage of hatchery origin salmon. Of the 11 CUs assessed, only 2 (one summer ocean type and one fall) are considered Green (not at risk). All assessed spring run timing CUs are in the Red Zone (4) and most of the summer stream type CUs are either Red (3), Red/Amber (1) or Amber (1).

In 2018, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) reviewed 12 CUS from the Fraser watershed and three from the Inner South Coast. COSEWIC assessed 58% (7) of the Fraser Chinook CUs as endangered, and 33% (4) as threatened. They found only 1 CU (8%) of the 12 they assessed was not at risk (Figure 2.2)

The low abundance of early timed Fraser Chinook also correlates with the increased circulation of Persistent Organic Pollutants in Southern Residents, such as flame retardants, PCBs and DDT, presumably due to increased fat metabolism in response to nutritional stress (Lundin *et al.* 2016). The release and metabolism of these pollutants may be a contributor to late term pregnancy failure and perinatal loss (i.e. calf death in the hours and days after birth) documented to have occurred in Southern Residents since 2008 (Wasser *et al.* 2017).

The Albion abundance index<sup>6</sup> for Chinook entering the lower Fraser shows that spring and early summer Chinook that enter the Fraser before mid-July are at a fraction of their former abundance (Figure 2.2). All of these Fraser CUs showed more than a 50% decrease in "spawner abundance"<sup>7</sup> in the last three generations (Riddell *et al.* 2013), and have persistently failed to meet their "spawner escapement targets."<sup>8</sup>

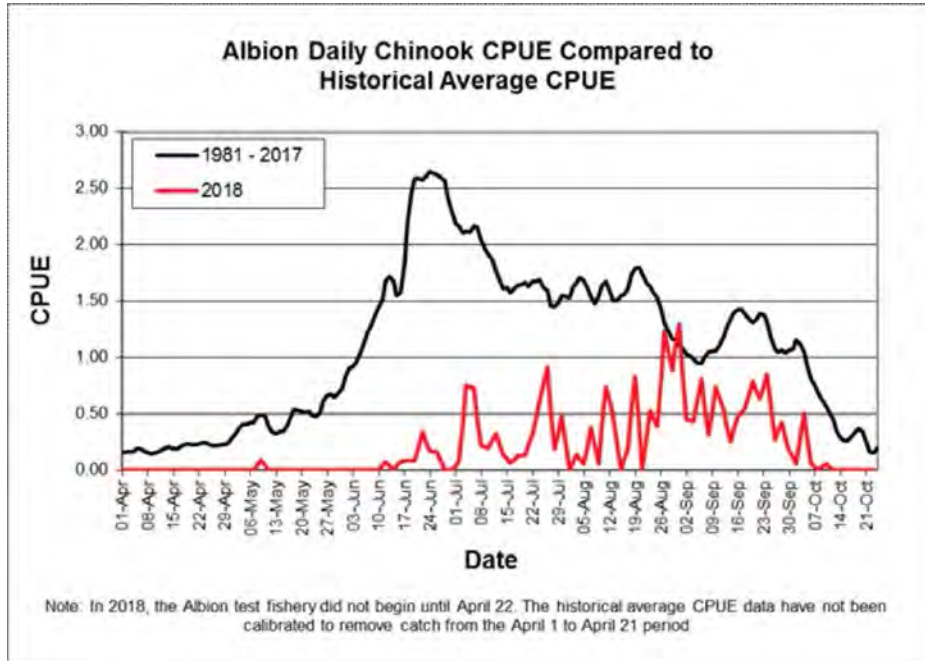
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<sup>6</sup> The number of spring and early summer Chinook returning to the Fraser watershed is determined from the Catch Per Unit Effort (CPUE) in the Albion test fishery gillnet. This catch provides an index of total abundance.

<sup>7</sup> Spawner abundance is number of mature salmon that escape fisheries and other predators to reach their spawning grounds to spawn.

<sup>8</sup> Escapement targets are the number of spawning salmon fisheries managers strive to achieve in order to produce the next generation of fish.

**Figure 2.3** DFO’s Albion test fishery shows the catch per unit effort (CPUE) on the three run-timing groups of Chinook salmon migrating through the lower Fraser River. 2018 was the worst return on record for these spring and early summer Chinook. Abundance peaks in the later run-timing groups through the lower Fraser in August (South Thompson) and fall (Harrison) have also declined.



### 2.1.3 Chinook declines are more than numbers

Decline in Chinook is not limited to abundance. The age and size of Chinook at maturity, the temporal run timing of Chinook, and the diversity of Chinook populations spatially and temporally are all also in decline. Fewer, smaller fish with truncated run timings adversely affect the nutritional and physiological requirements of Southern Residents, their foraging efficiency, their social ecology (sharing large fish), and their presence in historic habitats.

Historically, Chinook salmon matured from 3-8 years of age and prized fish were upwards of 80-100 lbs. Ohlberger *et al.* (2018) documented coast wide changes in Chinook demographics such as younger age-at-maturity, reduced size-at-age, and reduced fecundity of female spawners. These demographic changes are being observed in the Fraser River and Georgia Strait Chinook salmon populations. Today, very few fish are older than 5 years. Smaller fish represent a decline in productivity. In the last decade, Thompson Chinook (which originate in the Fraser watershed) have shown a 20% decline in their size at age and an associated decline in fecundity. This trend toward smaller female Chinook (with fewer eggs) is also seen in the Nicola and Chilco populations within the Fraser and the Quinsam and Big Qualicum in Georgia Strait (DFO CSAS 2018). Smaller and younger Chinook salmon will have lower caloric value. There is also considerable variability in caloric value (arising from body condition and lipid stores) of Chinook salmon, which means that the Southern

Residents need approximately twice as many “lean” salmon to survive as they would “calorie-rich” salmon (Noren 2011).

#### **2.1.4 Loss of Chinook diversity**

The potential for, and existence of, extirpated component populations and conservation units represents a decline in genetic diversity. The extirpation of CUs begins with the loss of their component spawning populations. Slaney *et al.* (1996) identified 17 Chinook spawning populations out of 447 (province wide) as extinct in 1996. They identified another 47 at high risk of extinction. In 2013, spawning populations in the Skwawka River, Toba River and Tzoonie River in the *Southern mainland-Georgia Strait* CU were identified as extirpated. Chinook spawning populations in the Ahnuhati River, Southgate River and Teaquahan River of the *Southern mainland- Fjords* CU have also been categorized as extirpated. Spawning populations in Deserted Creek, Eliza Creek and Park Creek in the *Southwest Vancouver Island* CU have also been categorized as extirpated. In the Fraser River, spring run timing populations from the Alouette and Stave Rivers that composed the lower Fraser-spring CU are considered extirpated. This original spring run timing conservation unit has been lost and while Chinook currently spawn in these rivers, they originate from another CU with a fall, ocean-type life history pattern. The known loss of at least one, and potentially more spring run timing conservation units from the Fraser is worrisome and represents a decline in diversity and abundance that has had and will continue to have ecosystem-level consequences.

#### **2.1.5 Failure of the Wild Salmon Policy and lack of recovery plans**

Canada suggests in its evidence filed in the reconsideration that DFO is addressing prey availability for Southern Residents through rebuilding of stocks.

The conservation of Pacific salmon, through the protection and rebuilding of depleted conservation units, is the intent and purpose of the Wild Salmon Policy. The status of Southern BC Chinook populations however has declined to where 15 conservation units with an assessed status show 11 in the ‘Red’ zone, and all the assessed Fraser River spring CUs are assessed as endangered under COSEWIC. Despite knowledge of this problem for many years, no recovery plans exist for any Chinook CUs in BC. Salmon management has failed to rebuild weak and collapsed wild Chinook CUs or manage them in a precautionary manner. Recovery efforts are a mandated part of DFO’s obligations under the Wild Salmon Policy and Canada’s Sustainable Fishery Framework, yet no plans exist

The latest iteration of the WSP 2018-2022 implementation plan further defers action on addressing depleted conservation units and fails to move forward with rebuilding plans for “red zone” CUs. Instead, it provides a 2022 deadline for preparing a strategy for “red zone” conservation units, which suggests that rebuilding is not a priority objective. This is despite a broad scientific understanding of salmon ecology and threats facing populations.

## **2.2 An oil spill could harm Fraser Chinook and further degrade prey availability for Southern Residents in critical habitat**

Chinook populations from the Fraser River are recognized as critically important to the diets and survival of Southern Resident killer whales. Many Fraser River populations are assessed as Red under Canada's Wild Salmon Policy and several were recently proposed for listing under the *Species at Risk* (COSEWIC 2018). Factors contributing to the degraded status of Chinook include habitat loss, overfishing and mixed stock fisheries, climate change effects on aquatic environments, predation, hatchery programs and marine carrying capacity. Given these threats, the importance of functioning habitat is paramount, especially during vulnerable juvenile life stages. Estuary residency is a critical period where Chinook undergo osmoregulatory<sup>9</sup> transition from a freshwater to a marine life stage. All types of Chinook rely on the estuary to varying degrees, however ocean-type Chinook rely on nearshore estuary habitat to the greatest extent. Oil spills that degrade estuary habitat can have lethal and sub-lethal consequences for Chinook survival at juvenile (including fry and smolt) and future (immature and adult) life stages. A full discussion of exposure pathways, potential toxicological consequences and oil spill implications to Fraser River Chinook (and other salmon) was undertaken by Raincoast and submitted to the NEB in the Logan *et al.* Report 2015 (NEB filing ID A4L9F4). This section is a bridge that links those findings with implications for Southern Resident killer whales and their critical habitat.

### **2.2.1 Southern Resident critical habitat includes availability of primary prey, Fraser Chinook salmon**

DFO's 2011 Recovery Strategy states that resident killer whales require habitat features that make salmon prey available to them, and as such their presence is closely associated with the presence of their preferred prey, Chinook salmon. Chinook salmon from the Fraser River can comprise 80-90% of Southern Resident diet in the summer months (Hanson *et al.* 2010). The recovery strategy identifies habitat that supports the presence of Southern Resident preferred prey (*i.e.* Fraser Chinook) to be an "overwhelming feature of the environment that affects their distribution". As such, habitat includes "food supply" and areas on which species depend "indirectly". In other words, Southern Residents rely indirectly on the Chinook salmon habitat in the Fraser River estuary, and a reduction in the quantity, quality, and availability of this habitat limits the carrying capacity and recovery of Southern Resident killer whales. As discussed below, Project related shipping and the risk of an oil spill in the Fraser River estuary threatens the health of Chinook salmon and could have significant consequences for Southern Residents.

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<sup>9</sup> Salmon must regulate their fluid and electrolyte (salts) balance with the salinity of their surroundings.

## 2.2.2 The importance of the Fraser River Estuary for Chinook salmon

The Fraser estuary is the largest estuary on the west coast of North America and is fundamental to the Fraser watershed's role as Canada's most important producer of Chinook salmon. All 19 Chinook salmon conservation units that spawn in the Fraser watershed rely on habitats within the Fraser estuary for rearing, feeding, migration, and protection from predators in their juvenile life stage. They equally rely on the estuary for holding and migration in their adult life stages.

The delta on Roberts Bank and Sturgeon Bank is characterized by shallow sloped sediments that create an intertidal area of more than 150 km<sup>2</sup> of habitats that include mudflats, sandflats, salt marshes, biofilm and eelgrass (Hutchinson, 1988; Luternauer *et al.*, 1995 in Balke 2017, Jardine *et al.* 2015).

The expanses of soft sediment habitats support diverse and abundant invertebrate communities (Otte and Levings 1975, Harrington *et al.* 1999) that in turn support Chinook salmon and the foodweb of which they are a part. The main primary producers on the mudflat surface are benthic microalgae (e.g. diatoms that dominate biofilm); however, benthic macroalgae<sup>10</sup> such as *Ulva* can also be present (Harrison *et al.* 1999, M. MacDuffee pers. observation). The dominate taxonomic groups on Sturgeon and Roberts Banks are from 35 species of amphipods, bivalves, decopods, harpacticoid (benthic) copepods, isopods, nematodes, oligochaetes and polychaete worms (Otte and Levings 1975).

The features and processes in these tidal, soft sediment flats and nearshore marshes combine to create nursery conditions that support the millions of out-migrating juvenile Chinook salmon moving into the estuary from the upper, middle and lower portions of the watershed every spring. They rely on the low salinity and shallow, protected habitats to feed, grow, evade predators and undergo osmoregulatory changes before migrating into deeper waters of Georgia Strait (Levy and Northcote 1982; Levings *et al.* 1995, Raincoast unpublished data).

Studies from estuaries all along the Pacific coast confirm the importance of the estuary environment for the development of juvenile salmon. Moore *et al.* (2016) found that 25% of juvenile Chinook individuals in the Skeena estuary spent at least 33 days to undertake these activities. Larger Chinook salmon resided in the Skeena estuary for longer durations, growing at an estimated 0.5 mm per day, evidence that estuary residency provides growth opportunities. In the Columbia estuary, McNatt *et al.* (2016) found many juvenile Chinook salmon remained in the saltmarsh for 2 – 4 weeks and increased their fork lengths by 10–20 mm, with an average growth rate of 0.53 mm/day. Levy and Northcote (1982) found that juvenile Chinook reared in the Fraser estuary from March until June and demonstrated significant growth over that period relative to fish captured upstream.

## 2.2.3 Environmental conditions in the Fraser River estuary

The boundaries of the estuary change with seasonal discharge, but the upstream river is tidal to Mission during low flow periods, with the saline wedge extending to New Westminster (Ages 1979; Hall and Schreier 1996). New Westminster is also where the river begins to fan out into its deltaic

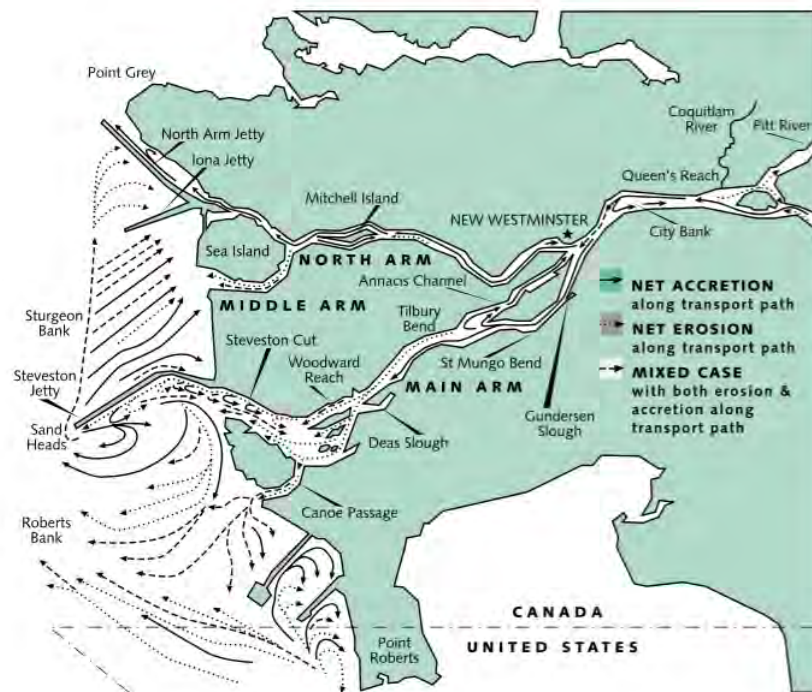
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<sup>10</sup> Macro algae are multi-cellular algae and include the kelps; micro algae are single celled and microscopic

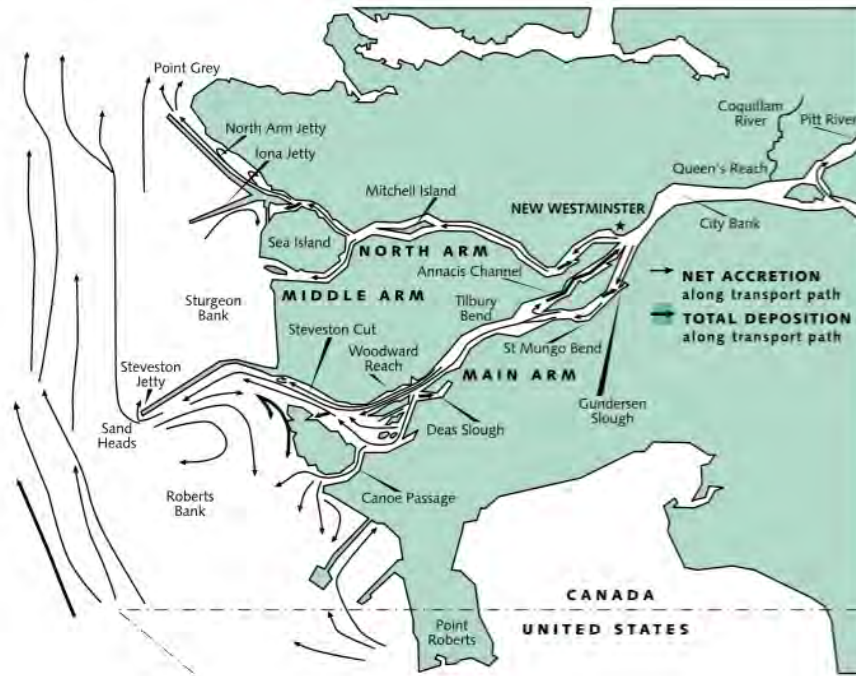
floodplain as it approaches Georgia Strait. On the marine side, the estuary comprises the majority of the Southern Strait of Georgia (Pawlowicz et al. 2017, Harrison *et al.* 1999).

Sediment discharge through the arms of the lower Fraser River and into Georgia Strait is sand-dominated followed by silt and clay, with the highest sediment discharge during the peak freshet in early summer, and lower sediment discharge from late summer to early spring (Milliman 1980; McLean *et al.* 1999). The average annual suspended sediment load moving through the lower Fraser is approximately 17 million tonnes/year (McLean *et al.* 1999). Suspended sediment drops out of suspension as the lower Fraser flows through the floodplain (Milliman 1980). The marshes and tidal flats on Sturgeon and Roberts bank receive more than 12 million m<sup>3</sup> of sediment from the Fraser annually (Schaefer 2004 *in* Balke 2017). Roberts and Sturgeon Banks are also characterized by the presence of several riprap and armoured jetties that repeatedly bisect the delta. Sediment transport on the delta is complicated by these structures but general pathways are depicted in Figure 3a and 3b (McLaren and Tuominen 1999).

**Figure 3a.** Sediment transport pathways for clay and silt coming from the north, middle and main arms of the Fraser River onto the outer delta of Roberts and Sturgeon Banks in the Fraser estuary. Source: McLaren and Tuominen 1999



**Figure 3b.** Sediment transport pathways for clay and silt coming from the north, middle and main arms of the Fraser River onto the outer delta of Roberts and Sturgeon Banks in the Fraser estuary. Source: McLaren and Tuominen 1999



Sediment leaving the Fraser can often be visually detected when it enters Georgia Strait as the “Fraser plume”. During the Fraser River freshet, a layer of brackish water with very high sediment loads and salinities of less than 15 ‰ forms the top few metres over most of the central and southern sections of Georgia Strait (Pawlowicz et al. 2017, Thomson 1981). The large concentrations of sediment delivered into the Fraser estuary increase the likelihood of forming oil-sediment aggregates if this sediment comes in contact with oil. This, in turn, increases the likelihood of oil sinking once these aggregates have been formed.

#### 2.2.4 Potential impacts of spilled oil in the Fraser River Estuary

Seasonal conditions of wind, waves and visibility are critical factors in spill response. The percentage of time that a marine spill response (on-water recovery with aerial reconnaissance) cannot be deployed due to environmental conditions is known as a spill response ‘gap’.<sup>11</sup> Estimates of oil spill response gaps for Georgia Strait were determined by Nuka Research (2015). Times when wind, wave, and on-water visibility would prevent responses in open and protected waters are roughly half of the

<sup>11</sup> The ability to deploy a response does not guarantee any level of success.

time (47% open water and 51% protected water). The response gap is higher during winter (63% for protected water systems; 48% for open water systems) than summer (38% protected water; 35% for open water). Across the entire tanker route (Burrard Inlet through Juan de Fuca Strait) response during the winter was not possible 56 -78% of the time.

Nuka Research (2015) also examined best case estimates of maximum oil recovery given timely response deployment. 72 hours after a summer oil spill in Georgia Strait, 27% of oil was expected to be recovered, 22% evaporated and 51% would still remain on the water. In winter, 15% was recovered, 21% evaporated, and 64% of the oil still remained on the water. Thus, under the most optimistic recovery scenarios, a 16,000 m<sup>3</sup> spill would have (on average) more than 9,000 m<sup>3</sup> of unrecovered oil after 3 days of spill recovery efforts.

When considering the consequence of oil spills in the rearing habitat of juvenile Chinook salmon, implications for direct toxicity, as well as contamination of food sources and habitat features depend on the type of oil, the physical and hydrogeological conditions in the estuary at the time (freshet stages of discharge, sediment and turbidity, tides, winds, currents, etc.), the nature of the shoreline, and the weathering of the oil. The presence of freshwater reduces water density and increases the potential for oil to sink.

Balke (2017) has described the salinity<sup>12</sup> in the salt marshes of Roberts and Sturgeon Banks as being within the oligohaline (practical salinities of 0.5 to 5 ‰ (parts per thousand)) to mesohaline (practical salinities of 5 to 18 ‰) range.

Weather and prevailing winds further influence the amount of fresh and saltwater mixing. The Fraser has strong, persistent westerly winds that slow water from draining the leading edge of the marshes during the ebb tide (Balke 2017). The intertidal marsh vegetation that forms the leading edge of the estuary also contributes organic material to the delta (Balke 2017). Wind and waves can mix salinities and sediment and physically transport spilled oil. This combination can result in the flocculation<sup>13</sup> and settling of sediment particles (NAS 2016).

Where oil is associated with these particles, it can submerge or sink mostly as a result of oil-particle interactions. Oil slicks, emulsions, and droplets can accumulate suspended particles in the water column, decreasing their buoyancy and increasing the likelihood that they will sink or submerge. Known as “oil-sediment aggregates” (OSAs), these small particles can be stable in water over periods of weeks (Lee *et al.* 2001). OSAs in the water column can release oil droplets over time (Lee *et al.* 2002), and sunken OSAs can shed their sediment burdens and refloat (Environment Canada 2013), creating chronic exposure routes.

The potential for OSA formation increases with increasing sediment concentration, decreasing grain size, increasing organic content, and low salinities (Ajjolaiya *et al.* 2006, Khelifa *et al.* 2008, Floch *et al.*

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<sup>12</sup> Seawater has an average salinity of 35 ‰; freshwater has a salinity near zero. The brackish conditions of estuaries range between these two depending on where measurements are taken and the conditions present.

<sup>13</sup> A condition in which clays and other small particles group together to form a larger structure, known as a floc.



2002). Le Floch *et al.* (2002) reported that if salinity is below 1‰, OSA formation is inhibited; values greater than 2‰ are typically required. Due to estuarine circulation in the lower Fraser River, this threshold of 2‰ is reached at 22 km upstream (New Westminster) in bottom waters, to Annacis Island at depths of 10 m, and throughout the water column as far as the Oak Street Bridge on the North Arm and to Steveston on the south arm (Ages 1979; Hall and Schreier 1996). The Fraser plume across the delta and into Georgia Strait has salinities that are typically below 15 ‰.

Salinity gradients can also be important in controlling the sinking rate of oil, with lower salinities (i.e. decreased density) dictating higher likelihoods of sinking. Low to moderate salinity with suspended particulate matter are typical conditions on the Fraser delta and within the Fraser plume of Georgia Strait, with exceptionally high suspended sediment loads during the freshet (Pawlowicz *et al.* 2017). These combined conditions would not only contribute to the submergence and sinking of spilled oil, but would stabilize water-in-oil emulsions. While heavily weathered dilbit may be so viscous that water cannot penetrate the oil mass (Fingas 2014), thereby preventing the formation of emulsions, the presence of diluent, at least in the first days of the spill, may decrease the viscosity sufficiently to allow for emulsion formation. These emulsions (stable to semi-stable mixtures of oil and water) are of concern because they can persist long after the spill is over (e.g. Short *et al.* 2007). While the outer shells are heavily weathered, the oil within the emulsion can remain compositionally similar to, and retain the toxicity of, the original product (Irvine *et al.* 2006).

The soft sediment marsh features of the Fraser estuary, along with man-made jetties, predispose spilled oil that reaches the estuary to strand. The likelihood of recovering stranded oil is affected by substrate type, depth of oil penetration, ocean and weather conditions. It is also affected by the ability of the shoreline to support traffic and other infrastructure required for clean-up. Further, as occurred following the Kalamazoo oil spill in 2010, the environmental costs of clean-up may be deemed to exceed the perceived benefits, such that the oil is simply left in place.

The intertidal shoreline of the Fraser delta is a difficult area to access in the best of conditions. Sediments are exceptionally soft in many locations (mud consisting of silt and clay), water depths shift rapidly, currents can be strong, and much of the intertidal zones on Roberts and Sturgeon Bank are challenging to access from shore.

Soft marsh sediments and riprap jetties also complicate recovery efforts. While low flow conditions in the winter may result in more stranding at lower elevations, tidal and wind conditions in all seasons can deliver oil to shore and facilitate its stranding on sandflats, mudflats, eelgrass, and throughout the marshes, coating and fouling these habitats for use by vertebrate and invertebrate species. Recovery of much of this oil would be extremely difficult, if not impossible, creating the potential for it to percolate into soft sediments and persist. Mixed and trapped in sediments, it could be protected from various types of weathering (e.g. biodegradation, photo-oxidation, evaporation, and dissolution) (e.g. Short *et al.* 2006), and available for re-oiling when disturbed, creating an ongoing source of toxicity. Stranding can also add further terrestrial materials (e.g. sediment), increasing the likelihood that any oil reintroduced to the water column will submerge and/or sink.

### 2.2.5 Consequences for juvenile Chinook and Southern Resident killer whales from an oil spill in the Fraser River Estuary

During smoltification, salmon are under physiological stress and highly sensitive to additional stressors, including disease and degraded habitat conditions (Folmar and Dickhoff 1980). Given the predicted rapid transit times of spilled oil to reach the delta (24-48 hrs) as modelled by Trans Mountain for oil spilled in Georgia Strait - or faster depending on the spill location and the conditions - it is possible that the oil will still contain acutely toxic low molecular weight components, such as BTEX and naphthalenes.

Juvenile Chinook that rely on the Fraser estuary for the first few weeks to months of their ocean entry are vulnerable to acute toxicity from the water soluble fractions of oil within the first few days of the spill. Contamination of shorelines and substrate can then further affect juvenile Chinook directly and indirectly.

Invertebrates are the primary food source for juvenile Chinook when feeding in the estuary (including cladocera, harpacticoid copepods, gammarid and other amphipods, mysids, *Daphnia*, chironomids etc.). Toxicity-induced mortality of invertebrates coated in oil may limit prey/food abundance for Chinook, and secondly, dietary exposure to PAHs can impact survival, growth, and development. PAHs have been shown to compromise immune function in fish, resulting in increased susceptibility to pathogens and disease and subsequent increases in mortality. (A detailed discussion of these effects can be found in Section 5 of Logan *et al.* 2015 (NEB ID A4L9F4).

In the shallower waters of the estuary, phototoxicity (sunlight-enhanced toxicity) may present an additional risk factor. Photosensitive PAHs exhibit enhanced toxicity to fish at concentrations as low as 1.0 µg/L (Dong *et al.* 2000, Little *et al.* 2000, Barron and Ka'Aihue 2001, Incardona *et al.* 2012).

PAH exposure from oil spills also has the potential to cause genotoxicity, including chromosomal damage and altered regulation of the genes responsible for multiple processes and products (Hose and Brown 1998, Aas *et al.* 2000; Whitehead *et al.* 2012; See section 5.4.3 of Logan *et al.* 2015 NEB ID A4L9F4)

Once oil has become entrained in the substrate and shorelines of the Fraser estuary or soluble in the water column, its presence and fate are not reversible. Mortality of juvenile Chinook can be caused by acute toxicity, the loss of food resources due to physical oiling of habitat, the loss of food resources due to chronic oil toxicity, and the lethal and sub-lethal effects that can accrue from consuming toxic prey. The effects from such exposure would not likely be restricted to the year of spill; they would likely extend over years, potentially through all age classes and brood years of Fraser Chinook. The ability to adversely affect year classes could have generational consequences for Chinook abundance.

In addition to the potential long term population-level consequences for Fraser Chinook, the immediate loss of Chinook abundance in any Fraser run timing group would have implications for Southern Residents in the same way that the existing collapse of early Fraser Chinook is linked to altered use of critical habitat (Shields *et al.* 2018), increased stress (as measured by T3 and GC

hormones), higher mobilization of contaminants, and pregnancy failure (Lundin *et al.* 2016, Wasser *et al.* 2017). These are important factors in the recruitment failure observed in Southern Residents (Wasser *et al.* 2017), their current declining trend (Lacy *et al.* 2017) and their failure to demonstrate signs of recovery (DFO 2017).

## Literature cited

Ages A. 1979. The salinity intrusion in the Fraser River: salinity, temperature and current observations, 1976, 1977. *Pacific Marine Science Reports*. 79-14: 193 p.

Ajjolaiya, L.O., P.S. Hill, A. Khelifa, R.M. Islam and K. Lee. 2006. Laboratory investigation of the effects of mineral size and concentration on the formation of oil–mineral aggregates. *Marine Pollution Bulletin* 52(8), 920-927

Barron, M.G. and L. Ka’aihue. 2001. Potential for photo-enhanced toxicity of spilled oil in Prince William Sound and Gulf of Alaska waters. *Marine Pollution Bulletin* 43:86-92.

Balke, Eric. 2017. Investigating the role of elevated salinity in the recession of a large brackish marsh in the Fraser River estuary. Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in the Ecological Restoration Program Faculty of Environment (SFU) and School of Construction and the Environment (BCIT).

Colegrove K.M., S. Venn-Watson, J. Litz, M. Kinsel, L. Garrison, K. Terio, C. Mori, A. Rosenstein, R. Carmichael, E. Fougères, B. Mase-Guthrie, R. Ewing, D. Shannon, S. Shippee, S. Smith, L. Staggs, E. Stratton, M. Tumlin, and T. Rowles. 2013. Marine mammals, oil and the Gulf of Mexico: perspectives on the 2010-2013 Northern Gulf of Mexico cetacean unusual mortality event. *Proceedings of the American College of Veterinary Pathologists 2013 General Meeting November 17, 2013*. 5pp.

DFO. 2011. Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada. *Species at Risk Act Recovery Strategy Series*, Fisheries & Oceans Canada, Ottawa, ix + 80 pp.

DFO. 2016. Integrated Biological Status of Southern British Columbia Chinook Salmon (*Oncorhynchus tshawytscha*) Under the Wild Salmon Policy. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2016/042.

DFO. 2018. Science information to support consultations on BC Chinook salmon fishery management measures in 2018. Canadian Science Advisory Secretariat Pacific Region Science Response 2018/035

Dong, S., H.M. Hwang, C. Harrison, L. Holloway, X. Shi, H. Yu. 2000. UVA light-induced DNA cleavage by selected polycyclic aromatic hydrocarbons. *Bulletin of Environmental Contamination and Toxicology* 64:467-474.

EBA Tetra Tech Company. 2013. Modelling the fate and behavior of marine oil spills for the TransMountain Expansion Project. Volume 8C Technical Report prepared for TransMountain Pipelines ULC, Calgary Alberta

Fingas, M. 2014. Water-in-oil emulsions: formation and prediction. *Journal of Petroleum Science Research* 3(1) doi: 10.14355/jpsr.2014.0301.04

Ford, J.K.B., G.M. Ellis, P.F. Olesiuk and K.C. Balcomb. 2010a. Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator? *Biology letters* 6:139–42.

Ford, J.K.B, B.M. Wright, G.M. Ellis and J.R. Candy. 2010b. Chinook salmon predation by resident killer whales: seasonal and regional selectivity, stock identity of prey, and consumption rates. DFO Canadian Science Advisory Secretariat Research Document 2009/101. iv + 43 p.

Ford, M.J., J. Hempelmann, M.B. Hanson, K.L. Ayres, R.W. Baird, C.K. Emmons, J.I. Lundin, G.S. Schorr, S.K. Wasser and L.K. Park. 2016. Estimation of a killer whale (*Orcinus orca*) population's diet using sequencing analysis of DNA from feces. *PLoS One*. 11(1):e0144956.

Geraci J.R. and D.J. St. Aubin. 1990. Sea mammals and oil: confronting the risks, Academic Press, San Diego, California.

Gunton, T. and S. Broadbent. 2015. An Assessment of Spill Risk for the Trans Mountain Expansion Project submitted to the National Energy Board. School of Resource and Environmental Management Simon Fraser University.

Hall, K. J., and H. Schreier. 1996. Urbanization and agricultural intensification in the Lower Fraser River valley: Impacts on water use and quality. *GeoJournal*, 40(1-2): 135-146.

Hanson, M. B., R.W. Baird, J.K.B. Ford, J. Hempelmann-Halos, D.M. Van Doornik, J.R. Candy, C.K. Emmons, G.S. Schorr, B. Gisborne, K.L. Ayres, S.K. Wasser, K.C. Balcomb, K. Balcomb-Bartok, J.G. Sneva and M.J. Ford. 2010. Species and stock identification of prey consumed by endangered killer by endangered Southern resident killer whales in their summer range. *Endangered Species Research* 11:69–82.

Harrison P.J., K. Yin, L. Ross, J. Arvai, K. Gordon, L. Bendell-Young, C. Thomas, R. Elnor, M. Sewell, P. Shepherd. 1999. The delta foreshore ecosystem: past and present status of geochemistry, benthic community production and shorebird utilization after sewage diversion. Chapter 3.10 in *Health of the Fraser River Aquatic Ecosystem, Volume 1: A Synthesis of Research Conducted Under the Fraser River Action Plan*. Gray, C. and Tuominen, T, eds. DOE-FRAP 1998. Environment Canada, Vancouver, BC.

Hauser, D.D.W., M. G. Logsdon, E.E. Holmes, G.R. VanBlaricom and R.W. Osborne. 2007. Summer distribution patterns of southern resident killer whales *Orcinus orca*: core areas and spatial segregation of social groups, *Marine Ecology Progress Series*, 351: 301-10.

Hutchinson, I. 1988. The biogeography of the coastal wetlands of the Puget Trough: deltaic form, environment, and marsh community structure. *Journal of Biogeography*, pp.729-745.

Incardona, J.P., C.A. Vines, T.L. Linbo, M.S. Myers, C.A. Sloan, B.F. Anulacion, D. Boyd, T.K. Collier, S. Morgan, , G.N. Cherr and N.L. Scholz. 2012. Potent phototoxicity of marine bunker oil to translucent herring embryos after prolonged weathering. *PLoS ONE* 7(2): e30116.

Irvine, G.V., D.H. Mann and J.W. Short. 2006. Persistence of 10-year old Exxon Valdez oil on Gulf of Alaska beaches: The importance of boulder-armoring. *Marine Pollution Bulletin* 52: 1011-1022.

Jardine, C.B., A. L. Bond, P.J. Davidson, R.W. Butler and T. Kuwae. 2015. Biofilm consumption and variable diet composition of Western Sandpipers (*Calidris mauri*) during migratory stopover. *PloS one*, 10(4), e0124164

Jarvela-Rosenberger, A.L. M. MacDuffee, A.G.J. Rosenberger and P.S. Ross. 2017. Oil Spills and Marine Mammals in British Columbia, Canada: Development and Application of a Risk-Based Conceptual Framework, *Archives of Environmental Contamination & Toxicology*, 73: 131-53.

Lacy, R.C., R. Williams, E. Ashe, K.C. Balcomb III, L.J.N. Brent, C.W. Clark, D.P. Croft, D.A. Giles, M. MacDuffee and P.C. Paquet. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans, *Scientific Reports*, 7: 14119.

Lacy, R.C., K.C. Balcomb III, L.J.N. Brent, C.W. Clark, D.P. Croft and P.C. Paquet. 2015. Report on the Population Viability Analysis model investigations of threats to the Southern Resident killer whale population from the Trans Mountain Expansion Project. Prepared for the National Energy Board (NEB) hearings reviewing Kinder Morgan Proposed Trans Mountain Expansion project.

Larson, S., J. Olsen and R. Osborne. "Sightings of Southern Resident killer whales in the Salish Sea 1976-2014" (2018). Salish Sea Ecosystem Conference. <https://cedar.wvu.edu/ssec/2018ssec/allsessions/25>

Levings, C. D., D.E. Boyle and T.R. Whitehouse. 1995. Distribution and feeding of juvenile Pacific salmon in freshwater tidal creeks of the lower Fraser River, British Columbia. *Fisheries Management and Ecology* 2(4): 299-308.

Levy, D. A., and Northcote, T. G. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. *Canadian Journal of Fisheries and Aquatic Sciences* 39(2): 270-276.

Logan, K. D.C. Scott, A.G.J. Rosenberger and M. MacDuffee. 2015. Potential effects on Fraser River Salmon from an oil spill by the Trans Mountain Expansion Project. Prepared for the National Energy Board (NEB) hearings reviewing Kinder Morgan's proposed Trans Mountain Expansion project. Raincoast Conservation Foundation.

Khelifa, A., B. Fieldhouse, Z. Wang, C. Yang, M. Landriault, C.E. Brown and M. Fingas. 2008. Effect of chemical dispersant on oil sedimentation due to oil-SPM flocculation: Experiments with the NIST Standard Reference Material 1941? In International Oil Spill Conference, Vol. 2008, no. 1, pp. 627-631. American Petroleum Institute, 2008.

- Little E., L. Cleveland, R. Calfee and M. Barron. 2000. Assessment of the photo-enhanced toxicity of a weathered oil to the tidewater silverside. *Environmental Toxicology and Chemistry* 19:926-932.
- Le Floch, S., J. Guyomarch, F.X. Merlin, P. Stoffyn-Egli, J. Dixon, and K. Lee. 2002. The influence of salinity on oil–mineral aggregate formation. *Spill Science & Technology Bulletin*, 8(1), pp.65-71.
- Lundin, J.I., G.M. Ylitalo, R.K Booth, B.F. Anulacion, J. Hempelmann, K.M. Parsons, D.A. Giles, E.A Seely, M.B. Hanson, C.K. Emmons and S.K. Wasser 2016. Modulation in persistent organic pollutant concentration and profile by prey availability and reproductive status in Southern Resident killer whale scat samples. *Environmental Science & Technology* 50, 6506–6516.
- Luternauer, J.L., Atkins, R.J., Moody, A.I., Williams, H.E., and Gibson, J.W., 1995. Salt marshes. *Developments in Sedimentology*, 53, pp.307-332.
- Matkin C.O., E.L. Saulitis, G.E. Ellis, P. Olesiuk and S.D. Rice. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the ‘Exxon Valdez’ oil spill in Prince William Sound, Alaska. *Marine Ecology Progress Series* 356:269-281.
- Matkin C.O., J.W. Durban, E.L. Saulitis, R.D. Andrews, J.M. Straley, D.R. Matkin and G.E. Ellis. 2012. Contrasting abundance and residency patterns of two sympatric populations of transient killer whales (*Orcinus orca*) in the northern Gulf of Alaska. *Fisheries Bulletin*, 110:143-155.
- McLaren, P. and T. Tuominen. 1999. Sediment Transport Patterns in the Lower Fraser River and Fraser Delta. Chapter 3.4 in *Health of the Fraser River Aquatic Ecosystem, Volume 1: A Synthesis of Research Conducted Under the Fraser River Action Plan*. Gray, C. and T. Tuominen, eds. DOE-FRAP 1998. Environment Canada, Vancouver, BC.
- McNatt, R.A., D.L. Bottom and S.A. Hinton. 2016. Residency and movement of juvenile Chinook salmon at multiple spatial scales in a tidal marsh of the Columbia River estuary. *Transactions of the American Fisheries Society*, 145(4), 774-785.
- Milliman, J. D. 1980. Sedimentation in the Fraser River and its estuary, southwestern British Columbia (Canada). *Estuarine and Coastal Marine Science* 10(6): 609-633.
- Montgomery, D.R. 2003. *King of fish: the thousand-year run of salmon*. Westview Press.
- Moore, J.W., J. Gordon, C. Carr-Harris, A.S. Gottesfeld, S.M. Wilson and J.H. Russell. 2016. Assessing estuaries as stopover habitats for juvenile Pacific salmon. *Marine Ecology Progress Series*, 559, 201 -215.
- NAS (National Academies of Sciences, Engineering, and Medicine). 2016. *Spills of Diluted Bitumen from Pipelines: A Comparative Study of Environmental Fate, Effects, and Response*. Washington, DC: The National Academies Press.
- NMFS (National Marine Fisheries Service). 2008. *Recovery Plan for Southern Resident Killer Whales (Orcinus orca)*. National Marine Fisheries Service, Northwest Region, Seattle, Washington.

NOAA. 2018. Southern Resident killer whale priority stocks report . Prepared by NOAA Fisheries West Coast Region and Washington Department of Fish and Wildlife June 22, 2018

Neff, J.M. 1990. Composition and fate of petroleum and spill-treating agents in the marine environment. In: Sea mammals and oil: confronting the risks, Geraci, J.R. and D.J. St. Aubin ed. Academic Press, San Diego, California 282pp.

Noren, D.P., 2011. Estimated field metabolic rates and prey requirements of resident killer whales. *Marine Mammal Science*, 27(1), pp.60-77.

Nuka Research. 2015. Technical Analysis of Oil Spill Response Capabilities and Limitations for Trans Mountain Expansion Project. Expert Report Prepared for the Tsleil-Waututh Nation, the City of Vancouver and the Tsawout First Nation by Nuka Research and Planning Group, LLC PO Box 175 Seldovia, AK 99663 USA 10 Samoset Street, Plymouth, MA 02360 USA

Ohlberger, J., E.J. Ward, D.E. Schindler and B. Lewis. 2018. Demographic changes in Chinook salmon across the Northeast Pacific Ocean, *Fish and Fisheries*, 19: 533-46.

Otte, G. and C.D. Levings. 1975. Distribution of macro invertebrate community on a mudflat influenced by sewage, Fraser River Estuary. Fisheries and Marine Service Technical Report 476, Environment Canada, West Vancouver, British Columbia

Pawlowicz, R., R. Di Costanzo, M. Halverson, E. Devred, and S. Johannessen. 2017. Advection, Surface Area, and Sediment Load of the Fraser River Plume Under Variable Wind and River Forcing, *Atmosphere-Ocean*, 55: 293-313.

Riddell, B., M. Bradford, R. Carmichael, D. Hankin, R. Peterman, and A. Wertheimer. 2013. 'Assessment of Status and Factors for Decline of Southern BC Chinook Salmon: Independent Panel's Report. Prepared with the assistance of D.R. Marmorek and A.W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for Fisheries and Oceans Canada (Vancouver, BC) and Fraser River Aboriginal Fisheries Secretariat (Merritt, BC). ': xxix + 165 pp. + Appendices.

Schaefer, V. 2004. Ecological setting of the Fraser River delta and its urban estuary; *in* Fraser River Delta, British Columbia: Issues of an Urban Estuary, (ed.) B.J. Groulx, D.C. Mosher, J.L. Luternauer, and D.E. Bilderback; *Geological Survey of Canada, Bulletin 567*, pp.35-47.

Schwacke L.H., C.R. Smith, F.I. Townsend, R.S. Wells, L.B. Hart, B.C. Balmer, T.K. Collier, S. De Guise, M.M. Fry, L.I. Guillette Jr., S.V. Lamb, W.E. McFee, N.J. Place, M.C. Tumlin, G.M. Ylitalo, E.S. Zolman and T.K. Rowles. 2014. Health of common bottlenose dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana, following the Deepwater Horizon oil spill. *Environmental Science & Technology* 48:93–103.

Short, J.W., J.M Maselko, M.R Lindeberg, P.M. Harris and S.D. Rice. 2006. Vertical distribution and probability of encountering intertidal Exxon Valdez oil on shorelines of three embayments within Prince William Sound, Alaska. *Environmental Science and Technology* 40: 3723-3729.



Shields, M.W., J. Lindell and J. Woodruff. 2018. Declining spring usage of core habitat by endangered fish-eating killer whales reflects decreased availability of their primary prey. *Pacific Conservation Biology*, 24: 189.

TERA Environmental Consultants. 2013. Environmental and socio-economic assessment for the Trans Mountain Pipeline ULC Trans Mountain expansion project. Volume 5A: ESA – Biophysical. Prepared for Trans Mountain Pipeline ULC, Calgary, AB.

Trans Mountain Pipeline ULC 2013. Trans Mountain Expansion Project: An Application Pursuant to Section 52 of the National Energy Board Act, December 2013. Volume 7: Risk Assessment and Management of Pipeline and Facility Spills. 221 p.

Thomson, Richard. E. 1981. Oceanography of the British Columbia coast. *Can. Spec. Publ. Fish. Aquat. Sci.* 56: 291 p.

Venn-Watson S., K.M Colegrove, J. Litz, M. Kinsel, K. Terio, J. Saliki, S. Fire, R. Carmichael, C. Chevis, W. Hatchett, J. Pitchford, M. Tumlin, C. Field, S. Smith, R. Ewing, D. Fauquier, G. Lovewell, H. Whitehead, D. Rotstein, W. McFee, E. Fougères and T. Rowles. 2015. Adrenal gland and lung lesions in Gulf of Mexico common bottlenose dolphins (*Tursiops truncatus*) found dead following the Deepwater Horizon oil spill. *PLoS One*, 10(5). doi:10.1371/journal.pone.0126538

Velez-Espino, L.A., J.K.B. Ford, C.K. Parken, G.M. Ellis, E. Ward, L. LaVoy, K.C. Balcomb, M.B. Hanson, D.P. Noren, T. Cooney and R. Sharma. 2013. Sensitivity of resident killer whale population dynamics to Chinook salmon abundance. Prepared for: Pacific Salmon Commission Southern Boundary Restoration and Enhancement Fund. Vancouver, BC. xvi +191 p

Vélez-Espino, L.A., J.K.B. Ford, H.A. Araujo, G. Ellis, C.K. Parken and R. Sharma. 2014. Relative importance of Chinook salmon abundance on resident killer whale population growth and viability. *Aquatic Conservation: Marine and Freshwater Ecosystems*.

Ward, E.J., E. Holmes and K.C. Balcomb. 2009. Quantifying the effects of prey abundance on killer whale reproduction. *Journal of Applied Ecology*, 46: 632-40.

Williams, R., C.W. Clark, D. Ponirakis and E. Ashe. 2014. Acoustic quality of critical habitats for three threatened whale populations, *Animal Conservation*, 17: 174-85

## Appendix I.

Table A1. 35 Chinook Conservation Units (CU) have been identified in southern BC. CU status was reviewed under the Wild Salmon Policy and by COSEWIC. Eleven south coast CUs could not be assessed under the WSP due to the unknown component of hatchery origin salmon. A further 9 could not be evaluated under the WSP due to the lack of data. A 2018 COSEWIC assessment of 12 CUs of Inner South Coast and Fraser River watershed found 8 CUs endangered, 4 threatened, 2 data deficient and 1 of special concern.

Region	CU Name	WSP Status	COSEWIC status
Columbia River	Okanagan	RED	RED
Lower Mainland	Boundary Bay	TBD	Not assessed
Fraser River	Lower Fraser spring -stream	TBD	Special Concern
Fraser River	Lower Fraser Fall -ocean	GREEN	Threatened
Fraser River	Lower Fraser Upper Pitt -Summer	DD	Endangered
Fraser River	Lower Fraser Summer -stream	DD	Threatened
Fraser River	Maria Slough Summer	TBD	Not Assessed
Fraser River	Middle Fraser Canyon - spring	DD	Not assessed
Fraser River	Middle Fraser Portage Fall- stream	RED	Endangered
Fraser River	Middle Fraser spring -stream	RED	Threatened
Fraser River	Middle Fraser River Summer	AMBER	Threatened
Fraser River	Upper Fraser spring	RED	Endangered
Fraser River	South Thompson Summer 0.3	GREEN	Not at Risk
Fraser River	South Thompson Summer 1.3	RED/AMBER	Not Assessed
Fraser River	Shuswap River Summer 0.3	TBD	Not Assessed
Fraser River	South Thompson -Bessette Summer 1.2	RED	Endangered
Fraser River	Lower Thompson Spring 1.2	RED	Not Assessed
Fraser River	North Thompson Spring 1.3	RED	Endangered
Fraser River	North Thompson summer 1.3	RED	Endangered

Fraser River	Upper Adams River	DD	Not Assessed
Fraser River	Fraser Harrison transplant Fall	TBD	Not Assessed
Inner South Coast	South Mainland -Georgia Strait Fall	DD	Not Assessed
Inner South Coast	East VI - Goldstream Fall	TBD	Not Assessed
Inner South Coast	East VI -Cowichan & Kosilah Fall	TBD	Not Assessed
Inner South Coast	East VI Nanaimo -spring	DD	Endangered
Inner South Coast	East VI -Nanaimo & Chemainus Fall	TBD	Not Assessed
Inner South Coast	East VI -Qualicum &Puntledge Fall	TBD	Not Assessed
Inner South Coast	South Mainland -Southern Fjords Fall	DD	Not Assessed
Inner South Coast	East VI-North Fall	RED	Not Assessed
Inner South Coast	Homathko summer	DD	Data Deficient
Inner South Coast	klinaklini Summer 1.3	DD	Data Deficient
Inner South Coast	East VI- Georgia Strait summer	TBD	Not Assessed
W. Coast Vancouver Island	WCVI -South Fall	RED	Not Assessed
W. Coast Vancouver Island	WCVI -Nootka & Kyuquot Fall	RED	Not Assessed
W. Coast Vancouver Island	WCVI -North Fall	TBD	Not Assessed

## Appendix II

Table A2: Physiological and behavioral criteria of marine mammal species used to determine likelihood of individual exposure to oil through five known exposure pathways as described by Jarvella – Rosenberger *et al.* 2017. Risks were categorized as low, medium, and high based on these criteria.

Exposure Pathway	Criteria	LOW	MEDIUM	HIGH
Contact	Time spent at surface approximated using feeding ecology Other factors if known i.e. dive time/depth Time spent hauled out on shore	A score of LOW was not assigned, as all marine mammals must breathe air at the surface;	Feed on benthic prey Long/deep dive duration	Surface feeders Feed on epi- or mesopelagic species. Known behaviours at surface and/or on shore
Adhesion	Skin texture	Smooth	Rough patches Short fur	Presence of true fur
Inhalation	Time spent breathing at the air/water interface Breathing physiology Grooming behaviour	A score of LOW was not assigned, as all marine mammals must breathe air at the surface	No blowhole OR Decreased time spent at surface	Blowhole Increased time spent at surface Grooming behaviour
Direct Ingestion	Feeding mechanism Other behaviours known to increase contact with oil	Teeth	Baleen plates OR Benthic Feeding	Baleen plates AND Benthic Feeding Grooming
Ingestion through contaminated prey	physiological ability of prey to metabolize oil products	Fish and other vertebrates	Fish and invertebrates	Invertebrates

Table A3. Species-specific biological, ecological, and demographic features of marine mammal species that could increase the likelihood of population-level consequences in the event of an oil spill. Risk was categorized as low, medium, and high based on the criteria examined for each characteristic and scored by Jarvella-Rosenberger et al. 2017.

Characteristic	Criteria examined	Score Low (1)	Score Medium (2)	Score High (3)
Population	Size of population that inhabits the study area, population trends	Large, stable population	Presence of small subpopulations	Small and/or declining populations
Distribution	Spatial & temporal use of habitat in study area	Only present in study area for a small portion of the year	Observed in study area for half of the year	Observed in study area at all times throughout year
Group Size	Average size of aggregations	Small group size	Small segregated groups (age class or gender)	Larger groups
Habitat	Habitat designated as critical for population survival or high site fidelity observed	No critical habitat or site fidelity within study area	Areas deemed critical for the survival of the population	Critical habitat or high site fidelity has been defined in study area
Reproduction	Habitat that is essential to life processes	Calving and breeding take place outside study area	Study area important to calving or breeding	Calving or breeding known to occur within the study area
Life History	Reproductive rates and age at sexual maturity	Low age at sexual maturity High reproductive rate	High age at sexual maturity OR Low reproductive rate	High age at sexual maturity AND Low reproductive rate
Diversity of Diet	Species is a generalist or obligate to one prey type	Opportunistic feeders that consume a wide variety of prey	Diets limited to a certain class or trophic level	Highly specialized diets limited to one or a few prey species
Prey Susceptibility to decline	The ability of prey species to maintain population numbers in the case of an oil spill	Feed on prey that are not susceptible to decline	Feed on prey that are both susceptible and resistant to decline	Feed on prey susceptible to decline

### Appendix III

#### Summary of Chinook Salmon assessed by COSEWIC November 2018

Endangered	Chinook Salmon (East Vancouver Island, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Endangered	Chinook Salmon (Lower Fraser, Stream, Summer (Upper Pitt))	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Endangered	Chinook Salmon (Middle Fraser, Stream, Fall)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Endangered	Chinook Salmon (Middle Fraser, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Endangered	Chinook Salmon (North Thompson, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Endangered	Chinook Salmon (North Thompson, Stream, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Endangered	Chinook Salmon (South Thompson, Stream, Summer 1.2)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Endangered	Chinook Salmon (Upper Fraser, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Threatened	Chinook Salmon (Lower Fraser, Ocean, Fall)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Threatened	Chinook Salmon (Lower Fraser, Stream, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Threatened	Chinook Salmon (Middle Fraser, Stream, Spring (MFR+GStr))	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Threatened	Chinook Salmon (Middle Fraser, Stream, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Special Concern	Chinook Salmon (Lower Fraser, Stream, Spring)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Not at Risk	Chinook Salmon (South Thompson, Ocean, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Data Deficient	Chinook Salmon (Southern Mainland, Ocean, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean
Data Deficient	Chinook Salmon (Southern Mainland, Stream, Summer)	<i>Oncorhynchus tshawytscha</i>	BC Pacific Ocean

**Misty MacDuffee, C.V.**

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250.629.3001  
misty@raincoast.org

**Introduction**

I am a conservation biologist with a focus on fisheries ecology in salmon ecosystems. For the past 15 years I have undertaken various types of field, laboratory, technical and conservation assessments in the salmon-bearing watersheds of the BC coast. I have a particular interest in the role of salmon as critical food sources for wildlife and incorporating their nutritional and energetic needs into salmon management decisions. I am also interested in historic stock assessment and run reconstructions in salmon watersheds. The application of my work is to implement ecosystem considerations in fisheries management. This often requires my engagement with management, dialogue and stakeholder forums that affect fisheries and wildlife policy and management.

**Education**

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Bachelor of Science

2002-2006 Biology, University of Victoria, Victoria, British Columbia,

1982-1985 Environmental Science and Environment Studies, Trent University, Peterborough, Ontario

**Work History**

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2005- current Conservation Biologist, Raincoast Conservation Foundation (RCF)

Program Focus: Sustainable fisheries and conservation of salmon ecosystems

- Salmonid inventories and status assessments
- Juvenile salmon field assessments of presence/absence, habitat indicators and use
- Fish community assessments in river, estuarine and marine ecosystems
- documentation/characterization of grizzlies diets and salmon use by grizzlies
- Examining the role of salmon nutrients to sockeye nursery lake production
- Use of paleolimnological tools to understand past trends and drivers (nutrients, climate, harvest) in sockeye abundance, productivity and population dynamics.
- Examination of stock recruitment models as appropriate management tools to meet objectives under Canada's Wild Salmon Policy.

2014- Present Naturalist and Guide, Maple Leaf Adventures

- Guiding and interpreting wildlife and natural history on BC's south, central and north coast with focus on toothed and baleen whales, birds, grizzlies and salmon

August 2010 - November 2010 Team Leader: Salmon enumeration/creek walker. Mainland Enhancement Salmonid Society, subcontract to Fisheries and Oceans Canada

- In-stream (live) enumeration and carcass counts of salmon species in 15 streams and rivers of the Broughton Archipelago
- Determining and assessing juvenile salmon presence and distribution
- Collection of tissues for molecular genetic analysis
- Stream and watershed reviews and recommendations for improved habitat conservation

Fall 2008. Salmon enumeration and creek walker. Sub contract to Simon Fraser University.

- In-stream (live) enumeration and carcass counts of salmon species in a dozen streams and rivers within Fisheries Management Area 7 on BC central coast.

Summers 2004-2006. Platform Observer and crew, Marine Mammal At- Sea Surveys, RCF

- Observation and identification of cetaceans and pinnipeds (whales, dolphins, seals, sea lions) from boat-based line transect surveys throughout the Queen Charlotte Basin.

1996 - 2002 Salmon Ecologist & Community Advisor, Institute of Ocean Sciences & University of Victoria

- Restoration elements of degraded freshwater and marine salmonid habitats including stream, watershed, hydrologic, near shore and foreshore assessments,
- salmonid assessments and stock assessment,
- habitat prescriptions and recommendations to governments and community agencies on improving freshwater and marine aquatic conditions for salmonids and other organisms.

### Field Skills

- 20 years experience operating small boats and zodiacs on the BC coast,
- SVOP certification and Marine Radio Operators license
- Marine Emergency Duties MED A1, A2 and A3 certification
- Red Cross Advanced Marine First Aid and Advanced Wilderness First Aid
- PADI open water diver certification
- Assistant bear-viewing guide certification with Commercial Bear Viewing Association
- Class 5 drivers license and extensive experience driving trucks and trailers
- have lead my own field research programs and crewed for others
- have sampled, collected, assessed and inventoried abiotic and biotic features of remote coastal regions
- can work safely and independently with wildlife and have been responsible for safety of others

### Scientific Published Papers

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Chalifour, L., D.C. Scott, **M. MacDuffee**, J.C. Iacarella, T.G. Martin and J.K. Baum. 2019. Habitat selectivity by juvenile salmon, resident and migratory species underscores the importance of estuarine habitat mosaics. *In review*

Gayeski, Nick, **Misty MacDuffee**, and Jack A. Stanford. 2018. Criteria for a Good Catch: A Conceptual Framework to Guide Sourcing of Sustainable Salmon Fisheries. *Facets*. 3: 300–314. <https://doi.org/10.1139/facets-2016-0078>

Kehoe, L.J., J.Lund, L. Chalifour, J.M. Casey, B. Connors, N. Cryer, M.C. Drever, C. Levings, **M. MacDuffee**, H. McGregor, D.C. Scott, R.G. Vennesland, C.E. Wilkinson, P. Zevit, J.K. Baum and T.G. Martin. *in review*. Prioritizing conservation action in a highly contested socio-ecological system.

Lacy, Robert C., R. Williams, E. Ashe, K.C. Balcomb III, L.J. N. Brent, C.W. Clark, D.P. Croft, D.A. Giles, **M. MacDuffee** and P.C. Paquet. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. *Scientific Reports*. 7, Article number: 14119 doi:10.1038/s41598-017-14471-0

Michael H.H. Price, K.K. English, A.G. Rosenberger, **M. MacDuffee**, and J.D. Reynolds. 2017. Canada's Wild Salmon Policy: an assessment of conservation progress in British Columbia. *Can J. Fish & Aquatic Sci.* <https://doi.org/10.1139/cjfas-2017-0127>

Jarvela Rosenberger, A.L., **M. MacDuffee**, A.G. J. Rosenberger and Peter S. Ross. 2017. Oil Spills and Marine Mammals in British Columbia, Canada: Development and Application of a Risk-Based Conceptual Framework. *Archives of Environmental Contamination and Toxicology* 73: 131. <https://doi.org/10.1007/s00244-017-0408-7>

Darimont, C.T., K. Artelle, H. Bryan, C. Genovali, **M. MacDuffee**, and P.C. Paquet. 2013. Brown bears, salmon, people: Traveling upstream to a sustainable future. Chapter 14 *in* Bear Necessities: Rescue, Rehab, Sanctuary and Advocacy. Lisa Kemmerer *ed.* Brill Press. Boston

Christensen, J.R., M.B. Yunker, **M. MacDuffee** and P.S. Ross. 2013. Plant consumption by grizzly bears reduces biomagnification of salmon-derived PCBs, PBDEs, and organochlorine pesticides. *Env. Tox. Chem.* 02/2013

Levi T., C.T. Darimont, **M. MacDuffee**, M. Mangel, P. Paquet, C.C. Wilmers. 2012. Using Grizzly Bears to Assess Harvest-Ecosystem Tradeoffs in Salmon Fisheries. *PLoS Biol* 10(4)

Darimont, C.T., Bryan, H.M., Carlson, S.M., Hocking, M.D., **MacDuffee, M.**, Paquet, P.C., Price, M.H.H., Reimchen, T.E., Reynolds, J.D., and Wilmers, C.C. 2010. Salmon for terrestrial protected areas. *Conservation Letters*. 3(6): 379–389

**MacDuffee, M.** and E. MacIsaac (eds). 2009. Applications of paleolimnology to sockeye salmon nursery lakes and ecosystems in the Pacific Northwest and Alaska: Proceedings of a workshop at the Institute of Ocean Sciences, October 2008. *Can. Tech. Rep. Fish. Aquat. Sci.* No. 2847



Price, M.H., C.T. Darimont, N.F. Temple and **M. MacDuffee**. 2008. Ghost Runs: Management and status assessment of Pacific salmon returning to British Columbia's central and north coasts. *Can. J. Fish. Aquat. Sci.* Vol 65, No 12, pp. 2712-2718(7)

Christensen, J.R., **MacDuffee, M.**, Yunker, M.B., and Ross, P.S. 2007. Hibernation associated changes in persistent organic pollutants (POP) levels and patterns in British Columbia grizzly bears. *Environ.Sci.Technol.* 41: 1834 - 1840;

Christensen, J.R., **MacDuffee, M.**, MacDonald, R.W., Whitticar, M. and Ross, P.S. 2005. Persistent Organic Pollutants in British Columbia's Grizzly Bears: Consequence of Divergent Diet. *Environ. Sci. Technol.* 39: 6952-6960

### **Expert Reports for Legal Proceedings**

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December 2011. Written evidence of Misty MacDuffee on the marine risks and impacts to British Columbia's wild salmon. Submitted to Canada's CEAA-NEB Joint Review Panel in the matter of Enbridge's Northern Gateway Environmental and Socio-economic Assessment.

May 2015. Written evidence of Kate Logan, Dave Scott and Misty MacDuffee on Potential Effects on Fraser River Salmon from an oil spill by the Trans Mountain Expansion Project. Submitted to National Energy Board in the matter of Trans Mountain ULC Environmental Assessment.

July 2013. Written evidence of Misty MacDuffee on the conservation status of British Columbia's south coast salmon populations. Submitted to the federal court in the matter of Morton vs. Fisheries and Oceans Canada and Marine Harvest.

### **Past Positions and Committees**

2009 - current Marine Conservation Caucus representative to Fisheries & Oceans Canada's Integrated Harvest Planning Committee (IHPC) for salmon fisheries

2012 – current Marine Conservation Caucus representative to Fisheries & Oceans Canada Technical Working Group to the Southern BC Chinook Strategic Planning Initiative

2018 – current Marine Conservation Caucus representative to Fisheries & Oceans Canada Southern Resident killer whale Prey Working Group

2018 – current Member of Fisheries & Oceans Canada's Southern Resident killer whale Stakeholder Working Group

2008 - current Raincoast Conservation Foundation representative to BC's Marine Conservation Caucus

2007- 2012 Committee member, Rivers Inlet Recovery Team/ Rivers-Smith Salmonid Ecosystem Society

2009 - 2011, Chair, Board of Directors, Gulf Islands Alliance

2011- 2017, Director, Gulf Islands Alliance

1999 - 2006 Chair, Board of Directors, Raincoast Conservation Foundation

## KATE LOGAN

1485 Elm Street, Prince George, BC | 250-562-9339 | kalogan14@gmail.com

## EDUCATION

University of Victoria, Victoria, BC

### **M.Sc. in Earth and Ocean Sciences**

**2010**

Thesis: "Hydrocarbons in sea otters (*Enhydra lutris*) and their habitat in coastal British Columbia, Canada"

University of Victoria, Victoria, BC

### **B.Sc. in Biology with Distinction**

**2005**

Areas of Concentration: Marine Biology, Ecology

## PROFESSIONAL EXPERIENCE

**Independent Consultant**, Prince George, BC

**January 2015 – present**

Clients include Raincoast Conservation Foundation, Vancouver Aquarium. Project work includes detailed technical review of behaviour, fate, and toxicity to salmon of diluted bitumen spilled in the Lower Fraser River; preparation of report on the same topics for general public; review of proposals for monitoring work and literature review in the wake of the April 2015 oil spill in English Bay; preparation of reports on the use of chemical dispersants (both for regulatory agencies and the media).

Stantec Consulting Ltd., Sidney, BC

### **Toxicologist/Project Coordinator**

**January 2012 – January 2015**

Toxicology: Collection and analysis of complex data sets with respect to potential health effects on wildlife species; method development using laser ablation of mammalian hair to monitor temporal changes in metal exposure.

Project Coordination: Worked as part of multi-city teams to coordinate complex projects. Tasks included deployment of dozens of field personnel; logistics planning and authorizations; document compilation and technical editing; discipline liaison and communication. Lead on achieving First Nations participation in, and engagement with, field programs, which required building respectful and effective working relationships with representatives from over two dozen First Nations across BC.

Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC

### **Contract scientist**

**January 2011 – December 2012**

Projects included publication of two manuscripts on hydrocarbons in BC sea otter food webs; a critical review of existing sediment quality guidelines on local and global scales; a comprehensive assessment of contaminant inputs into salmon habitat along the Fraser River in BC and potential impacts; and a collaborative assessment of the overall health of the BC sea otter population (e.g. hematology parameters, emerging infectious diseases).

University of Victoria/Institute of Ocean Sciences, Fisheries and Oceans Canada, Victoria/Sidney, BC

### **M.Sc. Candidate**

**Sept 2007 – December 2010**

My work focused on the source, transport, and fate of hydrocarbons in the food web of sea otters in British Columbia. The project included written, laboratory, and field components.

Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, BC

### **Contract scientist**

**January 2006 – August 2007**

Publication of technical reports on marine environmental quality in the Pacific North Coast Integrated Management Area (PNCIMA) and the North Coast and Haida Gwaii, including contaminant sources, types, risks, and recommendations; publication of a manuscript on pesticide residues in Lower Mainland salmon habitat; and extensive literature review on the long-term effects of oil spills, with particular focus on the *Exxon Valdez*.

## PUBLICATIONS AND PAPERS

**Logan, K.** Genovali, C. 2018. Canada should rethink unproven, dangerous chemical cleanup of marine oil spills. *The Narwhal*. December 1, 2018.

**Logan, K.A.,** Scott, D., MacDuffee, M. 2018. Wild Salmon, Pipelines, and the Trans Mountain Expansion: Canada's wild salmon habitat at risk. 2018. Report based on the evidence presented by the Raincoast Conservation Foundation to the National Energy Board, 2015.

**Logan, K.A.**, Scott, D., Rosenberger, A., MacDuffee, M. 2015. Potential Effects on Fraser River Salmon from an Oil Spill by the Trans Mountain Expansion Project. Attachment B of Written Evidence of Raincoast Conservation Foundation, submitted to the National Energy Board under Hearing Order OH-001-2014.

Noël, M., Spence, J., **Harris, K.A.**, Robbins, C.T., Fortin, J.K., Ross, P.S., Christensen, J.R. 2014. Grizzly bear hair reveals toxic exposure to mercury through salmon consumption. *Environmental Science and Technology*, 48 (13): 7560-7567.

Ross, P.S., **Harris, K.A.**, Dangerfield, N.J., Crewe, N.F., Dubetz, C.P., Fischer, M.B., Fraser, T.L., Ross, A.R.S. 2011. Sediment concentrations of PCBs, PBDEs, PCDDs and PCDFs from disposal at sea sites at Point Grey and Sand Heads, British Columbia in 2010. *Can. Data. Rep. Fish. Aquat. Sci.* 1239: vii + 115 p.

**Harris, K.A.**, Nichol, L.M., Ross, P.S. 2011. Hydrocarbon concentrations and patterns in British Columbia sea otters (*Enhydra lutris*) and their prey. *Environmental Toxicology and Chemistry*, doi: 10.1002/etc.627.

**Harris, K.A.**, Yunker, M.B., Dangerfield, N., Ross, P.S. 2011. Composition and sources of aliphatic and aromatic hydrocarbons in sediments from sea otter (*Enhydra lutris*) habitat in British Columbia, Canada. *Environmental Pollution* doi: 10.1016/j.envpol.2011.05.033.

**Harris, K.A.** 2010. Hydrocarbons in sea otters (*Enhydra lutris*) and their habitat in coastal British Columbia, Canada. MSc thesis, University of Victoria, Victoria, BC.

**Harris, K.A.**, Dangerfield, N., Woudneh, M., Brown, T.G., Verrin, S., Ross, P.S. 2009. Current-use pesticides in freshwater salmon habitat in remote, urban, and agricultural sites in British Columbia, Canada. *Environmental Toxicology and Chemistry*, 27 (11): 2253-2262.

Johannessen, D.I., Macdonald, J.S., **Harris, K.A.**, and Ross, P.S. 2007. Marine environmental quality in the Pacific North Coast Integrated Management Area (PNCIMA), British Columbia, Canada: A summary of contaminant sources, types, and risks. *Can. Tech. Rep. Fish. Aquat. Sci.* 2716: xi + 53p.

Johannessen, D.I., **Harris, K.A.**, Macdonald, J.S., and Ross, P.S. 2007. Marine environmental quality in the North Coast and Queen Charlotte Islands, British Columbia, Canada: A review of contaminant sources, types, and risks. *Can. Tech. Rep. Fish. Aquat. Sci.* 2717: xii + 87p.

#### CONFERENCE PRESENTATIONS

Harris, K.A., Nichol, L.M., Yunker, M.B., Dangerfield, N., Ross, P.S. 2010. Source, transport, and fate of hydrocarbons in British Columbia sea otter (*Enhydra lutris*) habitat. SETAC North America 31<sup>st</sup> Annual Meeting, 7-11 November 2010, Portland, Oregon (poster).

Harris, K.A., Telmer, K., Ross, P.S. 2010. Source, transport, and fate of hydrocarbons in BC sea otter habitat. University of Victoria School of Earth and Ocean Sciences Graduate Student Workshop, 22 April 2010, Victoria, British Columbia (platform presentation).

Harris, K.A., Nichol, L.M., Yunker, M.B., Dangerfield, N., Ross, P.S. 2009. The FCSAP-SARA link: Hydrocarbons in British Columbia sea otters. FCSAP DFO-NEST Technical Workshop, 20-22 October 2009, Sidney, British Columbia (platform presentation).

Harris, K.A., Nichol, L.M., Yunker, M.B., Dangerfield, N., Ross, P.S. 2009. Source, transport, and fate of hydrocarbons in British Columbia sea otter (*Enhydra lutris*) habitat. 18<sup>th</sup> Biennial Conference on the Biology of Marine Mammals, 12-16 October 2009, Quebec City, Quebec (poster).

Harris, K.A., Dangerfield, N., Ross, P.S. 2009. Marine mammal toxicology in BC. Meeting of the Fisheries and Oceans Canada Marine Mammal Working Group, 4-5 June 2009, Parksville, British Columbia (platform presentation).

Harris, K.A., Nichol, L.M., Ross, P.S. 2008. The influence of feeding ecology on hydrocarbon patterns in British Columbia sea otters (*Enhydra lutris*). Workshop: Assessing and Addressing Small Scale Maritime Oil Pollution and Ecosystem Impacts in BC, 4-5 December 2008, Vancouver, British Columbia (platform presentation).

Harris, K.A., Nichol, L.M., Ross, P.S. 2008. Does feeding ecology influence hydrocarbon patterns in British Columbia sea otters (*Enhydra lutris*)? 35<sup>th</sup> Annual Aquatic Toxicity Workshop, 5 – 8 October 2008, Saskatoon, Saskatchewan (platform presentation).

Harris, K.A., Tierney, K., Dangerfield, N., Woudneh, M., Brown, T.G., Kennedy, C.J., Ross, P.S. 2007. Current-use pesticides in British Columbia salmon habitat. 34<sup>th</sup> Annual Aquatic Toxicity Workshop, 30 September – 3 October 2007, Halifax, Nova Scotia (poster).

Harris, K.A., Tierney, K., Dangerfield, N., Woudneh, M., Brown, T.G., Kennedy, C.J., Ross, P.S. 2007. Current-use pesticides in Fraser River salmon habitat. Department of Fisheries and Oceans Regional Science Symposium, 24-25 May 2007, Sidney, British Columbia (poster).

Harris, K.A., Tierney, K., Dangerfield, N., Woudneh, M., Brown, T.G., Kennedy, C.J., Ross, P.S. 2007. Current-use pesticides in Fraser River salmon habitat. Proceedings of the 2007 Georgia Basin Puget Sound Research Conference, 26-29 March 2007, Vancouver, British Columbia (poster).

Ross, P.S., Harris, K.A., Tierney, K., Dangerfield, N., Woudneh, M., Brown, T.G., Kennedy, C.J. 2006. Risk of Adverse Health Effects in Salmon Associated with Current Use Pesticide Exposures in British Columbia. 2006 Pesticide Information Exchange (Environment Canada, Pacific and Yukon). 30 November 2006, Vancouver, British Columbia (oral presentation).

#### MEMBERSHIPS

College of Applied Biology (Registered Professional Biologist)  
Professional Association of Diving Instructors

- Curriculum Vitae -  
Short Form  
PAUL C. PAQUET, Ph.D.

Address: P.O. Box 150, Meacham, SK Canada  
Telephone No.: (306) 376 2015  
Email: ppaquet@baudoux.ca  
Date of Birth: 06 December 1948  
Citizenship: Canadian, U.S.A.

### Education

1966 - 1970 B.A., Philosophy, University of Santa Clara, Santa Clara, California.  
1967 - 1968 Undergraduate, Zoology, University of California, Berkeley, California.  
1970 - 1970 Graduate Philosophy, Oxford University, Oxford, England.  
1970 - 1971 Post Bacc., Biology, Portland State University, Portland, Oregon.  
1971 - 1972 Graduate Studies, Wildlife Management, Oregon State University,  
Corvallis, Oregon.  
1972 - 1974 B.S., Zoology (Wildlife Biology), Arizona State University, Tempe, Arizona.  
Thesis topic: Distribution and movements of coyotes along the lower  
Colorado River, Arizona.  
1976 - 1981 M.S., Biology (Ethology), Portland State University, Portland, Oregon.  
Thesis topic: Temporal and phenomenological aspects of social behavior  
in captive wolves.  
1982 - 1988 Ph.D., Zoology, University of Alberta, Edmonton, Alberta. Dissertation  
topic: Behavioural ecology of sympatric wolves and coyotes in Riding  
Mountain National Park, Manitoba.  
1989-1990 Postdoc, Yale University, New Haven, CT

### Academic Appointments

1988/89 Assistant Professor, Department of Biology, Brandon University, Brandon,  
Manitoba  
1989-2012 Adjunct Professor, Department of Biology, Brandon University, Brandon,  
Manitoba  
1995-2006 Faculty Associate, Faculty of Graduate Studies, Guelph University,  
Guelph, Ontario  
1994-2012 Adjunct Associate Professor, Faculty of Environmental Design, University  
of Calgary, Calgary, Alberta  
1997-2001 Adjunct Professor, Department of Biology, University of Calgary, Calgary,  
Alberta  
1997-2001 Adjunct Professor, Department of Zoology, University of Alberta,  
Edmonton, Alberta  
2003-2012 Adjunct Professor, Dept. of Environment and Geography, University of

- Manitoba, Winnipeg
- 2003- Honorary Research Associate, Department of Biology, University of New Brunswick, Fredericton
- 2006-2009 Adjunct Professor, Department of Veterinary Pathology, Western College of Veterinary Medicine, University of Saskatchewan
- 2012- Adjunct Professor, Department of Geography, University of Victoria, Victoria, BC

#### Other Appointments

- 2000-2008 Senior Scientist, Conservation Biology Institute, U.S.A.
- 1995-2009 Research Fellow, World Wildlife Fund – Canada
- 2000-present Senior Scientist, Raincoast Conservation Society, Canada
- 2005-present Research Fellow, Rewilding Institute, U.S.A.
- 2005-2016 Society for Conservation Biology – International Policy Committee
- 2007-2009 Wildlife Society Canada – Policy Committee
- 2000-2014 International Union for Conservation of Nature Breeding Specialist Group
- 2015 International Union for Conservation of Nature Wolf Specialist Group
- 2017 International Union for Conservation of Nature WCPA Connectivity Conservation Specialist Group

#### Certification

- 1972 1977 Instructor, Outward Bound Schools; Kayaking, Snow, Ice and Rock Climbing, Mountaineering
- 1982 "Animal damage control in coastal forests of the Pacific Northwest." Cooperative Extension, U.S. Fish & Wildlife Service, Department of Interior.
- 1984 "Biotelemetry, methods and applications." Telonics Inc., Mesa, Arizona in conjunction with Lethbridge Community College, Lethbridge, Alberta.
- 1987 Instructor's Certification "Safety in bear country", Departments of Natural Resources, N.W.T. and Manitoba.
- 1988 "Wildlife Immobilization", Canadian Parks Service, Environment Canada

#### Professional Societies

1974-2014	The Wildlife Society, Washington D.C.
1974-2014	The American Society of Mammalogists, Kansas City, Missouri
1984-1989	The Wildlife Society of Canada
1984-2014	Canadian Field Naturalists
1985-1999	Canadian Society of Zoologists
1989-present	Society for Conservation Biology
1992-2004	New York Academy of Science
1994-present	American Association for the Advancement of Science
2003-present	American Institute of Biological Sciences

### Committees and Boards

1986-1991	Riding Mountain Biosphere Reserve, Chairman, Manitoba
1989-2009	Central Canadian Rockies Wolf Project, Board of Directors, Canmore, AB
1991-1999	Board of Scientific Advisors, Canid Research Facility, Dalhousie University, Nova Scotia
1992-2008	Coordinator for World Wildlife Fund (Canada) Carnivore Conservation Program
1992-	Board of Directors, German Wolf Society, Cologne, Germany
1993-1999	Banff National Park Elk Advisory Committee, Banff National Park, Alberta
1993-1999	Scientific Advisor, European Wolf Federation, Liege, Belgium
1993-1999	Director of Gray Wolf Research, Tatra Mountains National Park Wolf Ecology Project, Tatra, Slovakia
1993-1999	Director of Gray Wolf Research, Slovakian Wolf Ecology Project, Slovakia
1994-1998	Advisory Board of the Environmental Research Center, University of Calgary, Calgary, AB.
1993-2001	Predator/Prey Study Steering Committee and Director of Research, Pukaskwa National Park, Pukaskwa, Ontario
1993-2005	East Slopes Steering Committee for Grizzly Bear Research in Central Canadian Rocky Mountains
1995-2000	Grizzly Bear Scientific Advisory Committee to Minister of Environment, British Columbia Provincial Grizzly Bear Strategy
1995-2000	Scientific Steering Committee, World Wild Fund for Nature - International, Pan-European Carnivore Conservation Strategy
1994-1999	Town of Canmore Wildlife Corridor Committee, Canmore Alberta.
1996	Columbia Basin Science Review Panel, U.S. Forest Service

- 1995 Tongas National Forest, Alaska - Scientific Review Committee. U.S. Forest Service
- 1997-2008 Northwest Territories, Ecology of Wolves in the Central Arctic, N.W.T., Research Associate, Yellowknife, Northwest Territories.
- 1997 Nez Pearce Wolf Recovery Scientific Advisory Committee, Idaho
- 1997-2003 Board of Directors and Founding Member, Conservation Biology Institute, Corvallis, Oregon.
- 1997 U.S. Forest Service Lynx Research Advisory Committee, Missoula, Mt.
- 1995-1997 Riding Mountain National Park Management Plan Science Advisory Committee, Riding Mountain National Park, Manitoba.
- 1998-2006 Animal Care Committee, American Society of Mammalogists
- 1999-2005 U.S. Fish & Wildlife Service, Red Wolf Reintroduction Advisory Committee
- 1996-2014 Parks and Wilderness Specialist Group; International Union for Conservation of Nature
- 2000-2014 Conservation Breeding Specialist Group, International Union for Conservation of Nature Species Specialists, Member and Strategic Associate
- 2002-2009 Board of Directors, Defenders of Wildlife Canada
- 2003-2007 Board of Directors, Wildlands League, USA
- 2004-2008 Chair, Science Advisory Committee, Infectious Wildlife Disease National Strategy, Canada
- 2004-present Chair, National Science Advisory Committee, for Wildlife Tuberculosis, Riding Mountain, Manitoba
- 2008-2015 Board of Directors, Society for Conservation biology
- 2012-present Woodland Caribou Technical Committee, Province of Saskatchewan
- 2014 Canid Specialist Group, International Union for Conservation of Nature Species Specialists, Member and Strategic Associate
- 2017-03-21 Connectivity Conservation Specialist Group, International Union for Conservation of Nature, Member

### **Periodicals and Reports**

- Paquet, P.C. 1974. Small mammals of the Colorado River islands (Arizona). Arizona Fish and Game Bull. 56.
- Paquet, P.C. 1974. Coyote literature review. Special report, Arizona State University Press, Tempe, Ariz.
- Paquet, P.C. 1976. Wolves. Portland Zoological Society Magazine, Portland Zoological Gardens, Portland, Oregon.
- Paquet, P.C., and J.O. Sullivan. 1977. Behavior of wild canids: Social systems of



- wolves in large and small enclosures. Proc. Amer. Assoc. Zool. Parks & Aquar., Hills Co., Topeka, Kansas.
- Paquet, P.C., and J.O. Sullivan. 1978. Management of wolves in captivity. Proc. W. Psychol. Assoc., San Francisco State Univ., San Francisco, California.
- Paquet, P.C. 1981. Behavior of Domesticated Dogs. Pamphlet, Multnomah County Animal Control, Multnomah County, Oregon, 12 pp.
- Carbyn, L.N., D.M. Meleshko, and P.C. Paquet. 1983. Ecological studies of wolves and coyotes in Riding Mountain National Park, Manitoba. Canadian Wildlife Service Annual Report: 15 June 1982 to 31 March 1983. 60 pp.
- Meleshko, D.M., and P.C. Paquet. 1983. Annual classified ungulate survey, Riding Mountain National Park, Manitoba. Canadian Wildlife Service Report, Large Mammal System Study Series.
- Paquet, P.C., and D.M. Meleshko. 1984. Annual classified ungulate survey, Riding Mountain National Park, Manitoba. Canadian Wildlife Service Report.
- Paquet, P.C., D.M. Meleshko, and L.N. Carbyn. 1985. Annual classified ungulate survey, Riding Mountain National Park, Manitoba. Canadian Wildlife Service Report.
- Carbyn, L.N., Paquet, P.C., and D.M. Meleshko. 1985. Ecological studies of wolves and coyotes in Riding Mountain National Park, Manitoba. Canadian Wildlife Service Annual Report: 1 April 1983 to 31 December 1984.
- Pesendorfer, J., P. C. Paquet, and L. N. Carbyn. 1986. A comparison of the 1984 and 1985 nocturnal howling surveys, RMNP, Manitoba. LMSS Series, Rep. No. 18.
- Carbyn, L. N., D. Meleshko, P. C. Paquet, S. Mckinlay, D. Burles, and J. Pessendorfer. 1986. Ecological studies of wolves and coyotes in Riding Mountain National Park, Manitoba. Canadian Wildlife Service Progress Report 3.
- Carbyn, L.N., and P.C. Paquet. 1986. Long distance movement of a coyote from Riding Mountain National Park. Journal of Wildlife Management 50:89.
- Meleshko, D.M., and P.C. Paquet. 1986. Annual classified ungulate survey, Riding Mountain National Park, Manitoba. Canadian Wildlife Service Report.
- Paquet, P.C. 1986. Wolves revisited. Nature Canada 15:54.

- Paquet, P.C., and L.N. Carbyn. 1986. Wolves, *Canis lupus*, killing denning black bears, *Ursus americanus*, in the Riding Mountain National Park area. *Canadian Field-Naturalist* 100:371-372.
- Pesendorfer J., P.C. Paquet, and L.N. Carbyn. 1986. A comparison of the 1984 and 1985 nocturnal howling surveys, Riding Mountain National Park, Manitoba. *Canadian Wildlife Service Report No. 18, Large Mammal System Study Series*, 18 pp.
- Carbyn, L.N., P.C. Paquet, and D.M. Meleshko. 1987. The Wolves of Riding Mountain. *Canadian Wildlife Service Report, Large Mammal System Study Series*.
- Paquet, P.C. 1987. Canid howling survey. Riding Mountain National Park, Manitoba. *Canadian Wildlife Service Report, Large Mammal System Study Series*.
- Paquet, P.C., Crichton, V.F.J., and Wotten. D.L. 1988. A study of cadmium levels in Manitoba wildlife. 1987 Progress Report. Prepared for Environment Canada and World Wildlife Fund Canada, Toxicology Fund.
- Kiliaan, H.P.L., Mamo, C. and Paquet, P.C., 1991. A coyote, *Canis latrans*, and badger, *Taxidea taxus*, interaction near Cypress Hills Provincial-Park, Alberta. *Canadian Field-Naturalist*, 105:122-123.
- Gibeau, M, and Paquet, P.C. 1991. Evaluation of telezol for immobilization of black bears. *Wildlife Society Bulletin* 19:400-402.
- Paquet, P.C. 1991. Winter spatial relationships of wolves and coyotes in Riding Mountain National Park, Manitoba. *Journal of Mammalogy* 72:397-401.
- Paquet P.C. 1991. Black bear ecology in the Riding Mountains. Final report. Prepared for Manitoba Natural Resources and Canadian Park Service by John/Paul & Associates. 143 pp.
- Paquet, P.C. 1991. Scent marking behavior of sympatric wolves (*Canis lupus*) and coyotes (*C. latrans*) in Riding Mountain National Park. *Canadian Journal of Zoology* 69:1721-1727.
- Irwin, G.H., Purves, H., Paquet, P.C., and J.G. Woods. 1992. An intervenor submission to the Natural Resource Board of Alberta on behalf of Environment Canada relating to application #9103 by Three Sisters Golf Resorts Inc. Recreational and Tourist Development in the Bow-Canmore Corridor. Environment Canada, Banff, AB. 72pp.

- McCallum, M.J. and P.C. Paquet. 1992. Preliminary wildlife study and analysis of ungulate travel corridors on CADCO property, Canmore, Alberta. Prepared for Canmore Alpine Development Company Ltd. 72pp.
- Paquet, P.C. 1992. Prey use strategies of sympatric wolves and coyotes in Riding Mountain National Park, Manitoba. *Journal of Mammalogy* 73:337-343.
- Purves, H.D., White, C.A., and P.C. Paquet. 1992. Wolf and grizzly bear habitat use and displacement by human use in Banff, Yoho, and Kootenay National Parks: a preliminary analysis. Canadian Parks Service, Banff. AB. 54pp.
- McCallum, M.J. and P.C. Paquet. 1993. Stone Creek Properties Inc. wildlife management plan, Canmore, Alberta. Prepared for Stone Creek Properties by McCallum Paquet Associates. 95pp.
- McTavish, C. and Paquet, P.C. 1993. Behavioral ecology of gray wolves in Kootenay National Park, British Columbia. Annual Report. Prepared for Parks Canada.
- Gibeau, M.L., Paquet, P.C., Herrero, S., J. Jorgenson, and G. Green. 1994. Wildlife corridors in the Bow Valley, Alberta: an analysis. Prepared for the Inter-government Committee on Wildlife Corridors. Canmore, AB. 37pp.
- Keister, R.A., Eckhardt, C., Benkman, C.W., Hansen, A.J., Houck, O. Jarvis, R.L., Lande, R., Lidicker, W.Z., McCullough, D.R., McLellan, B., Marcot, B., Mariani, J., Paquet, P.C., Pletscher, D., Powell, R., Ratti, J., Scott, J.M., Schaffer, M.L., Smith, C.C., Taber, R.D., Walters, J. 1994. Wildlife management and conservation biology on the Tongass National Forest: A synthetic review with recommendations. Pacific Northwest Research Station. USDA Forest Service, Corvallis, Ore.
- Krizan, P., Neale, G., Paquet, P.C. 1994. Behavioral ecology of gray wolves in Pukaskwa National Park, Ontario, Annual Report. Prepared for Parks Canada.
- Pacas, C., and Paquet, P.C. 1995. Analysis of black bear home range using a geographic information system. *International Conference on Bear Research and Management*. 9:419-425.
- McCallum, M.J. and P.C. Paquet. 1995. Special features in Yoho National Park, MT. Prepared for Parks Canada. Yoho National Park, B.C.
- McCallum, M.J. and P.C. Paquet. 1995. 1994 Wildlife Monitoring on the SilverTip property, Canmore, AB. Prepared for Stone Creek Properties by McCallum Paquet Associates, Canmore, Alberta. 47pp.

- Paquet, P.C., and Hackman, A. 1995. A large carnivore conservation strategy for the Rocky Mountains. World Wildlife Fund (Canada) and World Wildlife Fund (USA). 52pp.
- Alexander, S., C. Callaghan, P.C. Paquet and N. Waters. 1996. GIS predictive models for habitat use by wolves (*Canis lupus*). Conference Proceedings: CD-ROM. GIS '96: Ten Years of Excellence. Vancouver, BC. March 17-20, 1996.
- Clark, T.W., Paquet, P.C., and Purlee, P. (eds) 1996. Large Carnivore Conservation in the Rocky Mountains of the United States and Canada. Special Section. Conservation Biology 10:936-1055.
- Clark, T.W., Paquet, P.C., and Curlee, P.A. 1996. Introduction: Special Section: Large Carnivore Conservation in the Rocky Mountains of the United States and Canada. Conservation Biology 10:936-939.
- Clark, T.W., Paquet, P.C., and Curlee, P.A. 1996. General lessons and positive trends in large carnivore Conservation: Special Section: Large Carnivore Conservation in the Rocky Mountains of the United States and Canada. Conservation Biology 10:1055-1058.
- P.C. Paquet and C. Apps. 1996. Section 3.5.3 on gray wolves. In Herrero, S. and Herrero, J. Cheviot Mine Project: Specific and cumulative environmental effects analysis for mammalian carnivores. Prepared for Cardinal River Coal Ltd. Hinton, AB. 122pp
- McCallum, M.J. and P.C. Paquet. 1996. 1995 Wildlife Monitoring on the SilverTip property, Canmore, AB. Prepared for Stone Creek Properties by McCallum Paquet Associates, Canmore, Alberta. 47pp.
- Noss, F. R., Quigley, H.B., Hornocker, T.M., and Paquet, P.C. 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Conservation Biology 10:949-963.
- P5 Study. 1996. Interim report on ecology of gray wolves and associated prey species in the Greater Pukaskwa Ecosystem, Ontario, 1994-1996. Prepared by F. Burrows, P. Krizan, G. Neale, and P. Paquet for Pukaskwa National Park, ON.
- Weaver, J.L., Paquet, P.C., and L.F. Ruggiero. 1996. Resilience and Conservation of Large Carnivores in the Rocky Mountains. Conservation Biology 10:964-976.
- Alexander, S., P.C. Paquet and N. Waters. 1997. Playing God with GIS: Uncertainty in

- Wolf Habitat Suitability Models. Conference Proceedings: GIS World '97. Vancouver, BC. February 17-20, 1997.
- Sawyer, M.D., D. Mayhood, P. Paquet, C. Wallis, R. Thomas, and W. Haskins. 1997. Southern East Slopes Cumulative Effects Assessment Project. Prepared for Morrison Petroleum Ltd. Calgary, AB. 291 pp.
- Donelon, S. & P.C. Paquet. 1997. Technical report on development of a decision support model for the Lake O'hara socio-ecologic study. A Background report for the GIS decision-support model for the Lake O'Hara/McArthur Valley Socio-ecological Study. Parks Canada.
- McRory, W. McTavish, C. and P.C. Paquet. 1998. Grizzly bear background research document 1993-1996 for GIS bear encounter risk model, Yoho National Park, B.C. A Background report for the GIS decision-support model for the Lake O'Hara/McArthur Valley Socio-ecological Study. Parks Canada.
- Paquet, P.C. 1998. Kootenay/Yoho Summary Report. Parks Canada (Title and publication date has been revised by Parks Canada; requires update)
- Crichton, V. and P.C. Paquet. 1999. Cadmium in Manitoba's Wildlife. *Alces* 36:205-216.
- Paquet, P.C., Noss, R.F., Carroll, C., and S. Alexander. 1999. Conservation biology primer and carnivores as conservation species. Prepared for Sierra Club of British Columbia and Central Coast LRMP.
- Wilson, P. J., S. Grewal, I. D. Lawford, J. N. M. Heal, A. G. Granacki, D. Pennock, J. B. Theberge, M. T. Theberge, D. R. Voigt, W. Waddell, R. E. Chambers, P. C. Paquet, G. Goulet, D. Cluff, and B. N. White. 2000. DNA profiles of the eastern Canadian wolf and the red wolf provide evidence for a common evolutionary history independent of the gray wolf. *Canadian Journal of Zoology* 78:1-11.
- Carroll, C., Noss, R.F., and P.C. Paquet. 1999. Carnivores as focal species for conservation planning in the Rocky Mountain region. World Wildlife Fund Canada. Toronto, Ontario, Canada. 61pp.
- Carroll, C., Paquet, P.C., & R.F. Noss. 1999. Modeling carnivore habitat in the Rocky Mountain region. A literature review and suggested strategy. World Wildlife Fund Canada. Toronto, Ontario, Canada. 104pp.
- Terborgh, J., J. Estes, P. C. Paquet, K. Ralls, D. Boyd-Heger, B. Miller, and R. Noss. 1999. The role of top carnivores in regulating terrestrial ecosystems. *Wild Earth*

9:42-56.

Darimont, C.T. and P.C. Paquet. 2000. The gray wolves (*Canis lupus*) of British Columbia's coastal rainforests: Findings from year 2000 pilot study and conservation assessment. Prepared for Raincoast Conservation Society. Victoria, BC. 62pp.

Carroll, C., Noss, R.F., and P.C. Paquet. 2001. Carnivores as focal species for conservation planning in the Rocky Mountain Region. *Ecological Applications* 11:961-980.

Walton, H., D. Cluff, P. C. Paquet, and M.A. Ramsay. 2001. Performance of two models of satellite collars for wolves. *Wildlife Society Bulletin* 29:180-186.

Walton, H., D. Cluff, P. C. Paquet, and M.A. Ramsay. 2001. Movement patterns of barren-ground wolves in the Central Canadian arctic. *Journal of Mammalogy* 82:867-876.

Paquet, P.C., Vucetich, J.A. Phillips, M.K. and L.M. Vucetich et al. 2001. Mexican wolf recovery: three-year program review and assessment. Prepared by the Conservation Breeding Specialist Group (CBSG), Apple Valley, Minnesota; prepared for the United States Fish and Wildlife Service, Albuquerque, New Mexico. 86pp.

Fascione, N., Osborn, L.G.L., Kendrot, S.R., and P.C. Paquet. 2001. *Canis* soupus: Eastern wolf genetics and its implications for wolf recovery in the Northeast United States. *Endangered Species Update* 18:159-163.

Paquet, P.C., Burrows, F., Forshner, A., Neale, G., and K. Wade. 2002. Blastomycosis in a free ranging wolves, *Canis lupus*, on the North Shore of Lake Superior, Ontario - a response to P. Krizan. *Canadian Field Naturalist* 115:185.

Paquet, P.C. and Darimont, C.T. 2002. Yeo Island Wolf Home Site Recommendation A Proposed Solution To The Potential Conflict Between The Home Site Requirements Of Wolves And Areas Targeted For Timber Harvest Prepared For The Heiltsuk Nation, Western Forest Products, Raincoast Conservation Society.

Alexander, S.M., Duke, D.L., and P.C. Paquet. 2002. Modeling carnivore habitat-use, travel patterns and human activity around the town of Canmore. Prepared for the Wilburforce Foundation, Seattle, WA.

Carroll, C., Noss, R.F., and Paquet, P.C. 2002. Rocky Mountain carnivore project final report. Prepared For World Wildlife Fund Canada, Toronto, ON.

- Hebblewhite, M., D.H. Pletscher, and P.C. Paquet. 2002. Elk population dynamics in areas with and without predation by recolonizing wolves in Banff National Park, Alberta. *Canadian Journal of Zoology* 80:789-799.
- Darimont, C.T. and P.C. Paquet. 2002. The Gray Wolves, *Canis lupus*, of British Columbia's Central and North Coast: distribution and conservation assessment. *Canadian Field-Naturalist* 116:416-422.
- McCrorry, W., Paquet, P., and Cross, B. 2003. Assessing conservation values for the gray wolf and sitka deer of the B.C. Central Coast Rainforest.
- Cluff, D., M. Musiani, P.F. Frame, P. Paquet, and C.C. Gates. 2003. Multiple litters at den sites, Northwest Territories *Wolf Notes* 7:1-8.
- Darimont, C., Gerwing, K, Paquet, P., Reid, B., McCrorry, W. and Cross, B. 2003. Preliminary modeling of deer winter range in Heiltsuk Territory on the Central Coast of British Columbia. (Summary reference document to accompany maps) Prepared for the Heiltsuk Nation and Raincoast Conservation Society, British Columbia.
- Darimont, C.T., T.E. Reimchen and P.C. Paquet. 2003. Foraging behaviour by gray wolves on salmon streams in coastal British Columbia. *Canadian Journal of Zoology* 81:349-353.
- Hebblewhite, M.D., Paquet, P.C., and D.H. Pletscher. 2003. Development and application of a ratio-estimator to estimate wolf killing rates and variance in a multiple prey system. *Wildlife Society Bulletin* 31:933-946
- Hebblewhite, M.D., D.H. Pletscher, and Paquet, P.C. 2003. Elk population dynamics after wolf recolonization in the Bow Valley of Banff National Park. *Research Links* 11:1-13
- Carroll, C., Noss, R.F., Paquet, P.C., and Schumaker, N.H. 2003. Integrating population viability analysis and reserve selection algorithms into regional conservation plans. *Ecological Applications* 13: 1773-1789.
- Musiani, M. and P.C. Paquet. 2004. Wolf Persecution, Protection, and Restoration in Canada and the United States. *Bioscience*, 54:50-60.
- Gilbert, B., Craighead, L., Horejsi, B., Paquet, P., and W. McCrorry. 2004. Scientific criteria for evaluation and establishment of grizzly bear management areas in British Columbia. Panel of Independent Scientists, Victoria, B.C. 16pp.



- Paquet, P.C., C.T. Darimont, R. J. Nelson, and K. Bennett. 2004. A critical assessment of protection for key wildlife and salmon habitats under the proposed British Columbia Central Coast Land and Resource Management Plan. Raincoast Conservation Society. 23pp.
- Carroll, C., Noss, R.F., Paquet, P.C., and Schumaker, N.H. 2004. Extinction debt of protected areas in developing landscapes. *Conservation Biology* 18: 1110-1120.
- McLoughlin, P.D., Walton, L., Cluff, H.D., Paquet, P. 2004. Hierarchical habitat selection by tundra wolves. *Journal of Mammalogy* 85:576-580.
- Frame, P.F., D.S. Hik, H.D. Cluff, and P.C. Paquet. 2004. Long foraging movement of a denning tundra wolf. *Arctic* 58: 196-203.
- Forshner, S. A., P. Paquet, F. G. M. Burrows, G. K. Neale, and K. D. Wade. 2004. Demographic patterns and limitations of wolves (*Canis lupus*) in and near Pukaskwa National Park, Ontario, Canada. *Canadian Field Naturalist* 118:95-104.
- Carroll, C., Noss, R.F., and P.C. Paquet. 2004. A proposed wildlands network for carnivore conservation in the Rocky Mountains. *Wild Earth*, Spring: 38-41
- Darimont, C. T., M. H. H. Price, N. N. Winchester, J. Gordon-Walker and P. C. Paquet. 2004. Predators in natural fragments: foraging ecology of wolves in British Columbia's central and north coast archipelago. *Journal of Biogeography* 31: 1867-1877
- Paquet, P. C., C. T. Darimont, C. Genovali, and F. Moola. 2004-2005. In the Great Bear Rainforest: island-hopping gray wolves give new insights into island biogeography. *Wild Earth* Fall/Winter: 20-25
- Paquet, P., C. Darimont, C. Genovali, and F. Moola. 2005. Last of the best. *Wolf Print*. The UK Wolf Conservation Trust. Issue 24: 7-9.
- Paquet, P. C. and S. M. Alexander. 2004-2005. Banff National Park: how helpful is highway mitigation? *Wild Earth* Fall/Winter: 70-71.
- Paquet, P. C. and R. K. Brook. 2005. Island use as an anti-predator tactic by parturient elk and nursery herds in Riding Mountain National Park, Manitoba. *Wildlife Society Bulletin*.



- Darimont, C. T., P. C. Paquet, T. E. Reimchen, and V. Crichton. 2005. Range expansion by moose into coastal temperate rainforests of British Columbia, Canada. *Diversity and Distributions* 11: 235–239
- Jickling, R., and P.C. Paquet. 2005. Wolf stories: Reflections on science, ethics, and epistemology. *Environmental Ethics* 27:115-134.
- Alexander, S. M., P. C. Paquet, T. B. Logan, and D. J. Saher. 2005. Snow-tracking versus radio-telemetry for predicting wolf-environment relationships in the Rocky Mountains of Canada. *Wildlife Society Bulletin* 33: 1216-1224.
- Hebblewhite, M., C. White, C. Nietvelt, J. Mckenzie, T. Hurd, J. Fryxell, S. Bayley, and P. C. Paquet. 2005. Human activity mediates a trophic cascade caused by wolves. *Ecology* 86: 1320–1330
- Price, M. H., C. T. Darimont, N. N. Winchester, and P. C. Paquet. 2005. Facts from faeces: Prey remains in Wolf, *Canis lupus*, faeces revise occurrence records for mammals of British Columbia's coastal archipelago. *The Canadian Field Naturalist* 119: 192-196.
- Alexander, S. M., Waters, N. M. and Paquet, P. C. 2005. Traffic volume and highway permeability for a mammalian community in the Canadian Rocky Mountains. *Canadian Geographer / Le Géographe Canadien* 49: 321-331
- Paquet, P.C., C.T. Darimont, F.M. Moola, and C. Genovali. 2005. Connectivity where the land meets the sea; preserving the last of the best. *Wild Earth* 14: 21-25
- Paquet, P.C., C.T. Darimont, and C. Genovali. 2006. The Great Bear Rainforest; Home of island-hopping wolves. *Howlings Magazine*. Winter 2005/2006.
- Paquet, P.C., and C.T. Darimont. 2006. Old Growth, New Concern. *Monday Magazine*. August 30, 2006.
- Theberge, J. B., M. T. Theberge, J. A. Vucetich, and P. C. Paquet. 2006. Pitfalls of applying adaptive management to a wolf population in Algonquin Provincial Park, Ontario. *Environmental Management* 37: 451-460.
- Alexander, S. M., T. B. Logan, P. C. Paquet. 2006. Spatio-temporal co-occurrence of cougar (*Felis concolor*), wolves (*Canis lupus*) and their prey during winter: A comparison of two analytical methods. *Journal of Biogeography* 33: 2001-2012.
- Paquet, P. C. and E. G. Walker. 2006. Review of investigative findings relating to the death of Kenton Carnegie At Points North, Saskatchewan. Prepared for and

- submitted to Office of the Chief Coroner Saskatchewan Justice #920, 1801 Hamilton Street Regina, Saskatchewan S4P 4B4. 32 pp.
- Bryan, H., C.T. Darimont, T.E. Reimchen, and P.C. Paquet. 2006. Early ontogenetic diet in wolves, *Canis lupus*, of coastal British Columbia. *Canadian Field-Naturalist* 120:61-66.
- Darimont, C. T., P. C. Paquet, and T. E. Reimchen. 2007. Stable isotopic niche predicts fitness in a wolf-deer system. *Biological Journal of the Linnaean Society* 90: 125-137.
- Stronen, A. V, Brooks, R. K., Paquet, P. C., and S. Mclachlan. 2007. Farmer attitudes toward wolves: Implications for the role of predators in managing disease. *Biological Conservation* 135: 1-10.
- Stronen, A., P.C. Paquet, S. Herrero, S. Sharpe, N. Waters. 2007. Translocation and Recovery Efforts for the Telkwa Caribou, *Rangifer tarandus caribou*, Herd in westcentral British Columbia, 1997 – 2005. *Canadian Field-Naturalist*. 121:155-163.
- Nyhus, P. J., R. Lacy, F. R. Westley, P. Miller, H. Vredenburg, P. Paquet, and J. Pollak. 2007. Tackling biocomplexity with meta-models for species risk assessment. *Ecology and Society* 12(1): 31. [online] URL: <http://www.ecologyandsociety.org/vol12/iss1/art31/>
- Musiani M., Leonard J. A., Cluff H. D., Gates C. C., Mariani S., Paquet P. C., Vilà C., Wayne R. K. 2007. Differentiation of tundra and boreal coniferous forest wolves: genetics, coat color and association with migratory caribou. *Molecular Ecology* 16: 4149-4170
- Darimont, C.T., P.C. Paquet, and T.E. Reimchen. 2007. Stable isotopic niche predicts fitness of prey in a wolf-deer system. *Biological Journal of the Linnean Society* 90: 125-137
- Apps, C. D., J. L. Weaver, P. C. Paquet, B. Bateman and B. N. McLellan. 2007. Carnivores in the southern Canadian Rockies: Core areas and connectivity across the Crowsnest Highway. *Wildlife Conservation Society Canada Conservation Report No. 3*. Toronto, Ontario, Canada.
- Trapp, J.R., Beier, P., Mack, C., Parsons, D.R., and P.C. Paquet. 2008. Wolf, *Canis lupus*, den site selection in the Rocky Mountains. *Canadian Field-Naturalist* 122: 49-56.

- Darimont, C. T., P. C. Paquet, and T. E. Reimchen. 2008. Spawning salmon disrupt tight trophic coupling between wolves and ungulate prey in coastal British Columbia. *BMC Ecology* 8: 14
- Darimont, C.T., T.E. Reimchen, H. Bryan, and P.C. Paquet. 2008. Faecal-centric approaches to wildlife ecology and conservation; methods, data and ethics. *Wildlife Biology in Practice* 4: 73-87
- Darimont, C. T., Paquet, P. C. and T. E. Reimchen. 2009. Landscape heterogeneity and marine subsidy generate extensive intrapopulation niche diversity in a large terrestrial vertebrate. *Journal of Animal Ecology* 78: 126–133
- Muñoz-Fuentes, V., C.T. Darimont, R.K. Wayne, P.C. Paquet, and J.A. Leonard. 2009. The genetic legacy of extirpation and re-colonization in Vancouver Island wolves. *Conservation Genetics*. Early edition.  
[www.pnas.org/cgi/doi/10.1073/pnas.09007871106](http://www.pnas.org/cgi/doi/10.1073/pnas.09007871106)
- Muñoz-Fuentes, V., C.T. Darimont, R.K. Wayne, P.C. Paquet, and J.A. Leonard. 2009. Ecological factors drive genetic differentiation in British Columbia gray wolves. *Journal of Biogeography* 36: 1516-1531.
- Kinnison, M.T., E.P. Palkovacs, C.T. Darimont, S.M. Carlson, P.C. Paquet, and C.C. Wilmers. 2009. Some cautionary notes on fisheries evolutionary impact assessments. *Proceedings of the National Academy of Sciences*. Early edition, [www.pnas.org/cgi/doi/10.1073/pnas.09007871106](http://www.pnas.org/cgi/doi/10.1073/pnas.09007871106)
- Darimont, C.T., S.M. Carlson, M.T. Kinnison, P.C. Paquet, T.E. Reimchen, and C.C. Wilmers. 2009. Reply to Koons: Harvest-related trait changes in an increasingly variable world. *Proceedings of the National Academy of Sciences* 106: E33.
- Darimont, C.T., S.M. Carlson, M.T. Kinnison, P.C. Paquet, T.E. Reimchen, and C.C. Wilmers. 2009. Human predators outpace other agents of trait change. *Proceedings of the National Academy of Sciences* 106: 952-954 (Research Highlight and News & Views in *Nature*, F1000 Biology Recommended Paper; global media coverage in popular press, e.g. *New York Times*)
- Darimont, C.T., P.C. Paquet, and T.E. Reimchen. 2009. Landscape heterogeneity and marine subsidy generate extensive niche variation in a terrestrial carnivore. *Journal of Animal Ecology* 79: 126-133
- McCrary, W.P. and P. Paquet. 2009. Proposed bear-viewing strategy for the K'tzim-a-deen (Khutzeymateen) Grizzly Bear Sanctuary & K'tzim-a-deen Inlet Conservancies, British Columbia. Report for the K'tzim-a-deen Management

Committee & Planning Process, Prince Rupert, B.C.

Mathews, F., D.T. Blumstein, C. Darimont, K. Chan, L. Dill, D. Fraser, J. Kirkwood, K. Littin, D. Lusseau, and P. Paquet. 2010. Uniting wild animal welfare and conservation: guiding principles. *Animal Conservation*.

Bryan, H.M., Sim, K.A., Darimont, C.T., Paquet, P.C., Wagner, B.W., Muñoz-Fuentes, V., Smits, J.E., and Chilton, N.B. 2010. Identification of *Parelaphostrongylus odocoilei* (Nematoda: Protostrongylidae) first-stage larvae in the feces of gray wolves (*Canis lupus*) by molecular methods. *Journal of Wildlife Diseases* 46: 297-302.

Paquet, P.C., and C.T. Darimont. 2010. Wildlife conservation and animal welfare: two sides of the same coin? *Journal of Animal Welfare* 19: 177-190.

Stronen, A.V., Forbes, G.J., Sallows, T., Goulet, G., Musiani, M., and P. C. Paquet. 2010. Wolf body mass, skull morphology and mitochondrial DNA haplotypes in the Riding Mountain National Park region of Manitoba, Canada. *Canadian Journal of Zoology* 88: 496-507

Fox, C.H., Paquet, P.C., Reimchen, T.C. 2010. Active American black bear dens adjacent to a marine beach used for foraging. *Ursus* 21:195–197.

Darimont, C.T., Bryan, H.M., Carlson, S.M., Hocking, M.D., MacDuffee, M., Paquet, P.C., Price, M. H.H., Reimchen, T.E., Reynolds, J.D., and Wilmers, C. 2010. Salmon for terrestrial protected areas. *Conservation Letters* 3:379-389.

Stronen, A.V., Sallows, T. Forbes, G.J., and P.C. Paquet. 2011. Disease and parasite burden in an increasingly isolated wolf population. *Journal of Wildlife Diseases* 47:222–227

Bryan, H.M., Darimont, C.T., Paquet, P.C., Ellis, J.A., Goji, N., Gouix, M. and Smits, J.E. 2011. Exposure to infectious agents in dogs in remote coastal British Columbia: possible sentinels of diseases in wildlife and people. *Canadian Journal of Veterinary Research* 75:11-17.

Stronen, A.V., Forbes, G.J., Paquet, P. C., Goulet, G., Sallows, T., and M. Musiani. 2011. Dispersal in a plain landscape: short-distance genetic differentiation in southwestern Manitoba wolves, Canada. *Conservation Genetics* 13:359-371 DOI 10.1007/s10592-011-0290-1

Stronen AV, Schumaker NH, Forbes GJ, Paquet PC, Brook RK. 2011. Landscape resistance to dispersal: predicting long-term effects of human disturbance on a small

and isolated wolf population in southwestern Manitoba, Canada. *Environmental Monitoring and Assessment*. Published Online DOI 10.1007/s10661-011-2469-9

Nelson, M.P., Vecetich, J.A., Paquet, P.C. and J.K. Bump. 2011. An adequate construct? North American Model: What's flawed, what's missing, what's needed. *The Wildlife Professional*. Summer: 58-60

Daisuke Kawai, Caroline H. Fox, Paul C. Paquet and Falk Huettmann. Accepted. Predictive performances of 3 models for seabird distribution and abundance estimates; Random Forests, Boosted Regression Trees, and Generalized Additive Model. *Ecological Applications*

Darimont, C.T., Artelle, K., Bryan, H.M., Genovali, C., MacDuffee, M., and Paquet, P.C. Grizzlies, Salmon, and People: Traveling the Upstream Journey to a Sustainable Future. Prepared for a Bear Anthology edited by Lisa M. Kemmerer, in press August 2011.

Vander Wal, E.; Paquet, P.; and J. Andrés. 2012. Influence of landscape and social interactions on transmission of communicable disease in a social cervid. *Molecular Biology* 21: 271–1282 doi: 10.1111/j.1365-294X.2011.05431.x

Nelson, B., Hebblewhite, M., Ezenwa, V., Shury, T., Merrill, E.H., Paquet, P.C., Schmiegelow, F., Seip, D., Skinner, G., Webb, N. 2012. Seroprevalence of canine parvovirus and distemper in wolves in the Canadian Rocky Mountains. *Journal of Wildlife Diseases* 48:68-76.

Service, C., T. Nelson, W. McInnes, P.C. Paquet & C.T. Darimont. 2012. Evaluating external risks to protected areas; the proposed Enbridge Northern Gateway pipeline in British Columbia, Canada. *Natural Areas Journal*. 32: 500-509. DOI: <http://dx.doi.org/10.3375/043.032.0404> URL: <http://www.bioone.org/doi/full/10.3375/043.032.0404>

Levi, T., C. T. Darimont, M.M. MacDuffee, M. Mangel, P.C. Paquet, & C.C. Wilmers. 2012. Using grizzly bears to assess economic and ecosystem tradeoffs in Pacific salmon management. *PLoS Biology* 10: e1001303.

Bryan, H.M. C.T. Darimont, J. Hill, P.C. Paquet, R.C.A. Thompson, B. Wagner, & J. E.G. Smits. 2012. Seasonal and biogeographic patterns of gastrointestinal parasites in large carnivores; wolves in a coastal archipelago. *Parasitology* 139: 781-790.

Stronen, A.V., Tessier, N., Jolicoeur, H., Paquet, P.C., Hé nault, M., Villemure, M., Patterson, B.R., Sallows, T., Goulet, G. and F.J. Lapointe. 2012. *Canid*

- hybridization: contemporary evolution in human-modified landscapes. *Ecology and Evolution* 1-13.
- Vander Wal, E., Paquet, P., and J. Andrés. 2012. Influence of landscape and social interactions on transmission of communicable disease in a social cervid. *Molecular Biology* 21: 271–1282 doi: 10.1111/j.1365-294X.2011.05431.x
- van Beest, F.M., Vander Wal, E., Stronen, A.V., Paquet, P.C. and R.K. Brook. 2013. Temporal variation in site fidelity: Scale-dependent effects of forage abundance and predation risk in a non-migratory large herbivore. *Oecologia*. 173:409–420 DOI 10.1007/s00442-013-2647-2
- Vander Wal, E., Edey, I., Paquet, P.C., Coltman, D.W., Bayne, E., R.K. Brook, R.K., and J.A. Andres. 2013. Juxtaposition between an unstructured white-tailed deer population and a structured elk population: implications for disease transmission in a sympatric cervid community. *Evolutionary Applications*. 6:1001-1111.
- Vander Wal, E., Paquet, P.C., Messier, F., and P.D. McLoughlin. 2013. Effects of phenology and sex on social proximity in a gregarious ungulate Canadian *Journal of Zoology*. 91:601–609 dx.doi.org/10.1139/cjz-2012-0237
- Stronen, A.V. and Paquet, P.C. 2013. Perspectives on the conservation of wild hybrids. *Biological Conservation*. 167:390–395.  
<http://dx.doi.org/10.1016/j.biocon.2013.09.004>
- Artelle, K.A., S.C. Anderson, A.B. Cooper, P.C. Paquet, J.D. Reynolds, C.T. Darimont. 2013. Confronting uncertainty in wildlife management: performance of grizzly bear management. *PLoS ONE* 8(11): e78041.  
doi:10.1371/journal.pone.0078041
- MacDuffee, M., A.R. Rosenberger, R. Dixon, M.H.H. Price, and P.C. Paquet. 2013. Embroiled, Volume 1: Salmon, tankers and the Enbridge Northern Gateway Proposal. Raincoast Conservation Foundation. Sidney, British Columbia. Vers 01-13, pp. 107.
- Bryan, H.M., C.T. Darimont, P.C. Paquet, K.E. Wynne-Edwards and J.E. Smits. 2013. Stress and reproductive hormones in grizzly bears reflect nutritional benefits and social consequences of a salmon foraging niche. *PLOS ONE*
- Vander Wal, E., P.C. Paquet, F. Messier, and P.D. McLoughlin. 2013. Social proximity in an ungulate expressed as frequency and duration of interactions. *Canadian Journal of Zoology*.

- Fox, C.H., R. El-Sabaawi, P.C. Paquet, and T.E. Reimchen. 2014. Pacific herring (*Clupea pallasii*) and wrack macrophytes subsidize semi-terrestrial detritivores. *Marine Ecology Progress Series*.
- Adams, M. S., J. Carpenter, J. A. Housty, D. Neasloss, P. C. Paquet, C. Service, J. Walkus, and C. T. Darimont. 2014. Toward increased engagement between academic and indigenous community partners in ecological research. *Ecology and Society* **19**(3): 5.  
<http://dx.doi.org/10.5751/ES-06569-190305>
- Artelle, K.A., Reynolds, J.D. Paquet, P.C. & Darimont, C.T. 2014. When science-based management isn't. *Science* **343**, 1311.
- Darimont, C.T., C. Genovali, C. Service, and P.C. Paquet. In Press. Hunting for a trophy hunting ethic. In *Animals and the Environment: Advocacy, Activism, and the Quest for Common Ground* (L. Kemmerer, Ed). Routledge Press.
- Bryan, H.M., Darimont, C.T., Paquet, P.C., Wynne-Edwards, K.E., and Smits, J.E.G. 2014. Stress and reproductive hormones reflect inter-specific social and nutritional conditions mediated by resource availability in a bear-salmon system. *Conservation Physiology* 2(1): cou010doi: 10.1093/conphys/cou010
- Stronen, A.V., Navid, E.L., Quinn, M.S., Paquet, P.C., Bryan, H.M., and Darimont, C.T. 2014. Population genetic structure of gray wolves (*Canis lupus*) in a marine archipelago suggests island-mainland differentiation consistent with dietary niche. *BMC Ecology* 14:11. doi:10.1186/1472-6785-14-11
- Christina N. Service, Megan S. Adams, Kyle A. Artelle, Laura V. Grant, Paul C. Paquet, and Chris T. Darimont. 2014. Indigenous knowledge and science unite to reveal spatial and temporal dimensions of distributional shift in wildlife of conservation concern. *PLOS ONE* DOI: 10.1371/journal.pone.0101595
- Bryan, Heather M., Judit E. G. Smits, Lee Koren, Paul C. Paquet, Katherine E. Wynne-Edwards and Marco Musiani. 2014. Heavily hunted wolves have higher stress and reproductive steroids than wolves with lower hunting pressure. *Functional Ecology*. DOI: 10.1111/1365-2435.12354
- Brook, R.K., Cattet, M., Darimont, C.T., Paquet, P.C. and G. Proulx. 2015. Maintaining ethical standards during conservation crises. *Canadian Wildlife Biology & Management* 4: 72-79.



- Fox, C.H., Paquet, P.C., and T.E. Reimchen. 2015. Novel species interactions: American black bears respond to Pacific herring spawn. *BMC Ecology*. DOI 10.1186/s12898-015-0045-9.
- Best, B.D., Fox, C.H., Williams, R., Halprin, P.N., and P.C. Paquet. 2015. Updated marine mammal distribution and abundance estimates in British Columbia. *Journal Of Cetacean Research and Management*. 15: 9–26.
- Cullingham, C.I., Thiessen, C.D., Derocher, A.E., Paquet, P.C., Miller, J.M., Hamilton, J.A., and D.W. Coltman. 2016. Population structure and dispersal of wolves in the Canadian Rocky Mountains. *Journal of Mammalogy*. DOI: <http://dx.doi.org/10.1093/jmammal/gyw015>
- Caroline H. Fox, Aerin L. Jacob, Chris T. Darimont, Paul C. Paquet. 2016. Pacific herring and fisheries management in Canada: A new era or repeated history?, *Ocean & Coastal Management*. 125: 47-48, ISSN 0964-5691, <http://dx.doi.org/10.1016/j.ocecoaman.2016.03.004>.
- Artelle, K.A., Anderson, Reynolds, J.D., Cooper, A.B., Paquet, P.C., and C.T. Darimont. 2016. Ecology of conflict: marine food supply affects human-wildlife interactions on land. *Sci. Rep.* 6, 25936; doi: 10.1038/srep25936.
- C.H. Fox, P.D. O'Hara, S. Bertazzon, K. Morgan, F.E. Underwood, P.C. Paquet. 2016. A preliminary spatial assessment of risk: Marine birds and chronic oil pollution on Canada's Pacific coast. *Science of The Total Environment*. 573: 799-809, ISSN 0048-9697, <http://dx.doi.org/10.1016/j.scitotenv.2016.08.145>.
- Fox, C.H., Huettmann, F., Morgan, K., O' Hara, P., Paquet, P.C. 2017. Predictions from Machine Learning ensembles: marine bird distribution and density on Canada's Pacific coast. *Marine Ecology Progress Series*. Vol. 566: 199–216, 2017 doi: 10.3354/meps12030
- Proulx, G., Alexander, S., Barron, H., Bekoff, M., Brook, R., Bryan, H., Darimont, C., Dubois, S., Lukasik, V., McCrory, W., Paquet, P., Parr, S., Powell, R. Vik Sronen, A., and A. Wallach. 2017. Killing wolves and farming caribou benefit industry, not caribou: a response to Stan Boutin. *Nature Alberta* Volume 47, Number 1, pages 4-11
- Adams, M. S., C. N. Service, A. Bateman, M. Bourbonnais, K. A. Artelle, T. Nelson, P. C. Paquet, T. Levi, and C. T. Darimont. 2017. Intrapopulation diversity in isotopic niche over landscapes: Spatial patterns inform conservation of bear–salmon systems. *Ecosphere* 8(6):e01843. 10.1002/ecs2.1843



- Harvey, G. K. A., T. A. Nelson, C. H. Fox, and P. C. Paquet. 2017. Quantifying marine mammal hotspots in British Columbia, Canada. *Ecosphere* 00(00):e01884. 10.1002/ecs2.1884
- Lacy, R. C., R. Williams, E. Ashe, K. C. Balcomb III, L. J. N. Brent, C. W. Clark, D. P. Croft, D. A. Giles, M. MacDuffee, and P. C. Paquet. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. *Scientific Reports* 7:14119.
- Treves, A., K. A. Artelle, C. T. Darimont, W. S. Lynn, P. Paquet, F. J. Santiago-Ávila, R. Shaw, and M. C. Wood. 2018. Intergenerational equity can help to prevent climate change and extinction. *Nature Ecology & Evolution* 2:204-207.
- Darimont, C. T., P. C. Paquet, A. Treves, K. A. Artelle, and G. Chapron. 2018. Political populations of large carnivores. *Conservation Biology*, Volume 32: 747–749. DOI: 10.1111/cobi.13065
- K. A. Artelle, J. D. Reynolds, A. Treves, J. C. Walsh, P. C. Paquet, C. T. Darimont, Hallmarks of science missing from North American wildlife management. *Sci. Adv.* 4, eaao0167 (2018). DOI: <https://doi.org/10.1126/sciadv.aao0167>
- C. H. Fox, P. C. Paquet, T. E. Reimchen. 2018. Pacific herring spawn events influence nearshore subtidal and intertidal species. *MEPS* <https://doi.org/10.3354/meps12539>
- Hendricks, S., R. Schweizer, R. Harrigan, J. Pollinger, R. Brown, P. Paquet, C. Darimont, J. Adams, L. Waits, B. vonHoldt, P. Hohenlohe, and R. Wayne. In Press 2018. Natural re-colonization and admixture of wolves (*Canis lupus*) in the US Pacific Northwest: challenges for the protection and management of rare and endangered taxa. *Heredity*. <https://doi.org/10.1038/s41437-018-0094-x>
- Batavia C, Nelson MP, Darimont CT, Paquet PC, Ripple WJ, Wallach AD. The elephant (head) in the room: A critical look at trophy hunting. *Conservation Letters*.2018;e12565. <https://doi.org/10.1111/conl.12565>
- K.A. Artelle, J.D. Reynolds, A.Treves, J.C. Walsh, P.C. Paquet, C.T. Darimont. 2018. Working constructively toward an improved North American approach to wildlife management. *Sci Adv* 4 (10), eaav2571. DOI: 10.1126/sciadv.aav2571
- Treves, A., Artelle, K.A., and P.C. Paquet. 2018. Differentiating between regulation and hunting as conservation interventions. *Conservation Biology*. DOI:10.1111/cobi.13211

Paquet, P.C. and Alexander, S.M. 2018. Habitat loss: changing how animals think? Pages 4-14 *In* Andrew Butterworth, editor. Animal welfare in a changing world. 2018. CABI Wallingford, Oxfordshire, UK; Boston, MA. LC record available at <https://lccn.loc.gov/2017059470>

Service, C. et al. In press. Salmonid species diversity predicts salmon consumption by terrestrial wildlife. *Journal of Animal Ecology*

### **Peer Reviewed Books and Chapters**

Harrington, F.H. and P.C. Paquet (Eds.). 1982. *Wolves of the world: Perspectives of behavior, ecology, and conservation*. Noyes Publications, New Jersey

Harrington, F.H. and P.C. Paquet (Eds.). 1982. *Wolves of the world: Perspectives of behavior, ecology, and conservation*. 2<sup>nd</sup> edition. Noyes Publications, New Jersey

Paquet, P.C., S. Bragdon, and S. McCusker. 1982. Cooperative rearing of simultaneous litters in captive wolves. *In* F.H. Harrington and P.C. Paquet (Eds.) *Wolves of the World*, Noyes Publications, New Jersey, p. 223-237.

Harrington, F.H., P.C. Paquet, J. Ryon, and J.C. Fentress. 1982. Monogamy in wolves: A review of the evidence. *In* F.H. Harrington and P.C. Paquet (Eds.) *Wolves of the World*, Noyes Publications, New Jersey, p. 209-222.

Paquet, P.C. and W.A. Fuller. 1990. Scent marking and territoriality in wolves of Riding Mountain National Park. *In* *Chemical signals in vertebrates 5*. Eds. D.W. Macdonald, D. Muller-Schwarze, and S.E. Natynczuk. Oxford University Press, N.Y. pp 394-400.

Boyd, D.K., Paquet, P.C., Donelon S., Ream, R.R., Pletscher, D.H., and C.C. White. 1995. Transboundary movements of a recolonizing wolf population in the Rocky Mountains. Pages 135-140 *In* L.N. Carbyn, S.H. Fritts, and D.R. Seip, editors, *Ecology and conservation of wolves in a changing world*. Canadian Circumpolar Institute, Edmonton, Alberta.

Woods, J., Cornwell, L.L., Hurd, T., Kunelius, R., Paquet, P., and J. Wierzchowski 1996. Elk and Other Ungulates. Chapter 8 in: Green J., Pacas, C, Bayley, S., and Cornwell, L. (eds). *A cumulative effects assessment and futures outlook for the Banff Bow Valley*. Prepared for the Banff Bow Valley Study, Department of Canadian Heritage, Ottawa, On.

Paquet, P.C., Wierzchowski, J. and Callaghan, C. 1996. Summary report on the

- effects of human activity on gray wolves in the Bow River Valley, Banff National Park, Alberta. Chapter 7 in: Green J., Pacas, C, Bayley, S., and Cornwell, L. (eds). A cumulative effects assessment and futures outlook for the Banff Bow Valley. Prepared for the Banff Bow Valley Study, Department of Canadian Heritage, Ottawa, On.
- Paquet, P.C., and C. Callaghan. 1996. Effects of linear developments on winter movements of gray wolves in the Bow River Valley in Banff National Park, Alberta. Pages 46-66 In G.L. Evink, P. Garrett, D. Ziegler, and J. Berry, editors. Trends in Addressing Transportation Related Wildlife Mortality. Proceedings of the Transportation Related Wildlife Mortality Seminar. FL-ER-58-96. Florida Department of Transportation, Tallahassee, Florida, U.S.A.
- Paquet, P.C. and Callaghan, C. 1997. GIS decision support models for highway planning. In G. Evink, D. Ziegler, P. Garret, and J. Barry, editors, Highways and movements of wildlife: improving habitat connections and wildlife passageways across highway corridors. Proceedings of the Florida Department of Transportation/Federal Highway Administration Transportation-Related Wildlife Mortality Seminar.
- Terborgh, J., Estes, J.A., P.C. Paquet, K, Ralls, D. Boyd-Heger, B.J. Miller, and R.F. Noss. 1999. The role of top carnivores in regulating terrestrial ecosystems. Pages 39-64 in Continental Conservation, eds. M.E. Soule and J. Terborgh. Island Press, Washington, D.C. 227pp.
- Carroll, C., Noss, R.F., Shoemaker, N, and P.C. Paquet. 2001. Is the restoration of wolf, wolverine, and grizzly bear to Oregon and California biologically feasible? In D. S. Maehar, R. F. Noss, and J. L. Larkin (eds.) Large Mammal Restoration, Island Press, Washington, D.C.
- Duke, D.L., Hebblewhite, M., Paquet, P.C., Callaghan, C., and M. Percy. 2001. Restoration of a large carnivore corridor in Banff National Park, Alberta. Pages 261-276 in D. S. Maehar, R. F. Noss, and J. L. Larkin (eds.) Large Mammal Restoration, Island Press, Washington, D.C..
- Paquet, P.C., J. R. Strittholt, N. L. Staus, P. J. Wilson, S. Grewal, and B. N. White. 2001. Feasibility of timber wolf reintroduction in Adirondack Park. Pages 47 - 64, in D. S. Maehar, R. F. Noss, and J. L. Larkin (eds.). Large Mammal Restoration, Island Press, Washington, D.C.
- Paquet, P.C. 2001. Wolves. Pages 42-45, In D. Macdonald (ed) New Encyclopedia of Mammals, Oxford University Press, Oxford.

- Paquet, P.C. 2001. An ongoing genetic mystery. Pages 46-47, in D. Macdonald (ed) *New Encyclopedia of Mammals*, Oxford University Press, Oxford.
- Alexander, S., N. Waters, and P.C. Paquet. 2002. A Uncertainty-Based Decision Support Model for Restoring Wildlife Landscape Connectivity in Road Fragmented Environments. In G. Clarke and J. Stillwell, editors. *Applied GIS and Spatial Modelling*. University of Leeds, United Kingdom.
- Paquet, P. C. and L. N. Carbyn. 2003. Wolf, *Canis lupus* and allies. Pages 482-510 in G. A. Feldhamer, B. C. Thompson, and J. A. Chapman, editors. *Wild Mammals of North America: Biology, Management, and Conservation*. Johns Hopkins University Press, Baltimore, MD
- Alexander, S., N. Waters, and P.C. Paquet. 2004. A Probability-based GIS Model for Identifying Focal Species Linkage Zones across Highways in the Canadian Rocky Mountains. Pages 233-255 in G. Clarke and J. Stillwell, editors. *Applied GIS and Spatial Modelling*. University of Leeds, United Kingdom.
- Paquet, P. C., S. M. Alexander, P. L. Swan, and C. T. Darimont. 2006. Pages 130-156 in *Connectivity Conservation*, eds K. R. Crooks and M. Sanjayan. Influence of natural landscape fragmentation and resource availability on distribution and connectivity of marine gray wolf (*Canis lupus*) populations on Central Coast, British Columbia, Canada. Cambridge University Press. N.Y. & England.
- Paquet, P.C., S.M. Alexander, P.L. Swan, and C.T. Darimont. 2006. The influence of natural landscape fragmentation and resource availability on connectivity and distribution of marine gray wolf populations on the Central Coast, British Columbia, Canada. In Crooks, K. and M.A. Sanjayan (Eds.) Connectivity Conservation. Cambridge University Press. Cambridge, UK.
- Paquet, P.C. Introduction. In McAllister, I., and C.T. Darimont. 2007. *The Last Wild Wolves. Ghosts of the Great Bear Rainforest*. University of California Press. Berkeley, CA.
- Musiani, M., Boitani, L. and P. C. Paquet (eds.). 2009. *A New Era for Wolves and People: Wolf Recovery, Human Attitudes, and Policy*. University of Calgary Press, Calgary. AB Canada.
- Bloch, G. , Dettling, P., Paquet, P. C., Gibeau, M. 2009. *Auge in Auge mit dem Wolf*. Kosmos, Koln, Germany.
- Musiani, M, Boitani, L, and P. C. Paquet (eds.). 2010. *The world of wolves: new perspectives on ecology, behaviour and policy*. University of Calgary Press,

Calgary. AB, Canada.

Musiani, M, Boitani, L, and P. Paquet (eds). 2010. A new era for wolves and people: wolf recovery, human attitudes and policy. University of Calgary Press, Calgary. AB, Canada.

H. Dean Cluff, H.D., Paquet, P.C., Walton, L.R., and M. Musiani. 2010. Wolf Ecology and Management in Northern Canada: Perspectives from a Snowmobile Wolf Hunt. In Musiani, M, Boitani, L, and P. Paquet (eds) The world of wolves: new perspectives on ecology, behaviour, and policy. University of Calgary Press, Calgary. AB, Canada.

Paquet, P.C., Alexander, S., Donelon, S., and C. Callaghan. 2010. Influence of anthropogenically modified snow conditions on movements and predatory behaviour of gray wolves. In Musiani, M, Boitani, L, and P. Paquet (eds) The world of wolves: new perspectives on ecology, behaviour, and policy. University of Calgary Press, Calgary. AB, Canada

Paquet, P.C., Miller, B., Kunkel, K., Reading, R.P., and M.K. Phillips. 2010. The importance of large carnivores. Pages 49-60 in Reading, R.P., B. J. Miller, A. Masching, R. Edward, and M. Phillips (eds.). *Awakening Spirits: Wolves in the Southern Rockies*. Fulcrum Publishing, Golden, CO.

Phillips, M.K. Miller, B., Kunkel, K., Paquet, P.C., Martin, W.W. and D.W. Smith. Potential for and implications of wolf restoration in the Southern Rockies. 2010. Pages 197-218 in Reading, R.P., B. J. Miller, A. Masching, R. Edward, and M. Phillips (eds.). *Awakening Spirits: Wolves in the Southern Rockies*. Fulcrum Publishing, Golden, CO.

Paquet, P.C. 2010. Foreword in Dettling, P. *Will of the Land*. Rocky Mountain Press. Canmore, AB.

DellaSala, D., Moola, F., Paquet, P., Noss, R. 2011. North America Coastal Rainforest: Alaska to the Redwoods. In DellaSala, D. (ed). *Temperate and Lesser Known Rainforests of the World: Their Ecology and Conservation*. Island Press

DellaSala, D., Paquet, P., McClellan, B., Alaback, P., Goward, T., Craighead, L. and T. Spribille. 2011. Inland Temperate Rainforests of the Interior Northwest. In DellaSala, D. (ed). *Temperate and Lesser Known Rainforests of the World: Their Ecology and Conservation*. Island Press

DellaSala, D.A., Alaback, P., Kirkpatrick, J., Paquet, P., von Wehrden, H., Techlin, D.,

- Krestov, P., Noss, R., Hakon, H., Craighead, L., Nakamura, Y., Moola, F., Nauman, R., and T. Spribille. 2011. Rainforests at the brink: A call for international action. In DellaSala, D. (ed). *Temperate and Lesser Known Rainforests of the World: Their Ecology and Conservation*. Island Press
2011. *Crosscutting Issues and Conservation Strategies*. In DellaSala, D. (ed). *Temperate and Lesser Known Rainforests of the World: Their Ecology and Conservation*. Island Press.
- Paquet, P.C. (guest statement). The Role of Traditional Ecological Knowledge in Conservation *in* Alexander, S.M. 2015. *Carnivore Management and the Role of Conservation GIS*. Chapter 13 (Pages 293-317) *in* *Resources and the Environmental Management in Canada*, 5<sup>th</sup> Ed., Mitchell, B., Ed. Oxford University Press. Pages 308-309.
- Darimont, C., Artelle, K., Bryan, H., Genovali, C., MacDuffee, M., and P. Paquet. 2015. Brown bears, salmon, people: travelling upstream to a sustainable future. Chapter 14 *in* *Bear Necessities, rescue, rehabilitation, sanctuary, and advocacy* (Kemmerer, L., Ed.). Brill, Boston, U.S.A. Pages 149-164.
- Paquet, P.C. and Alexander, S.M. 2018. Habitat loss: changing how animals think? Pages 4-14 *In* Andrew Butterworth, editor. *Animal welfare in a changing world*. 2018. CABI Wallingford, Oxfordshire, UK; Boston, MA. LC record available at <https://lccn.loc.gov/2017059470>

## Peer reviewing

I review  $\geq 10$  submissions per year, including those made to the following Journals: Biology Letters, Oikos, Oecologia, Animal Conservation, Aquatic Biology, Journal of Applied Ecology, Functional Ecology, Animal Behaviour, Marine Ecology Progress Series, Conservation Biology, Journal of Mammalogy, Behavioral Ecology, Biological Conservation, Rangifer, Northeastern Naturalist, Wildlife Biology.

## Areas of Expertise

- Environmental Ethics
- Large Carnivores
- Predator Prey Relationships
- Population Ecology & Wildlife Disease
- Population Dynamics of Large Mammals
- Habitat Analysis

- Computer Modelling
- Telemetry
- Remote Sensing Techniques
- GIS applications
- Live Capture and Immobilization of Carnivores

#### Additional Interests and Skills

- Photography
- Auto Mechanics
- Mountaineering
- Carpentry

# TAB P



[Fisheries and Oceans Canada](#)

[Home](#) → [Pacific Region](#) → [Marine Mammals](#)

# Necropsy results: Humpback whale and killer whale calf

A killer whale calf, confirmed by DNA testing to be a transient ecotype, was found deceased near Gold River, BC on Wednesday, November 14, 2018. A humpback whale was found deceased near the Tsawassen Ferry terminal in Delta, BC on Friday, November 16, 2018. Necropsies were performed on both animals on Friday, November 16, 2018, to determine the cause of death.

Necropsy results confirm that the transient (also known as Biggs) killer whale calf had been born alive, breathed and likely died 3 to 5 days postpartum. The examination indicates that the cause of death was a result of one of the following: maternal separation (separated from mother), maternal loss (mother died), neglect, or failure to thrive. Further analysis is required to determine cause of death. Blood and tissue samples will be further analyzed, and will likely require 2 to 3 weeks for results.

Necropsy results from the female humpback whale are consistent with catastrophic ship strike with propeller injuries. DFO is investigating.

The results of these necropsies will feed into a growing body of knowledge to assist in assessing the threats to whales from a population health perspective. This data allows us to look at trends, pathogens, or other indicators that may affect their life cycles.

We would like to acknowledge the Mowachaht/Muchalaht and Tsawassen First Nations communities for their ceremonial offerings before the necropsy on both the deceased killer whale and the humpback whale, and also acknowledge the efforts and collaboration from the BC Ministry of Agriculture (and in particular, Dr. Stephen Raverty, Veterinary Pathologist who performed the necropsy exam), and the University of British Columbia.

## Related material

- [Report a Marine Mammal sighting](#)
- [Protecting Canada's Endangered Whales](#)
- [Government of Canada taking further action to protect Southern Resident Killer Whales](#)

### Date modified:

2018-11-28

# TAB Q

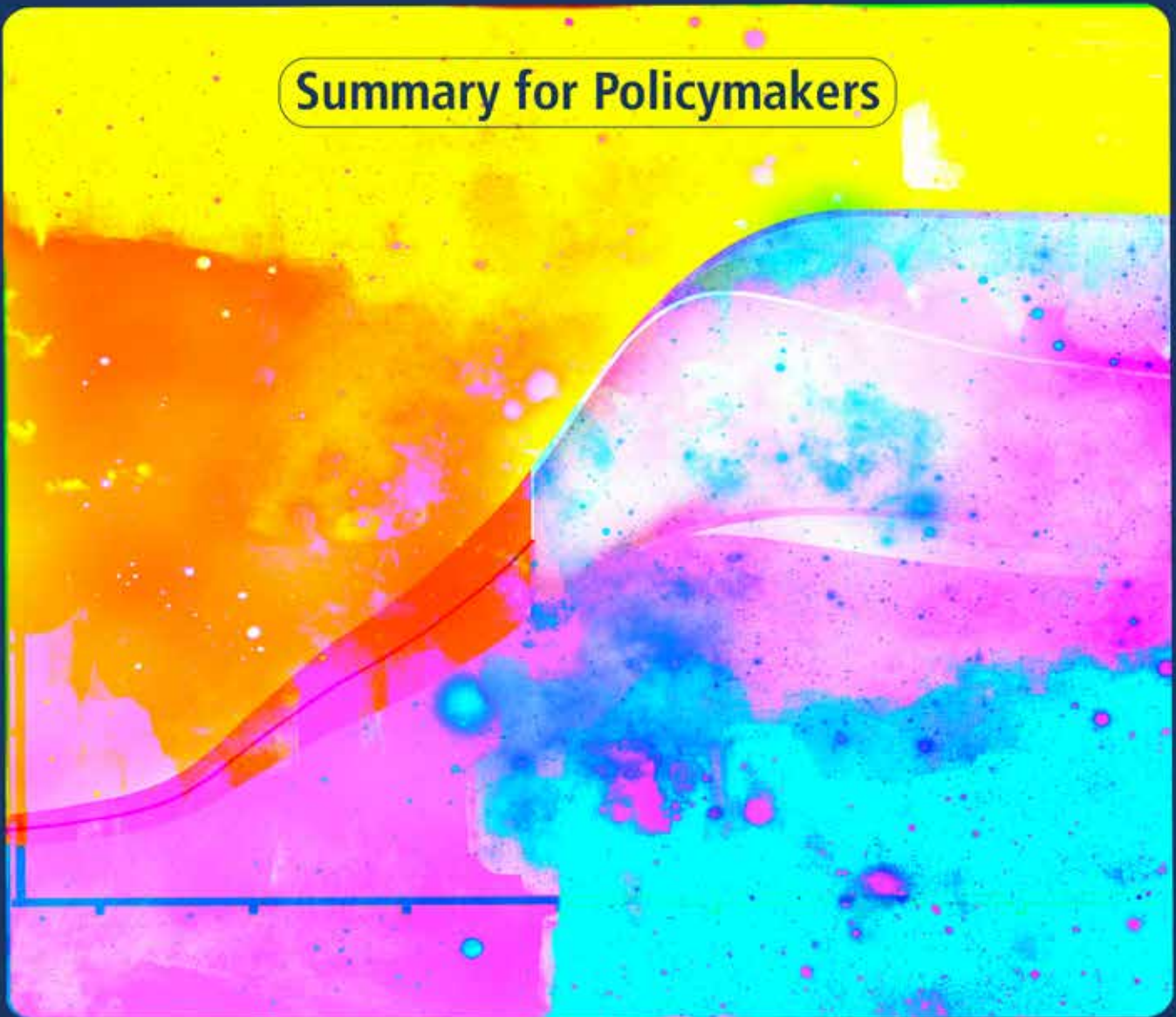
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INTERGOVERNMENTAL PANEL ON climate change

# Global Warming of 1.5°C

An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

Summary for Policymakers



WG I

WG II

WG III





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## Summary for Policymakers

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# Summary for Policymakers





# SPM

## Summary for Policymakers

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## Introduction

This Report responds to the invitation for IPCC ‘... to provide a Special Report in 2018 on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways’ contained in the Decision of the 21st Conference of Parties of the United Nations Framework Convention on Climate Change to adopt the Paris Agreement.<sup>1</sup>

The IPCC accepted the invitation in April 2016, deciding to prepare this Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

This Summary for Policymakers (SPM) presents the key findings of the Special Report, based on the assessment of the available scientific, technical and socio-economic literature<sup>2</sup> relevant to global warming of 1.5°C and for the comparison between global warming of 1.5°C and 2°C above pre-industrial levels. The level of confidence associated with each key finding is reported using the IPCC calibrated language.<sup>3</sup> The underlying scientific basis of each key finding is indicated by references provided to chapter elements. In the SPM, knowledge gaps are identified associated with the underlying chapters of the Report.

## A. Understanding Global Warming of 1.5°C<sup>4</sup>

**A.1 Human activities are estimated to have caused approximately 1.0°C of global warming<sup>5</sup> above pre-industrial levels, with a *likely* range of 0.8°C to 1.2°C. Global warming is *likely* to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (*high confidence*) (Figure SPM.1) {1.2}**

A.1.1 Reflecting the long-term warming trend since pre-industrial times, observed global mean surface temperature (GMST) for the decade 2006–2015 was 0.87°C (*likely* between 0.75°C and 0.99°C)<sup>6</sup> higher than the average over the 1850–1900 period (*very high confidence*). Estimated anthropogenic global warming matches the level of observed warming to within ±20% (*likely range*). Estimated anthropogenic global warming is currently increasing at 0.2°C (*likely* between 0.1°C and 0.3°C) per decade due to past and ongoing emissions (*high confidence*). {1.2.1, Table 1.1, 1.2.4}

A.1.2 Warming greater than the global annual average is being experienced in many land regions and seasons, including two to three times higher in the Arctic. Warming is generally higher over land than over the ocean. (*high confidence*) {1.2.1, 1.2.2, Figure 1.1, Figure 1.3, 3.3.1, 3.3.2}

A.1.3 Trends in intensity and frequency of some climate and weather extremes have been detected over time spans during which about 0.5°C of global warming occurred (*medium confidence*). This assessment is based on several lines of evidence, including attribution studies for changes in extremes since 1950. {3.3.1, 3.3.2, 3.3.3}

<sup>1</sup> Decision 1/CP.21, paragraph 21.

<sup>2</sup> The assessment covers literature accepted for publication by 15 May 2018.

<sup>3</sup> Each finding is grounded in an evaluation of underlying evidence and agreement. A level of confidence is expressed using five qualifiers: very low, low, medium, high and very high, and typeset in italics, for example, *medium confidence*. The following terms have been used to indicate the assessed likelihood of an outcome or a result: virtually certain 99–100% probability, very likely 90–100%, likely 66–100%, about as likely as not 33–66%, unlikely 0–33%, very unlikely 0–10%, exceptionally unlikely 0–1%. Additional terms (extremely likely 95–100%, more likely than not >50–100%, more unlikely than likely 0–<50%, extremely unlikely 0–5%) may also be used when appropriate. Assessed likelihood is typeset in italics, for example, *very likely*. This is consistent with AR5.

<sup>4</sup> See also Box SPM.1: Core Concepts Central to this Special Report.

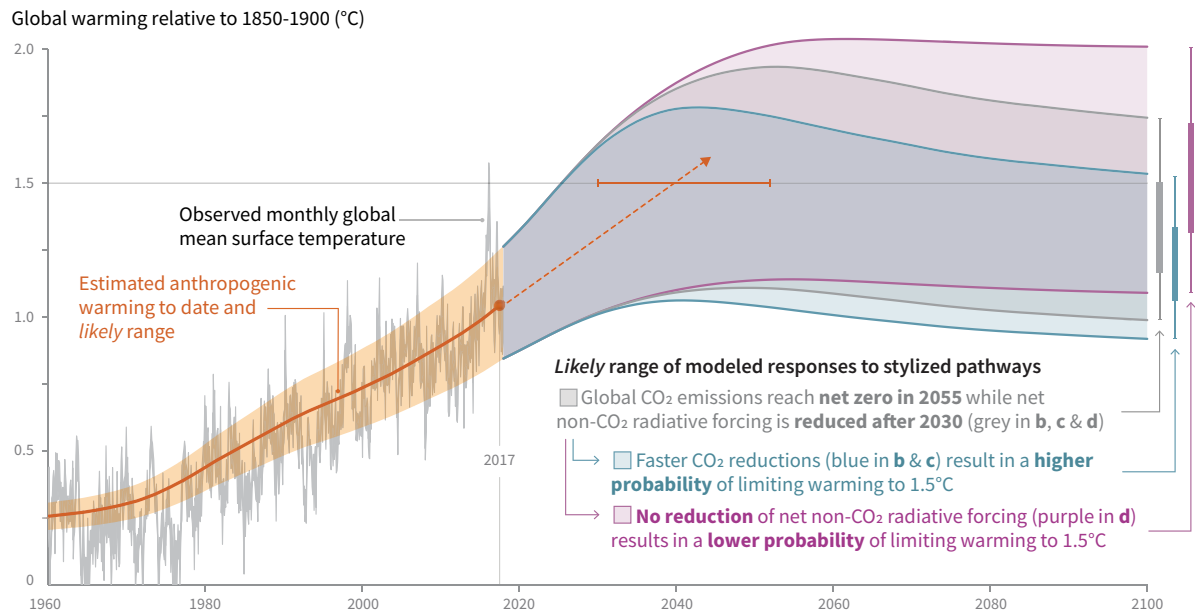
<sup>5</sup> Present level of global warming is defined as the average of a 30-year period centred on 2017 assuming the recent rate of warming continues.

<sup>6</sup> This range spans the four available peer-reviewed estimates of the observed GMST change and also accounts for additional uncertainty due to possible short-term natural variability. {1.2.1, Table 1.1}

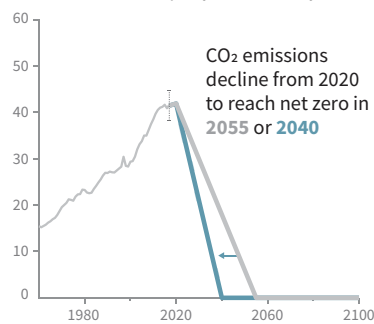
- A.2 Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (*high confidence*), but these emissions alone are *unlikely* to cause global warming of 1.5°C (*medium confidence*). (Figure SPM.1) {1.2, 3.3, Figure 1.5}**
- A.2.1 Anthropogenic emissions (including greenhouse gases, aerosols and their precursors) up to the present are *unlikely* to cause further warming of more than 0.5°C over the next two to three decades (*high confidence*) or on a century time scale (*medium confidence*). {1.2.4, Figure 1.5}
- A.2.2 Reaching and sustaining net zero global anthropogenic CO<sub>2</sub> emissions and declining net non-CO<sub>2</sub> radiative forcing would halt anthropogenic global warming on multi-decadal time scales (*high confidence*). The maximum temperature reached is then determined by cumulative net global anthropogenic CO<sub>2</sub> emissions up to the time of net zero CO<sub>2</sub> emissions (*high confidence*) and the level of non-CO<sub>2</sub> radiative forcing in the decades prior to the time that maximum temperatures are reached (*medium confidence*). On longer time scales, sustained net negative global anthropogenic CO<sub>2</sub> emissions and/or further reductions in non-CO<sub>2</sub> radiative forcing may still be required to prevent further warming due to Earth system feedbacks and to reverse ocean acidification (*medium confidence*) and will be required to minimize sea level rise (*high confidence*). {Cross-Chapter Box 2 in Chapter 1, 1.2.3, 1.2.4, Figure 1.4, 2.2.1, 2.2.2, 3.4.4.8, 3.4.5.1, 3.6.3.2}
- A.3 Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C (*high confidence*). These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options (*high confidence*). (Figure SPM.2) {1.3, 3.3, 3.4, 5.6}**
- A.3.1 Impacts on natural and human systems from global warming have already been observed (*high confidence*). Many land and ocean ecosystems and some of the services they provide have already changed due to global warming (*high confidence*). (Figure SPM.2) {1.4, 3.4, 3.5}
- A.3.2 Future climate-related risks depend on the rate, peak and duration of warming. In the aggregate, they are larger if global warming exceeds 1.5°C before returning to that level by 2100 than if global warming gradually stabilizes at 1.5°C, especially if the peak temperature is high (e.g., about 2°C) (*high confidence*). Some impacts may be long-lasting or irreversible, such as the loss of some ecosystems (*high confidence*). {3.2, 3.4.4, 3.6.3, Cross-Chapter Box 8 in Chapter 3}
- A.3.3 Adaptation and mitigation are already occurring (*high confidence*). Future climate-related risks would be reduced by the upscaling and acceleration of far-reaching, multilevel and cross-sectoral climate mitigation and by both incremental and transformational adaptation (*high confidence*). {1.2, 1.3, Table 3.5, 4.2.2, Cross-Chapter Box 9 in Chapter 4, Box 4.2, Box 4.3, Box 4.6, 4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.3.5, 4.4.1, 4.4.4, 4.4.5, 4.5.3}

# Cumulative emissions of CO<sub>2</sub> and future non-CO<sub>2</sub> radiative forcing determine the probability of limiting warming to 1.5°C

## a) Observed global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways

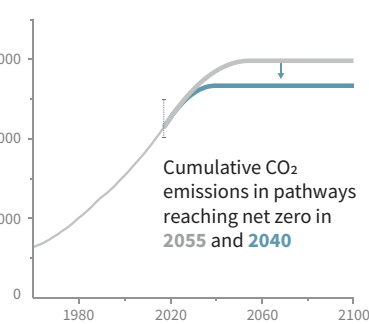


### b) Stylized net global CO<sub>2</sub> emission pathways Billion tonnes CO<sub>2</sub> per year (GtCO<sub>2</sub>/yr)



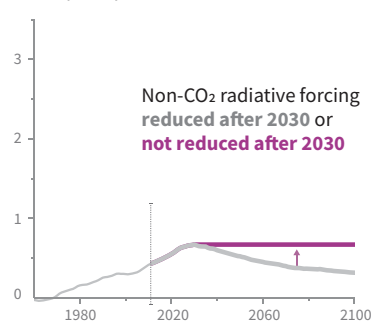
Faster immediate CO<sub>2</sub> emission reductions limit cumulative CO<sub>2</sub> emissions shown in panel (c).

### c) Cumulative net CO<sub>2</sub> emissions Billion tonnes CO<sub>2</sub> (GtCO<sub>2</sub>)



Maximum temperature rise is determined by cumulative net CO<sub>2</sub> emissions and net non-CO<sub>2</sub> radiative forcing due to methane, nitrous oxide, aerosols and other anthropogenic forcing agents.

### d) Non-CO<sub>2</sub> radiative forcing pathways Watts per square metre (W/m<sup>2</sup>)



**Figure SPM.1** | Panel a: Observed monthly global mean surface temperature (GMST, grey line up to 2017, from the HadCRUT4, GISTEMP, Cowtan–Way, and NOAA datasets) change and estimated anthropogenic global warming (solid orange line up to 2017, with orange shading indicating assessed *likely* range). Orange dashed arrow and horizontal orange error bar show respectively the central estimate and *likely* range of the time at which 1.5°C is reached if the current rate of warming continues. The grey plume on the right of panel a shows the *likely* range of warming responses, computed with a simple climate model, to a stylized pathway (hypothetical future) in which net CO<sub>2</sub> emissions (grey line in panels b and c) decline in a straight line from 2020 to reach net zero in 2055 and net non-CO<sub>2</sub> radiative forcing (grey line in panel d) increases to 2030 and then declines. The blue plume in panel a shows the response to faster CO<sub>2</sub> emissions reductions (blue line in panel b), reaching net zero in 2040, reducing cumulative CO<sub>2</sub> emissions (panel c). The purple plume shows the response to net CO<sub>2</sub> emissions declining to zero in 2055, with net non-CO<sub>2</sub> forcing remaining constant after 2030. The vertical error bars on right of panel a show the *likely* ranges (thin lines) and central terciles (33rd – 66th percentiles, thick lines) of the estimated distribution of warming in 2100 under these three stylized pathways. Vertical dotted error bars in panels b, c and d show the *likely* range of historical annual and cumulative global net CO<sub>2</sub> emissions in 2017 (data from the Global Carbon Project) and of net non-CO<sub>2</sub> radiative forcing in 2011 from AR5, respectively. Vertical axes in panels c and d are scaled to represent approximately equal effects on GMST. [1.2.1, 1.2.3, 1.2.4, 2.3, Figure 1.2 and Chapter 1 Supplementary Material, Cross-Chapter Box 2 in Chapter 1]

## B. Projected Climate Change, Potential Impacts and Associated Risks

**B.1 Climate models project robust<sup>7</sup> differences in regional climate characteristics between present-day and global warming of 1.5°C,<sup>8</sup> and between 1.5°C and 2°C.<sup>8</sup> These differences include increases in: mean temperature in most land and ocean regions (*high confidence*), hot extremes in most inhabited regions (*high confidence*), heavy precipitation in several regions (*medium confidence*), and the probability of drought and precipitation deficits in some regions (*medium confidence*). {3.3}**

B.1.1 Evidence from attributed changes in some climate and weather extremes for a global warming of about 0.5°C supports the assessment that an additional 0.5°C of warming compared to present is associated with further detectable changes in these extremes (*medium confidence*). Several regional changes in climate are assessed to occur with global warming up to 1.5°C compared to pre-industrial levels, including warming of extreme temperatures in many regions (*high confidence*), increases in frequency, intensity, and/or amount of heavy precipitation in several regions (*high confidence*), and an increase in intensity or frequency of droughts in some regions (*medium confidence*). {3.2, 3.3.1, 3.3.2, 3.3.3, 3.3.4, Table 3.2}

B.1.2 Temperature extremes on land are projected to warm more than GMST (*high confidence*): extreme hot days in mid-latitudes warm by up to about 3°C at global warming of 1.5°C and about 4°C at 2°C, and extreme cold nights in high latitudes warm by up to about 4.5°C at 1.5°C and about 6°C at 2°C (*high confidence*). The number of hot days is projected to increase in most land regions, with highest increases in the tropics (*high confidence*). {3.3.1, 3.3.2, Cross-Chapter Box 8 in Chapter 3}

B.1.3 Risks from droughts and precipitation deficits are projected to be higher at 2°C compared to 1.5°C of global warming in some regions (*medium confidence*). Risks from heavy precipitation events are projected to be higher at 2°C compared to 1.5°C of global warming in several northern hemisphere high-latitude and/or high-elevation regions, eastern Asia and eastern North America (*medium confidence*). Heavy precipitation associated with tropical cyclones is projected to be higher at 2°C compared to 1.5°C global warming (*medium confidence*). There is generally *low confidence* in projected changes in heavy precipitation at 2°C compared to 1.5°C in other regions. Heavy precipitation when aggregated at global scale is projected to be higher at 2°C than at 1.5°C of global warming (*medium confidence*). As a consequence of heavy precipitation, the fraction of the global land area affected by flood hazards is projected to be larger at 2°C compared to 1.5°C of global warming (*medium confidence*). {3.3.1, 3.3.3, 3.3.4, 3.3.5, 3.3.6}

**B.2 By 2100, global mean sea level rise is projected to be around 0.1 metre lower with global warming of 1.5°C compared to 2°C (*medium confidence*). Sea level will continue to rise well beyond 2100 (*high confidence*), and the magnitude and rate of this rise depend on future emission pathways. A slower rate of sea level rise enables greater opportunities for adaptation in the human and ecological systems of small islands, low-lying coastal areas and deltas (*medium confidence*). {3.3, 3.4, 3.6}**

B.2.1 Model-based projections of global mean sea level rise (relative to 1986–2005) suggest an indicative range of 0.26 to 0.77 m by 2100 for 1.5°C of global warming, 0.1 m (0.04–0.16 m) less than for a global warming of 2°C (*medium confidence*). A reduction of 0.1 m in global sea level rise implies that up to 10 million fewer people would be exposed to related risks, based on population in the year 2010 and assuming no adaptation (*medium confidence*). {3.4.4, 3.4.5, 4.3.2}

B.2.2 Sea level rise will continue beyond 2100 even if global warming is limited to 1.5°C in the 21st century (*high confidence*). Marine ice sheet instability in Antarctica and/or irreversible loss of the Greenland ice sheet could result in multi-metre rise in sea level over hundreds to thousands of years. These instabilities could be triggered at around 1.5°C to 2°C of global warming (*medium confidence*). (Figure SPM.2) {3.3.9, 3.4.5, 3.5.2, 3.6.3, Box 3.3}

<sup>7</sup> Robust is here used to mean that at least two thirds of climate models show the same sign of changes at the grid point scale, and that differences in large regions are statistically significant.

<sup>8</sup> Projected changes in impacts between different levels of global warming are determined with respect to changes in global mean surface air temperature.



B.2.3 Increasing warming amplifies the exposure of small islands, low-lying coastal areas and deltas to the risks associated with sea level rise for many human and ecological systems, including increased saltwater intrusion, flooding and damage to infrastructure (*high confidence*). Risks associated with sea level rise are higher at 2°C compared to 1.5°C. The slower rate of sea level rise at global warming of 1.5°C reduces these risks, enabling greater opportunities for adaptation including managing and restoring natural coastal ecosystems and infrastructure reinforcement (*medium confidence*). (Figure SPM.2) {3.4.5, Box 3.5}

**B.3 On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C. Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater and coastal ecosystems and to retain more of their services to humans (*high confidence*). (Figure SPM.2) {3.4, 3.5, Box 3.4, Box 4.2, Cross-Chapter Box 8 in Chapter 3}**

B.3.1 Of 105,000 species studied,<sup>9</sup> 6% of insects, 8% of plants and 4% of vertebrates are projected to lose over half of their climatically determined geographic range for global warming of 1.5°C, compared with 18% of insects, 16% of plants and 8% of vertebrates for global warming of 2°C (*medium confidence*). Impacts associated with other biodiversity-related risks such as forest fires and the spread of invasive species are lower at 1.5°C compared to 2°C of global warming (*high confidence*). {3.4.3, 3.5.2}

B.3.2 Approximately 4% (interquartile range 2–7%) of the global terrestrial land area is projected to undergo a transformation of ecosystems from one type to another at 1°C of global warming, compared with 13% (interquartile range 8–20%) at 2°C (*medium confidence*). This indicates that the area at risk is projected to be approximately 50% lower at 1.5°C compared to 2°C (*medium confidence*). {3.4.3.1, 3.4.3.5}

B.3.3 High-latitude tundra and boreal forests are particularly at risk of climate change-induced degradation and loss, with woody shrubs already encroaching into the tundra (*high confidence*) and this will proceed with further warming. Limiting global warming to 1.5°C rather than 2°C is projected to prevent the thawing over centuries of a permafrost area in the range of 1.5 to 2.5 million km<sup>2</sup> (*medium confidence*). {3.3.2, 3.4.3, 3.5.5}

**B.4 Limiting global warming to 1.5°C compared to 2°C is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels (*high confidence*). Consequently, limiting global warming to 1.5°C is projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm-water coral reef ecosystems (*high confidence*). {3.3, 3.4, 3.5, Box 3.4, Box 3.5}**

B.4.1 There is *high confidence* that the probability of a sea ice-free Arctic Ocean during summer is substantially lower at global warming of 1.5°C when compared to 2°C. With 1.5°C of global warming, one sea ice-free Arctic summer is projected per century. This likelihood is increased to at least one per decade with 2°C global warming. Effects of a temperature overshoot are reversible for Arctic sea ice cover on decadal time scales (*high confidence*). {3.3.8, 3.4.4.7}

B.4.2 Global warming of 1.5°C is projected to shift the ranges of many marine species to higher latitudes as well as increase the amount of damage to many ecosystems. It is also expected to drive the loss of coastal resources and reduce the productivity of fisheries and aquaculture (especially at low latitudes). The risks of climate-induced impacts are projected to be higher at 2°C than those at global warming of 1.5°C (*high confidence*). Coral reefs, for example, are projected to decline by a further 70–90% at 1.5°C (*high confidence*) with larger losses (>99%) at 2°C (*very high confidence*). The risk of irreversible loss of many marine and coastal ecosystems increases with global warming, especially at 2°C or more (*high confidence*). {3.4.4, Box 3.4}

<sup>9</sup> Consistent with earlier studies, illustrative numbers were adopted from one recent meta-study.



- B.4.3 The level of ocean acidification due to increasing CO<sub>2</sub> concentrations associated with global warming of 1.5°C is projected to amplify the adverse effects of warming, and even further at 2°C, impacting the growth, development, calcification, survival, and thus abundance of a broad range of species, for example, from algae to fish (*high confidence*). {3.3.10, 3.4.4}
- B.4.4 Impacts of climate change in the ocean are increasing risks to fisheries and aquaculture via impacts on the physiology, survivorship, habitat, reproduction, disease incidence, and risk of invasive species (*medium confidence*) but are projected to be less at 1.5°C of global warming than at 2°C. One global fishery model, for example, projected a decrease in global annual catch for marine fisheries of about 1.5 million tonnes for 1.5°C of global warming compared to a loss of more than 3 million tonnes for 2°C of global warming (*medium confidence*). {3.4.4, Box 3.4}
- B.5 Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C. (Figure SPM.2) {3.4, 3.5, 5.2, Box 3.2, Box 3.3, Box 3.5, Box 3.6, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 5.2}**
- B.5.1 Populations at disproportionately higher risk of adverse consequences with global warming of 1.5°C and beyond include disadvantaged and vulnerable populations, some indigenous peoples, and local communities dependent on agricultural or coastal livelihoods (*high confidence*). Regions at disproportionately higher risk include Arctic ecosystems, dryland regions, small island developing states, and Least Developed Countries (*high confidence*). Poverty and disadvantage are expected to increase in some populations as global warming increases; limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050 (*medium confidence*). {3.4.10, 3.4.11, Box 3.5, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5, 4.2.2.2, 5.2.1, 5.2.2, 5.2.3, 5.6.3}
- B.5.2 Any increase in global warming is projected to affect human health, with primarily negative consequences (*high confidence*). Lower risks are projected at 1.5°C than at 2°C for heat-related morbidity and mortality (*very high confidence*) and for ozone-related mortality if emissions needed for ozone formation remain high (*high confidence*). Urban heat islands often amplify the impacts of heatwaves in cities (*high confidence*). Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including potential shifts in their geographic range (*high confidence*). {3.4.7, 3.4.8, 3.5.5.8}
- B.5.3 Limiting warming to 1.5°C compared with 2°C is projected to result in smaller net reductions in yields of maize, rice, wheat, and potentially other cereal crops, particularly in sub-Saharan Africa, Southeast Asia, and Central and South America, and in the CO<sub>2</sub>-dependent nutritional quality of rice and wheat (*high confidence*). Reductions in projected food availability are larger at 2°C than at 1.5°C of global warming in the Sahel, southern Africa, the Mediterranean, central Europe, and the Amazon (*medium confidence*). Livestock are projected to be adversely affected with rising temperatures, depending on the extent of changes in feed quality, spread of diseases, and water resource availability (*high confidence*). {3.4.6, 3.5.4, 3.5.5, Box 3.1, Cross-Chapter Box 6 in Chapter 3, Cross-Chapter Box 9 in Chapter 4}
- B.5.4 Depending on future socio-economic conditions, limiting global warming to 1.5°C compared to 2°C may reduce the proportion of the world population exposed to a climate change-induced increase in water stress by up to 50%, although there is considerable variability between regions (*medium confidence*). Many small island developing states could experience lower water stress as a result of projected changes in aridity when global warming is limited to 1.5°C, as compared to 2°C (*medium confidence*). {3.3.5, 3.4.2, 3.4.8, 3.5.5, Box 3.2, Box 3.5, Cross-Chapter Box 9 in Chapter 4}
- B.5.5 Risks to global aggregated economic growth due to climate change impacts are projected to be lower at 1.5°C than at 2°C by the end of this century<sup>10</sup> (*medium confidence*). This excludes the costs of mitigation, adaptation investments and the benefits of adaptation. Countries in the tropics and Southern Hemisphere subtropics are projected to experience the largest impacts on economic growth due to climate change should global warming increase from 1.5°C to 2°C (*medium confidence*). {3.5.2, 3.5.3}

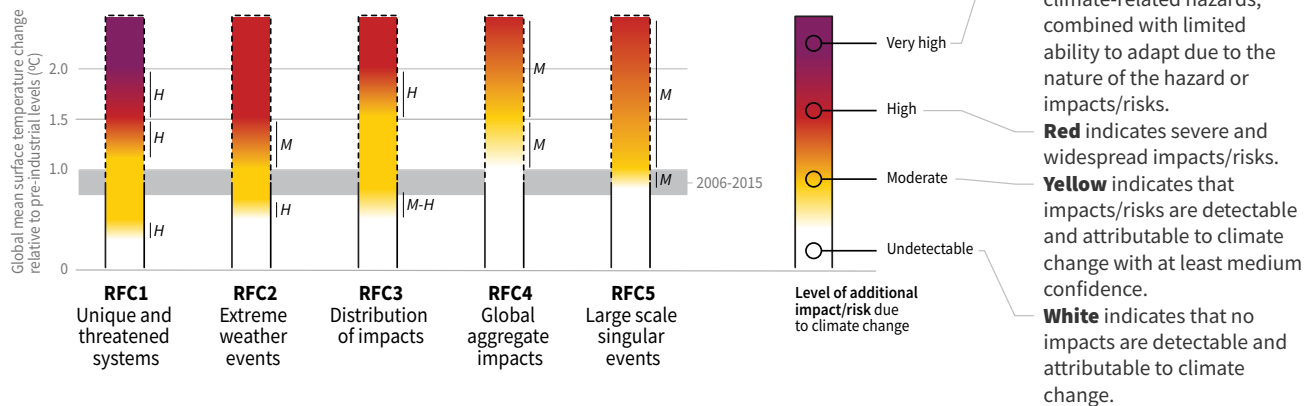
<sup>10</sup> Here, impacts on economic growth refer to changes in gross domestic product (GDP). Many impacts, such as loss of human lives, cultural heritage and ecosystem services, are difficult to value and monetize.

- B.5.6 Exposure to multiple and compound climate-related risks increases between 1.5°C and 2°C of global warming, with greater proportions of people both so exposed and susceptible to poverty in Africa and Asia (*high confidence*). For global warming from 1.5°C to 2°C, risks across energy, food, and water sectors could overlap spatially and temporally, creating new and exacerbating current hazards, exposures, and vulnerabilities that could affect increasing numbers of people and regions (*medium confidence*). {Box 3.5, 3.3.1, 3.4.5.3, 3.4.5.6, 3.4.11, 3.5.4.9}
- B.5.7 There are multiple lines of evidence that since AR5 the assessed levels of risk increased for four of the five Reasons for Concern (RFCs) for global warming to 2°C (*high confidence*). The risk transitions by degrees of global warming are now: from high to very high risk between 1.5°C and 2°C for RFC1 (Unique and threatened systems) (*high confidence*); from moderate to high risk between 1°C and 1.5°C for RFC2 (Extreme weather events) (*medium confidence*); from moderate to high risk between 1.5°C and 2°C for RFC3 (Distribution of impacts) (*high confidence*); from moderate to high risk between 1.5°C and 2.5°C for RFC4 (Global aggregate impacts) (*medium confidence*); and from moderate to high risk between 1°C and 2.5°C for RFC5 (Large-scale singular events) (*medium confidence*). (Figure SPM.2) {3.4.13; 3.5, 3.5.2}
- B.6 Most adaptation needs will be lower for global warming of 1.5°C compared to 2°C (*high confidence*). There are a wide range of adaptation options that can reduce the risks of climate change (*high confidence*). There are limits to adaptation and adaptive capacity for some human and natural systems at global warming of 1.5°C, with associated losses (*medium confidence*). The number and availability of adaptation options vary by sector (*medium confidence*). {Table 3.5, 4.3, 4.5, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 12 in Chapter 5}**
- B.6.1 A wide range of adaptation options are available to reduce the risks to natural and managed ecosystems (e.g., ecosystem-based adaptation, ecosystem restoration and avoided degradation and deforestation, biodiversity management, sustainable aquaculture, and local knowledge and indigenous knowledge), the risks of sea level rise (e.g., coastal defence and hardening), and the risks to health, livelihoods, food, water, and economic growth, especially in rural landscapes (e.g., efficient irrigation, social safety nets, disaster risk management, risk spreading and sharing, and community-based adaptation) and urban areas (e.g., green infrastructure, sustainable land use and planning, and sustainable water management) (*medium confidence*). {4.3.1, 4.3.2, 4.3.3, 4.3.5, 4.5.3, 4.5.4, 5.3.2, Box 4.2, Box 4.3, Box 4.6, Cross-Chapter Box 9 in Chapter 4}.
- B.6.2 Adaptation is expected to be more challenging for ecosystems, food and health systems at 2°C of global warming than for 1.5°C (*medium confidence*). Some vulnerable regions, including small islands and Least Developed Countries, are projected to experience high multiple interrelated climate risks even at global warming of 1.5°C (*high confidence*). {3.3.1, 3.4.5, Box 3.5, Table 3.5, Cross-Chapter Box 9 in Chapter 4, 5.6, Cross-Chapter Box 12 in Chapter 5, Box 5.3}
- B.6.3 Limits to adaptive capacity exist at 1.5°C of global warming, become more pronounced at higher levels of warming and vary by sector, with site-specific implications for vulnerable regions, ecosystems and human health (*medium confidence*). {Cross-Chapter Box 12 in Chapter 5, Box 3.5, Table 3.5}

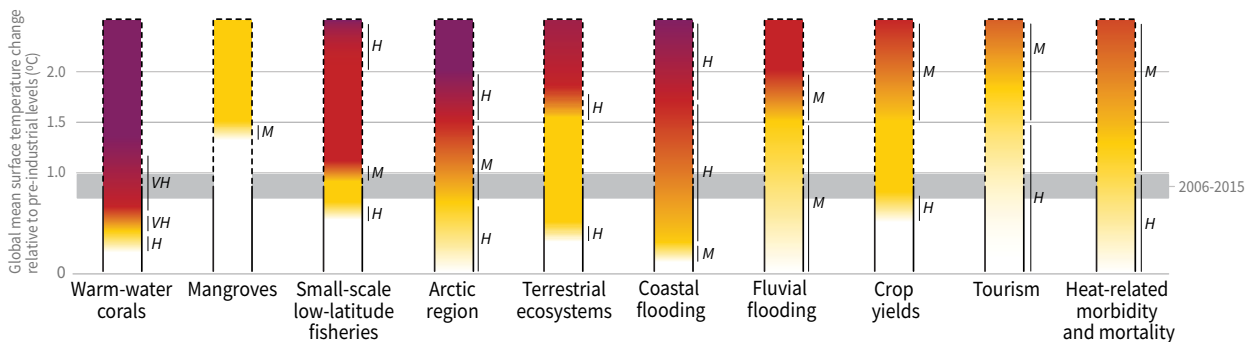
## How the level of global warming affects impacts and/or risks associated with the Reasons for Concern (RFCs) and selected natural, managed and human systems

Five Reasons For Concern (RFCs) illustrate the impacts and risks of different levels of global warming for people, economies and ecosystems across sectors and regions.

### Impacts and risks associated with the Reasons for Concern (RFCs)



### Impacts and risks for selected natural, managed and human systems



Confidence level for transition: L=Low, M=Medium, H=High and VH=Very high

**Figure SPM.2** | Five integrative reasons for concern (RFCs) provide a framework for summarizing key impacts and risks across sectors and regions, and were introduced in the IPCC Third Assessment Report. RFCs illustrate the implications of global warming for people, economies and ecosystems. Impacts and/or risks for each RFC are based on assessment of the new literature that has appeared. As in AR5, this literature was used to make expert judgments to assess the levels of global warming at which levels of impact and/or risk are undetectable, moderate, high or very high. The selection of impacts and risks to natural, managed and human systems in the lower panel is illustrative and is not intended to be fully comprehensive. {3.4, 3.5, 3.5.2.1, 3.5.2.2, 3.5.2.3, 3.5.2.4, 3.5.2.5, 5.4.1, 5.5.3, 5.6.1, Box 3.4}

**RFC1 Unique and threatened systems:** ecological and human systems that have restricted geographic ranges constrained by climate-related conditions and have high endemism or other distinctive properties. Examples include coral reefs, the Arctic and its indigenous people, mountain glaciers and biodiversity hotspots.

**RFC2 Extreme weather events:** risks/impacts to human health, livelihoods, assets and ecosystems from extreme weather events such as heat waves, heavy rain, drought and associated wildfires, and coastal flooding.

**RFC3 Distribution of impacts:** risks/impacts that disproportionately affect particular groups due to uneven distribution of physical climate change hazards, exposure or vulnerability.

**RFC4 Global aggregate impacts:** global monetary damage, global-scale degradation and loss of ecosystems and biodiversity.

**RFC5 Large-scale singular events:** are relatively large, abrupt and sometimes irreversible changes in systems that are caused by global warming. Examples include disintegration of the Greenland and Antarctic ice sheets.

## C. Emission Pathways and System Transitions Consistent with 1.5°C Global Warming

**C.1 In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO<sub>2</sub> emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). For limiting global warming to below 2°C<sup>11</sup> CO<sub>2</sub> emissions are projected to decline by about 25% by 2030 in most pathways (10–30% interquartile range) and reach net zero around 2070 (2065–2080 interquartile range). Non-CO<sub>2</sub> emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C. (*high confidence*) (Figure SPM.3a) {2.1, 2.3, Table 2.4}**

**C.1.1** CO<sub>2</sub> emissions reductions that limit global warming to 1.5°C with no or limited overshoot can involve different portfolios of mitigation measures, striking different balances between lowering energy and resource intensity, rate of decarbonization, and the reliance on carbon dioxide removal. Different portfolios face different implementation challenges and potential synergies and trade-offs with sustainable development. (*high confidence*) (Figure SPM.3b) {2.3.2, 2.3.4, 2.4, 2.5.3}

**C.1.2** Modelled pathways that limit global warming to 1.5°C with no or limited overshoot involve deep reductions in emissions of methane and black carbon (35% or more of both by 2050 relative to 2010). These pathways also reduce most of the cooling aerosols, which partially offsets mitigation effects for two to three decades. Non-CO<sub>2</sub> emissions<sup>12</sup> can be reduced as a result of broad mitigation measures in the energy sector. In addition, targeted non-CO<sub>2</sub> mitigation measures can reduce nitrous oxide and methane from agriculture, methane from the waste sector, some sources of black carbon, and hydrofluorocarbons. High bioenergy demand can increase emissions of nitrous oxide in some 1.5°C pathways, highlighting the importance of appropriate management approaches. Improved air quality resulting from projected reductions in many non-CO<sub>2</sub> emissions provide direct and immediate population health benefits in all 1.5°C model pathways. (*high confidence*) (Figure SPM.3a) {2.2.1, 2.3.3, 2.4.4, 2.5.3, 4.3.6, 5.4.2}

**C.1.3** Limiting global warming requires limiting the total cumulative global anthropogenic emissions of CO<sub>2</sub> since the pre-industrial period, that is, staying within a total carbon budget (*high confidence*).<sup>13</sup> By the end of 2017, anthropogenic CO<sub>2</sub> emissions since the pre-industrial period are estimated to have reduced the total carbon budget for 1.5°C by approximately 2200 ± 320 GtCO<sub>2</sub> (*medium confidence*). The associated remaining budget is being depleted by current emissions of 42 ± 3 GtCO<sub>2</sub> per year (*high confidence*). The choice of the measure of global temperature affects the estimated remaining carbon budget. Using global mean surface air temperature, as in AR5, gives an estimate of the remaining carbon budget of 580 GtCO<sub>2</sub> for a 50% probability of limiting warming to 1.5°C, and 420 GtCO<sub>2</sub> for a 66% probability (*medium confidence*).<sup>14</sup> Alternatively, using GMST gives estimates of 770 and 570 GtCO<sub>2</sub>, for 50% and 66% probabilities,<sup>15</sup> respectively (*medium confidence*). Uncertainties in the size of these estimated remaining carbon budgets are substantial and depend on several factors. Uncertainties in the climate response to CO<sub>2</sub> and non-CO<sub>2</sub> emissions contribute ±400 GtCO<sub>2</sub> and the level of historic warming contributes ±250 GtCO<sub>2</sub> (*medium confidence*). Potential additional carbon release from future permafrost thawing and methane release from wetlands would reduce budgets by up to 100 GtCO<sub>2</sub> over the course of this century and more thereafter (*medium confidence*). In addition, the level of non-CO<sub>2</sub> mitigation in the future could alter the remaining carbon budget by 250 GtCO<sub>2</sub> in either direction (*medium confidence*). {1.2.4, 2.2.2, 2.6.1, Table 2.2, Chapter 2 Supplementary Material}

**C.1.4** Solar radiation modification (SRM) measures are not included in any of the available assessed pathways. Although some SRM measures may be theoretically effective in reducing an overshoot, they face large uncertainties and knowledge gaps

11 References to pathways limiting global warming to 2°C are based on a 66% probability of staying below 2°C.

12 Non-CO<sub>2</sub> emissions included in this Report are all anthropogenic emissions other than CO<sub>2</sub> that result in radiative forcing. These include short-lived climate forcers, such as methane, some fluorinated gases, ozone precursors, aerosols or aerosol precursors, such as black carbon and sulphur dioxide, respectively, as well as long-lived greenhouse gases, such as nitrous oxide or some fluorinated gases. The radiative forcing associated with non-CO<sub>2</sub> emissions and changes in surface albedo is referred to as non-CO<sub>2</sub> radiative forcing. {2.2.1}

13 There is a clear scientific basis for a total carbon budget consistent with limiting global warming to 1.5°C. However, neither this total carbon budget nor the fraction of this budget taken up by past emissions were assessed in this Report.

14 Irrespective of the measure of global temperature used, updated understanding and further advances in methods have led to an increase in the estimated remaining carbon budget of about 300 GtCO<sub>2</sub> compared to AR5. (*medium confidence*) {2.2.2}

15 These estimates use observed GMST to 2006–2015 and estimate future temperature changes using near surface air temperatures.

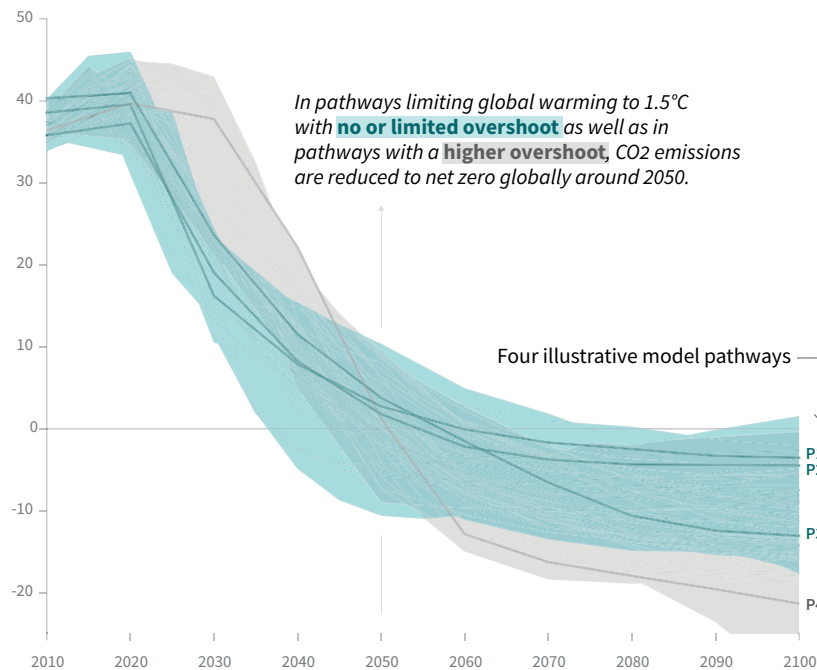
as well as substantial risks and institutional and social constraints to deployment related to governance, ethics, and impacts on sustainable development. They also do not mitigate ocean acidification. (*medium confidence*) {4.3.8, Cross-Chapter Box 10 in Chapter 4}

## Global emissions pathway characteristics

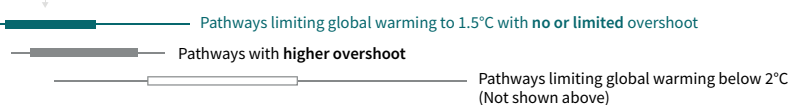
General characteristics of the evolution of anthropogenic net emissions of CO<sub>2</sub>, and total emissions of methane, black carbon, and nitrous oxide in model pathways that limit global warming to 1.5°C with no or limited overshoot. Net emissions are defined as anthropogenic emissions reduced by anthropogenic removals. Reductions in net emissions can be achieved through different portfolios of mitigation measures illustrated in Figure SPM.3b.

### Global total net CO<sub>2</sub> emissions

Billion tonnes of CO<sub>2</sub>/yr



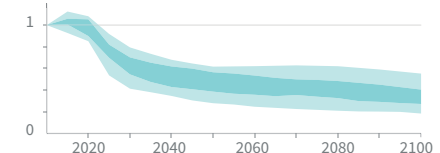
Timing of net zero CO<sub>2</sub>  
Line widths depict the 5-95th percentile and the 25-75th percentile of scenarios



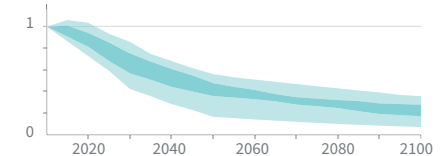
### Non-CO<sub>2</sub> emissions relative to 2010

Emissions of non-CO<sub>2</sub> forcers are also reduced or limited in pathways limiting global warming to 1.5°C with **no or limited overshoot**, but they do not reach zero globally.

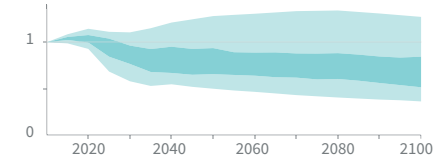
#### Methane emissions



#### Black carbon emissions



#### Nitrous oxide emissions

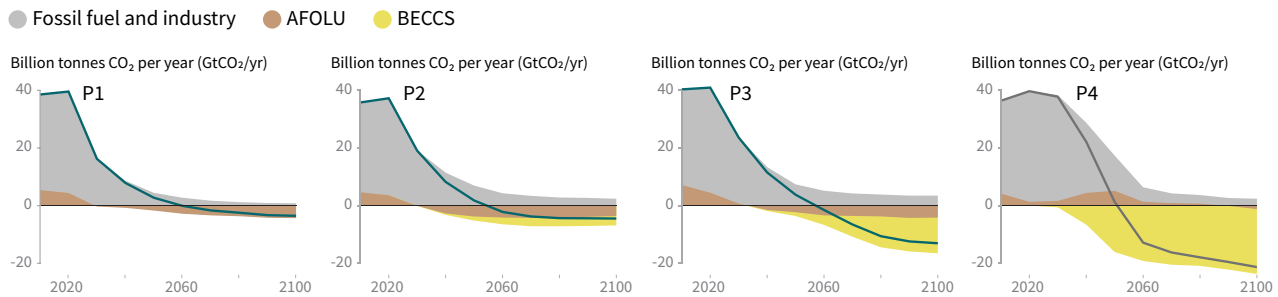


**Figure SPM.3a** | Global emissions pathway characteristics. The main panel shows global net anthropogenic CO<sub>2</sub> emissions in pathways limiting global warming to 1.5°C with no or limited (less than 0.1°C) overshoot and pathways with higher overshoot. The shaded area shows the full range for pathways analysed in this Report. The panels on the right show non-CO<sub>2</sub> emissions ranges for three compounds with large historical forcing and a substantial portion of emissions coming from sources distinct from those central to CO<sub>2</sub> mitigation. Shaded areas in these panels show the 5–95% (light shading) and interquartile (dark shading) ranges of pathways limiting global warming to 1.5°C with no or limited overshoot. Box and whiskers at the bottom of the figure show the timing of pathways reaching global net zero CO<sub>2</sub> emission levels, and a comparison with pathways limiting global warming to 2°C with at least 66% probability. Four illustrative model pathways are highlighted in the main panel and are labelled P1, P2, P3 and P4, corresponding to the LED, S1, S2, and S5 pathways assessed in Chapter 2. Descriptions and characteristics of these pathways are available in Figure SPM.3b. {2.1, 2.2, 2.3, Figure 2.5, Figure 2.10, Figure 2.11}

## Characteristics of four illustrative model pathways

Different mitigation strategies can achieve the net emissions reductions that would be required to follow a pathway that limits global warming to 1.5°C with no or limited overshoot. All pathways use Carbon Dioxide Removal (CDR), but the amount varies across pathways, as do the relative contributions of Bioenergy with Carbon Capture and Storage (BECCS) and removals in the Agriculture, Forestry and Other Land Use (AFOLU) sector. This has implications for emissions and several other pathway characteristics.

### Breakdown of contributions to global net CO<sub>2</sub> emissions in four illustrative model pathways



**P1:** A scenario in which social, business and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A downsized energy system enables rapid decarbonization of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

**P2:** A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

**P3:** A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

**P4:** A resource- and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas-intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

Global indicators	P1	P2	P3	P4	Interquartile range
Pathway classification	No or limited overshoot	No or limited overshoot	No or limited overshoot	Higher overshoot	No or limited overshoot
CO <sub>2</sub> emission change in 2030 (% rel to 2010)	-58	-47	-41	4	(-58,-40)
↳ in 2050 (% rel to 2010)	-93	-95	-91	-97	(-107,-94)
Kyoto-GHG emissions* in 2030 (% rel to 2010)	-50	-49	-35	-2	(-51,-39)
↳ in 2050 (% rel to 2010)	-82	-89	-78	-80	(-93,-81)
Final energy demand** in 2030 (% rel to 2010)	-15	-5	17	39	(-12,7)
↳ in 2050 (% rel to 2010)	-32	2	21	44	(-11,22)
Renewable share in electricity in 2030 (%)	60	58	48	25	(47,65)
↳ in 2050 (%)	77	81	63	70	(69,86)
Primary energy from coal in 2030 (% rel to 2010)	-78	-61	-75	-59	(-78,-59)
↳ in 2050 (% rel to 2010)	-97	-77	-73	-97	(-95,-74)
from oil in 2030 (% rel to 2010)	-37	-13	-3	86	(-34,3)
↳ in 2050 (% rel to 2010)	-87	-50	-81	-32	(-78,-31)
from gas in 2030 (% rel to 2010)	-25	-20	33	37	(-26,21)
↳ in 2050 (% rel to 2010)	-74	-53	21	-48	(-56,6)
from nuclear in 2030 (% rel to 2010)	59	83	98	106	(44,102)
↳ in 2050 (% rel to 2010)	150	98	501	468	(91,190)
from biomass in 2030 (% rel to 2010)	-11	0	36	-1	(29,80)
↳ in 2050 (% rel to 2010)	-16	49	121	418	(123,261)
from non-biomass renewables in 2030 (% rel to 2010)	430	470	315	110	(245,436)
↳ in 2050 (% rel to 2010)	833	1327	878	1137	(576,1299)
Cumulative CCS until 2100 (GtCO <sub>2</sub> )	0	348	687	1218	(550,1017)
↳ of which BECCS (GtCO <sub>2</sub> )	0	151	414	1191	(364,662)
Land area of bioenergy crops in 2050 (million km <sup>2</sup> )	0.2	0.9	2.8	7.2	(1.5,3.2)
Agricultural CH <sub>4</sub> emissions in 2030 (% rel to 2010)	-24	-48	1	14	(-30,-11)
in 2050 (% rel to 2010)	-33	-69	-23	2	(-47,-24)
Agricultural N <sub>2</sub> O emissions in 2030 (% rel to 2010)	5	-26	15	3	(-21,3)
in 2050 (% rel to 2010)	6	-26	0	39	(-26,1)

NOTE: Indicators have been selected to show global trends identified by the Chapter 2 assessment. National and sectoral characteristics can differ substantially from the global trends shown above.

\* Kyoto-gas emissions are based on IPCC Second Assessment Report GWP-100  
 \*\* Changes in energy demand are associated with improvements in energy efficiency and behaviour change



**Figure SPM.3b** | Characteristics of four illustrative model pathways in relation to global warming of 1.5°C introduced in Figure SPM.3a. These pathways were selected to show a range of potential mitigation approaches and vary widely in their projected energy and land use, as well as their assumptions about future socio-economic developments, including economic and population growth, equity and sustainability. A breakdown of the global net anthropogenic CO<sub>2</sub> emissions into the contributions in terms of CO<sub>2</sub> emissions from fossil fuel and industry; agriculture, forestry and other land use (AFOLU); and bioenergy with carbon capture and storage (BECCS) is shown. AFOLU estimates reported here are not necessarily comparable with countries' estimates. Further characteristics for each of these pathways are listed below each pathway. These pathways illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate requirements. For comparison, the right-most column shows the interquartile ranges across pathways with no or limited overshoot of 1.5°C. Pathways P1, P2, P3 and P4 correspond to the LED, S1, S2 and S5 pathways assessed in Chapter 2 (Figure SPM.3a). {2.2.1, 2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.4.1, 2.4.2, 2.4.4, 2.5.3, Figure 2.5, Figure 2.6, Figure 2.9, Figure 2.10, Figure 2.11, Figure 2.14, Figure 2.15, Figure 2.16, Figure 2.17, Figure 2.24, Figure 2.25, Table 2.4, Table 2.6, Table 2.7, Table 2.9, Table 4.1}

**C.2 Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (*high confidence*). These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (*medium confidence*). {2.3, 2.4, 2.5, 4.2, 4.3, 4.4, 4.5}**

- C.2.1 Pathways that limit global warming to 1.5°C with no or limited overshoot show system changes that are more rapid and pronounced over the next two decades than in 2°C pathways (*high confidence*). The rates of system changes associated with limiting global warming to 1.5°C with no or limited overshoot have occurred in the past within specific sectors, technologies and spatial contexts, but there is no documented historic precedent for their scale (*medium confidence*). {2.3.3, 2.3.4, 2.4, 2.5, 4.2.1, 4.2.2, Cross-Chapter Box 11 in Chapter 4}
- C.2.2 In energy systems, modelled global pathways (considered in the literature) limiting global warming to 1.5°C with no or limited overshoot (for more details see Figure SPM.3b) generally meet energy service demand with lower energy use, including through enhanced energy efficiency, and show faster electrification of energy end use compared to 2°C (*high confidence*). In 1.5°C pathways with no or limited overshoot, low-emission energy sources are projected to have a higher share, compared with 2°C pathways, particularly before 2050 (*high confidence*). In 1.5°C pathways with no or limited overshoot, renewables are projected to supply 70–85% (interquartile range) of electricity in 2050 (*high confidence*). In electricity generation, shares of nuclear and fossil fuels with carbon dioxide capture and storage (CCS) are modelled to increase in most 1.5°C pathways with no or limited overshoot. In modelled 1.5°C pathways with limited or no overshoot, the use of CCS would allow the electricity generation share of gas to be approximately 8% (3–11% interquartile range) of global electricity in 2050, while the use of coal shows a steep reduction in all pathways and would be reduced to close to 0% (0–2% interquartile range) of electricity (*high confidence*). While acknowledging the challenges, and differences between the options and national circumstances, political, economic, social and technical feasibility of solar energy, wind energy and electricity storage technologies have substantially improved over the past few years (*high confidence*). These improvements signal a potential system transition in electricity generation. (Figure SPM.3b) {2.4.1, 2.4.2, Figure 2.1, Table 2.6, Table 2.7, Cross-Chapter Box 6 in Chapter 3, 4.2.1, 4.3.1, 4.3.3, 4.5.2}
- C.2.3 CO<sub>2</sub> emissions from industry in pathways limiting global warming to 1.5°C with no or limited overshoot are projected to be about 65–90% (interquartile range) lower in 2050 relative to 2010, as compared to 50–80% for global warming of 2°C (*medium confidence*). Such reductions can be achieved through combinations of new and existing technologies and practices, including electrification, hydrogen, sustainable bio-based feedstocks, product substitution, and carbon capture, utilization and storage (CCUS). These options are technically proven at various scales but their large-scale deployment may be limited by economic, financial, human capacity and institutional constraints in specific contexts, and specific characteristics of large-scale industrial installations. In industry, emissions reductions by energy and process efficiency by themselves are insufficient for limiting warming to 1.5°C with no or limited overshoot (*high confidence*). {2.4.3, 4.2.1, Table 4.1, Table 4.3, 4.3.3, 4.3.4, 4.5.2}
- C.2.4 The urban and infrastructure system transition consistent with limiting global warming to 1.5°C with no or limited overshoot would imply, for example, changes in land and urban planning practices, as well as deeper emissions reductions in transport and buildings compared to pathways that limit global warming below 2°C (*medium confidence*). Technical measures

and practices enabling deep emissions reductions include various energy efficiency options. In pathways limiting global warming to 1.5°C with no or limited overshoot, the electricity share of energy demand in buildings would be about 55–75% in 2050 compared to 50–70% in 2050 for 2°C global warming (*medium confidence*). In the transport sector, the share of low-emission final energy would rise from less than 5% in 2020 to about 35–65% in 2050 compared to 25–45% for 2°C of global warming (*medium confidence*). Economic, institutional and socio-cultural barriers may inhibit these urban and infrastructure system transitions, depending on national, regional and local circumstances, capabilities and the availability of capital (*high confidence*). {2.3.4, 2.4.3, 4.2.1, Table 4.1, 4.3.3, 4.5.2}

- C.2.5 Transitions in global and regional land use are found in all pathways limiting global warming to 1.5°C with no or limited overshoot, but their scale depends on the pursued mitigation portfolio. Model pathways that limit global warming to 1.5°C with no or limited overshoot project a 4 million km<sup>2</sup> reduction to a 2.5 million km<sup>2</sup> increase of non-pasture agricultural land for food and feed crops and a 0.5–11 million km<sup>2</sup> reduction of pasture land, to be converted into a 0–6 million km<sup>2</sup> increase of agricultural land for energy crops and a 2 million km<sup>2</sup> reduction to 9.5 million km<sup>2</sup> increase in forests by 2050 relative to 2010 (*medium confidence*).<sup>16</sup> Land-use transitions of similar magnitude can be observed in modelled 2°C pathways (*medium confidence*). Such large transitions pose profound challenges for sustainable management of the various demands on land for human settlements, food, livestock feed, fibre, bioenergy, carbon storage, biodiversity and other ecosystem services (*high confidence*). Mitigation options limiting the demand for land include sustainable intensification of land-use practices, ecosystem restoration and changes towards less resource-intensive diets (*high confidence*). The implementation of land-based mitigation options would require overcoming socio-economic, institutional, technological, financing and environmental barriers that differ across regions (*high confidence*). {2.4.4, Figure 2.24, 4.3.2, 4.3.7, 4.5.2, Cross-Chapter Box 7 in Chapter 3}
- C.2.6 Additional annual average energy-related investments for the period 2016 to 2050 in pathways limiting warming to 1.5°C compared to pathways without new climate policies beyond those in place today are estimated to be around 830 billion USD<sub>2010</sub> (range of 150 billion to 1700 billion USD<sub>2010</sub> across six models<sup>17</sup>). This compares to total annual average energy supply investments in 1.5°C pathways of 1460 to 3510 billion USD<sub>2010</sub> and total annual average energy demand investments of 640 to 910 billion USD<sub>2010</sub> for the period 2016 to 2050. Total energy-related investments increase by about 12% (range of 3% to 24%) in 1.5°C pathways relative to 2°C pathways. Annual investments in low-carbon energy technologies and energy efficiency are upscaled by roughly a factor of six (range of factor of 4 to 10) by 2050 compared to 2015 (*medium confidence*). {2.5.2, Box 4.8, Figure 2.27}
- C.2.7 Modelled pathways limiting global warming to 1.5°C with no or limited overshoot project a wide range of global average discounted marginal abatement costs over the 21st century. They are roughly 3–4 times higher than in pathways limiting global warming to below 2°C (*high confidence*). The economic literature distinguishes marginal abatement costs from total mitigation costs in the economy. The literature on total mitigation costs of 1.5°C mitigation pathways is limited and was not assessed in this Report. Knowledge gaps remain in the integrated assessment of the economy-wide costs and benefits of mitigation in line with pathways limiting warming to 1.5°C. {2.5.2; 2.6; Figure 2.26}

<sup>16</sup> The projected land-use changes presented are not deployed to their upper limits simultaneously in a single pathway.

<sup>17</sup> Including two pathways limiting warming to 1.5°C with no or limited overshoot and four pathways with higher overshoot.



- C.3 All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 GtCO<sub>2</sub> over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5°C following a peak (*high confidence*). CDR deployment of several hundreds of GtCO<sub>2</sub> is subject to multiple feasibility and sustainability constraints (*high confidence*). Significant near-term emissions reductions and measures to lower energy and land demand can limit CDR deployment to a few hundred GtCO<sub>2</sub> without reliance on bioenergy with carbon capture and storage (BECCS) (*high confidence*). {2.3, 2.4, 3.6.2, 4.3, 5.4}**
- C.3.1 Existing and potential CDR measures include afforestation and reforestation, land restoration and soil carbon sequestration, BECCS, direct air carbon capture and storage (DACCS), enhanced weathering and ocean alkalization. These differ widely in terms of maturity, potentials, costs, risks, co-benefits and trade-offs (*high confidence*). To date, only a few published pathways include CDR measures other than afforestation and BECCS. {2.3.4, 3.6.2, 4.3.2, 4.3.7}
- C.3.2 In pathways limiting global warming to 1.5°C with limited or no overshoot, BECCS deployment is projected to range from 0–1, 0–8, and 0–16 GtCO<sub>2</sub> yr<sup>-1</sup> in 2030, 2050, and 2100, respectively, while agriculture, forestry and land-use (AFOLU) related CDR measures are projected to remove 0–5, 1–11, and 1–5 GtCO<sub>2</sub> yr<sup>-1</sup> in these years (*medium confidence*). The upper end of these deployment ranges by mid-century exceeds the BECCS potential of up to 5 GtCO<sub>2</sub> yr<sup>-1</sup> and afforestation potential of up to 3.6 GtCO<sub>2</sub> yr<sup>-1</sup> assessed based on recent literature (*medium confidence*). Some pathways avoid BECCS deployment completely through demand-side measures and greater reliance on AFOLU-related CDR measures (*medium confidence*). The use of bioenergy can be as high or even higher when BECCS is excluded compared to when it is included due to its potential for replacing fossil fuels across sectors (*high confidence*). (Figure SPM.3b) {2.3.3, 2.3.4, 2.4.2, 3.6.2, 4.3.1, 4.2.3, 4.3.2, 4.3.7, 4.4.3, Table 2.4}
- C.3.3 Pathways that overshoot 1.5°C of global warming rely on CDR exceeding residual CO<sub>2</sub> emissions later in the century to return to below 1.5°C by 2100, with larger overshoots requiring greater amounts of CDR (Figure SPM.3b) (*high confidence*). Limitations on the speed, scale, and societal acceptability of CDR deployment hence determine the ability to return global warming to below 1.5°C following an overshoot. Carbon cycle and climate system understanding is still limited about the effectiveness of net negative emissions to reduce temperatures after they peak (*high confidence*). {2.2, 2.3.4, 2.3.5, 2.6, 4.3.7, 4.5.2, Table 4.11}
- C.3.4 Most current and potential CDR measures could have significant impacts on land, energy, water or nutrients if deployed at large scale (*high confidence*). Afforestation and bioenergy may compete with other land uses and may have significant impacts on agricultural and food systems, biodiversity, and other ecosystem functions and services (*high confidence*). Effective governance is needed to limit such trade-offs and ensure permanence of carbon removal in terrestrial, geological and ocean reservoirs (*high confidence*). Feasibility and sustainability of CDR use could be enhanced by a portfolio of options deployed at substantial, but lesser scales, rather than a single option at very large scale (*high confidence*). (Figure SPM.3b) {2.3.4, 2.4.4, 2.5.3, 2.6, 3.6.2, 4.3.2, 4.3.7, 4.5.2, 5.4.1, 5.4.2; Cross-Chapter Boxes 7 and 8 in Chapter 3, Table 4.11, Table 5.3, Figure 5.3}
- C.3.5 Some AFOLU-related CDR measures such as restoration of natural ecosystems and soil carbon sequestration could provide co-benefits such as improved biodiversity, soil quality, and local food security. If deployed at large scale, they would require governance systems enabling sustainable land management to conserve and protect land carbon stocks and other ecosystem functions and services (*medium confidence*). (Figure SPM.4) {2.3.3, 2.3.4, 2.4.2, 2.4.4, 3.6.2, 5.4.1, Cross-Chapter Boxes 3 in Chapter 1 and 7 in Chapter 3, 4.3.2, 4.3.7, 4.4.1, 4.5.2, Table 2.4}

## D. Strengthening the Global Response in the Context of Sustainable Development and Efforts to Eradicate Poverty

**D.1 Estimates of the global emissions outcome of current nationally stated mitigation ambitions as submitted under the Paris Agreement would lead to global greenhouse gas emissions<sup>18</sup> in 2030 of 52–58 GtCO<sub>2</sub>eq yr<sup>-1</sup> (*medium confidence*). Pathways reflecting these ambitions would not limit global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030 (*high confidence*). Avoiding overshoot and reliance on future large-scale deployment of carbon dioxide removal (CDR) can only be achieved if global CO<sub>2</sub> emissions start to decline well before 2030 (*high confidence*). {1.2, 2.3, 3.3, 3.4, 4.2, 4.4, Cross-Chapter Box 11 in Chapter 4}**

D.1.1 Pathways that limit global warming to 1.5°C with no or limited overshoot show clear emission reductions by 2030 (*high confidence*). All but one show a decline in global greenhouse gas emissions to below 35 GtCO<sub>2</sub>eq yr<sup>-1</sup> in 2030, and half of available pathways fall within the 25–30 GtCO<sub>2</sub>eq yr<sup>-1</sup> range (interquartile range), a 40–50% reduction from 2010 levels (*high confidence*). Pathways reflecting current nationally stated mitigation ambition until 2030 are broadly consistent with cost-effective pathways that result in a global warming of about 3°C by 2100, with warming continuing afterwards (*medium confidence*). {2.3.3, 2.3.5, Cross-Chapter Box 11 in Chapter 4, 5.5.3.2}

D.1.2 Overshoot trajectories result in higher impacts and associated challenges compared to pathways that limit global warming to 1.5°C with no or limited overshoot (*high confidence*). Reversing warming after an overshoot of 0.2°C or larger during this century would require upscaling and deployment of CDR at rates and volumes that might not be achievable given considerable implementation challenges (*medium confidence*). {1.3.3, 2.3.4, 2.3.5, 2.5.1, 3.3, 4.3.7, Cross-Chapter Box 8 in Chapter 3, Cross-Chapter Box 11 in Chapter 4}

D.1.3 The lower the emissions in 2030, the lower the challenge in limiting global warming to 1.5°C after 2030 with no or limited overshoot (*high confidence*). The challenges from delayed actions to reduce greenhouse gas emissions include the risk of cost escalation, lock-in in carbon-emitting infrastructure, stranded assets, and reduced flexibility in future response options in the medium to long term (*high confidence*). These may increase uneven distributional impacts between countries at different stages of development (*medium confidence*). {2.3.5, 4.4.5, 5.4.2}

**D.2 The avoided climate change impacts on sustainable development, eradication of poverty and reducing inequalities would be greater if global warming were limited to 1.5°C rather than 2°C, if mitigation and adaptation synergies are maximized while trade-offs are minimized (*high confidence*). {1.1, 1.4, 2.5, 3.3, 3.4, 5.2, Table 5.1}**

D.2.1 Climate change impacts and responses are closely linked to sustainable development which balances social well-being, economic prosperity and environmental protection. The United Nations Sustainable Development Goals (SDGs), adopted in 2015, provide an established framework for assessing the links between global warming of 1.5°C or 2°C and development goals that include poverty eradication, reducing inequalities, and climate action. (*high confidence*) {Cross-Chapter Box 4 in Chapter 1, 1.4, 5.1}

D.2.2 The consideration of ethics and equity can help address the uneven distribution of adverse impacts associated with 1.5°C and higher levels of global warming, as well as those from mitigation and adaptation, particularly for poor and disadvantaged populations, in all societies (*high confidence*). {1.1.1, 1.1.2, 1.4.3, 2.5.3, 3.4.10, 5.1, 5.2, 5.3, 5.4, Cross-Chapter Box 4 in Chapter 1, Cross-Chapter Boxes 6 and 8 in Chapter 3, and Cross-Chapter Box 12 in Chapter 5}

D.2.3 Mitigation and adaptation consistent with limiting global warming to 1.5°C are underpinned by enabling conditions, assessed in this Report across the geophysical, environmental-ecological, technological, economic, socio-cultural and institutional

<sup>18</sup> GHG emissions have been aggregated with 100-year GWP values as introduced in the IPCC Second Assessment Report.

dimensions of feasibility. Strengthened multilevel governance, institutional capacity, policy instruments, technological innovation and transfer and mobilization of finance, and changes in human behaviour and lifestyles are enabling conditions that enhance the feasibility of mitigation and adaptation options for 1.5°C-consistent systems transitions. (*high confidence*) {1.4, Cross-Chapter Box 3 in Chapter 1, 2.5.1, 4.4, 4.5, 5.6}

**D.3 Adaptation options specific to national contexts, if carefully selected together with enabling conditions, will have benefits for sustainable development and poverty reduction with global warming of 1.5°C, although trade-offs are possible (*high confidence*). {1.4, 4.3, 4.5}**

D.3.1 Adaptation options that reduce the vulnerability of human and natural systems have many synergies with sustainable development, if well managed, such as ensuring food and water security, reducing disaster risks, improving health conditions, maintaining ecosystem services and reducing poverty and inequality (*high confidence*). Increasing investment in physical and social infrastructure is a key enabling condition to enhance the resilience and the adaptive capacities of societies. These benefits can occur in most regions with adaptation to 1.5°C of global warming (*high confidence*). {1.4.3, 4.2.2, 4.3.1, 4.3.2, 4.3.3, 4.3.5, 4.4.1, 4.4.3, 4.5.3, 5.3.1, 5.3.2}

D.3.2 Adaptation to 1.5°C global warming can also result in trade-offs or maladaptations with adverse impacts for sustainable development. For example, if poorly designed or implemented, adaptation projects in a range of sectors can increase greenhouse gas emissions and water use, increase gender and social inequality, undermine health conditions, and encroach on natural ecosystems (*high confidence*). These trade-offs can be reduced by adaptations that include attention to poverty and sustainable development (*high confidence*). {4.3.2, 4.3.3, 4.5.4, 5.3.2; Cross-Chapter Boxes 6 and 7 in Chapter 3}

D.3.3 A mix of adaptation and mitigation options to limit global warming to 1.5°C, implemented in a participatory and integrated manner, can enable rapid, systemic transitions in urban and rural areas (*high confidence*). These are most effective when aligned with economic and sustainable development, and when local and regional governments and decision makers are supported by national governments (*medium confidence*). {4.3.2, 4.3.3, 4.4.1, 4.4.2}

D.3.4 Adaptation options that also mitigate emissions can provide synergies and cost savings in most sectors and system transitions, such as when land management reduces emissions and disaster risk, or when low-carbon buildings are also designed for efficient cooling. Trade-offs between mitigation and adaptation, when limiting global warming to 1.5°C, such as when bioenergy crops, reforestation or afforestation encroach on land needed for agricultural adaptation, can undermine food security, livelihoods, ecosystem functions and services and other aspects of sustainable development. (*high confidence*) {3.4.3, 4.3.2, 4.3.4, 4.4.1, 4.5.2, 4.5.3, 4.5.4}

**D.4 Mitigation options consistent with 1.5°C pathways are associated with multiple synergies and trade-offs across the Sustainable Development Goals (SDGs). While the total number of possible synergies exceeds the number of trade-offs, their net effect will depend on the pace and magnitude of changes, the composition of the mitigation portfolio and the management of the transition. (*high confidence*) (Figure SPM.4) {2.5, 4.5, 5.4}**

D.4.1 1.5°C pathways have robust synergies particularly for the SDGs 3 (health), 7 (clean energy), 11 (cities and communities), 12 (responsible consumption and production) and 14 (oceans) (*very high confidence*). Some 1.5°C pathways show potential trade-offs with mitigation for SDGs 1 (poverty), 2 (hunger), 6 (water) and 7 (energy access), if not managed carefully (*high confidence*). (Figure SPM.4) {5.4.2; Figure 5.4, Cross-Chapter Boxes 7 and 8 in Chapter 3}

D.4.2 1.5°C pathways that include low energy demand (e.g., see P1 in Figure SPM.3a and SPM.3b), low material consumption, and low GHG-intensive food consumption have the most pronounced synergies and the lowest number of trade-offs with respect to sustainable development and the SDGs (*high confidence*). Such pathways would reduce dependence on CDR. In modelled pathways, sustainable development, eradicating poverty and reducing inequality can support limiting warming to 1.5°C (*high confidence*). (Figure SPM.3b, Figure SPM.4) {2.4.3, 2.5.1, 2.5.3, Figure 2.4, Figure 2.28, 5.4.1, 5.4.2, Figure 5.4}

# Indicative linkages between mitigation options and sustainable development using SDGs (The linkages do not show costs and benefits)

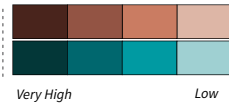
Mitigation options deployed in each sector can be associated with potential positive effects (synergies) or negative effects (trade-offs) with the Sustainable Development Goals (SDGs). The degree to which this potential is realized will depend on the selected portfolio of mitigation options, mitigation policy design, and local circumstances and context. Particularly in the energy-demand sector, the potential for synergies is larger than for trade-offs. The bars group individually assessed options by level of confidence and take into account the relative strength of the assessed mitigation-SDG connections.

Length shows strength of connection

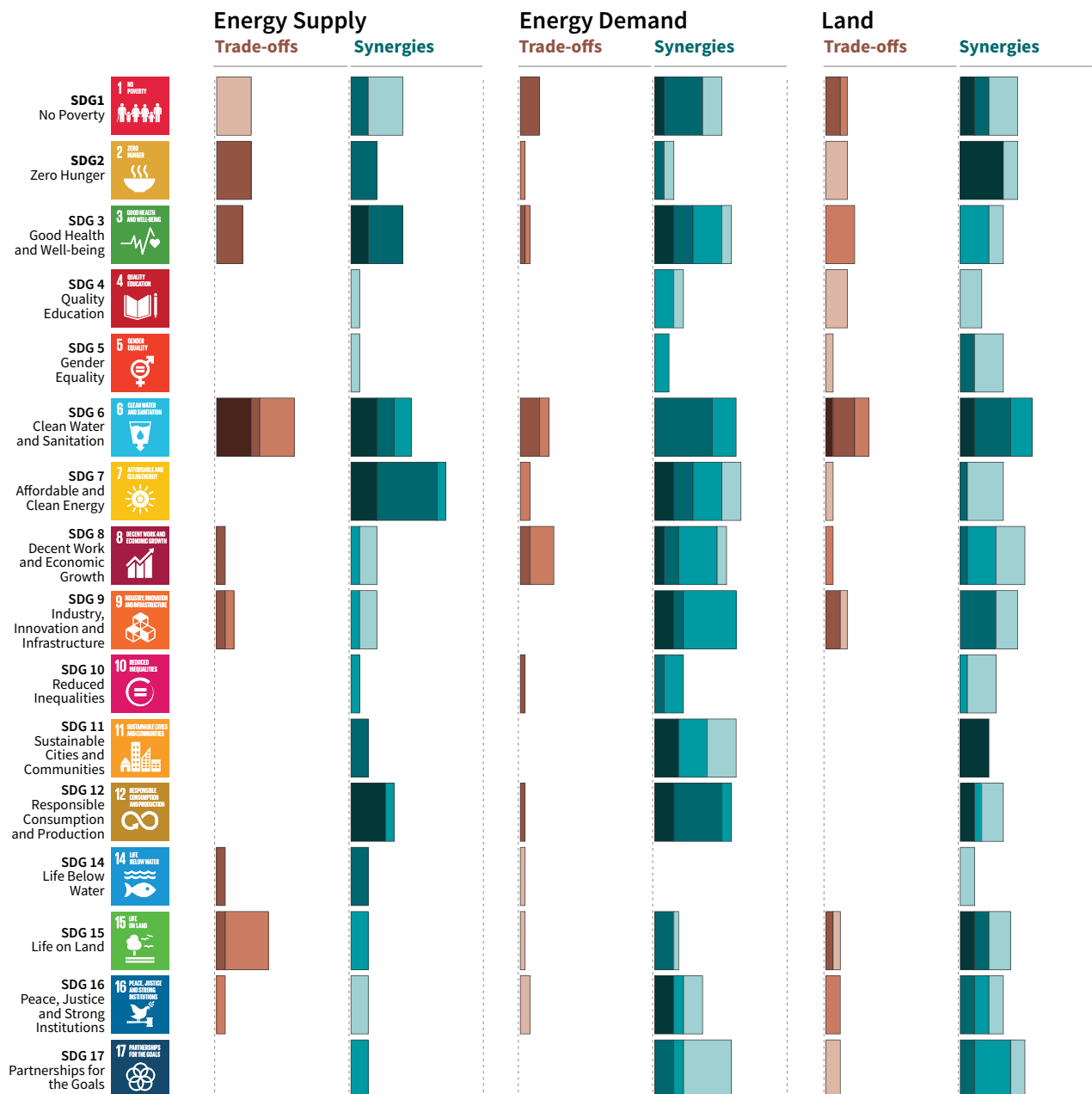


The overall size of the coloured bars depict the relative potential for synergies and trade-offs between the sectoral mitigation options and the SDGs.

Shades show level of confidence



The shades depict the level of confidence of the assessed potential for Trade-offs/Synergies.



**Figure SPM.4** | Potential synergies and trade-offs between the sectoral portfolio of climate change mitigation options and the Sustainable Development Goals (SDGs). The SDGs serve as an analytical framework for the assessment of the different sustainable development dimensions, which extend beyond the time frame of the 2030 SDG targets. The assessment is based on literature on mitigation options that are considered relevant for 1.5°C. The assessed strength of the SDG interactions is based on the qualitative and quantitative assessment of individual mitigation options listed in Table 5.2. For each mitigation option, the strength of the SDG-connection as well as the associated confidence of the underlying literature (shades of green and red) was assessed. The strength of positive connections (synergies) and negative connections (trade-offs) across all individual options within a sector (see Table 5.2) are aggregated into sectoral potentials for the whole mitigation portfolio. The (white) areas outside the bars, which indicate no interactions, have *low confidence* due to the uncertainty and limited number of studies exploring indirect effects. The strength of the connection considers only the effect of mitigation and does not include benefits of avoided impacts. SDG 13 (climate action) is not listed because mitigation is being considered in terms of interactions with SDGs and not vice versa. The bars denote the strength of the connection, and do not consider the strength of the impact on the SDGs. The energy demand sector comprises behavioural responses, fuel switching and efficiency options in the transport, industry and building sector as well as carbon capture options in the industry sector. Options assessed in the energy supply sector comprise biomass and non-biomass renewables, nuclear, carbon capture and storage (CCS) with bioenergy, and CCS with fossil fuels. Options in the land sector comprise agricultural and forest options, sustainable diets and reduced food waste, soil sequestration, livestock and manure management, reduced deforestation, afforestation and reforestation, and responsible sourcing. In addition to this figure, options in the ocean sector are discussed in the underlying report. {5.4, Table 5.2, Figure 5.2}

Information about the net impacts of mitigation on sustainable development in 1.5°C pathways is available only for a limited number of SDGs and mitigation options. Only a limited number of studies have assessed the benefits of avoided climate change impacts of 1.5°C pathways for the SDGs, and the co-effects of adaptation for mitigation and the SDGs. The assessment of the indicative mitigation potentials in Figure SPM.4 is a step further from AR5 towards a more comprehensive and integrated assessment in the future.

- D.4.3 1.5°C and 2°C modelled pathways often rely on the deployment of large-scale land-related measures like afforestation and bioenergy supply, which, if poorly managed, can compete with food production and hence raise food security concerns (*high confidence*). The impacts of carbon dioxide removal (CDR) options on SDGs depend on the type of options and the scale of deployment (*high confidence*). If poorly implemented, CDR options such as BECCS and AFOLU options would lead to trade-offs. Context-relevant design and implementation requires considering people's needs, biodiversity, and other sustainable development dimensions (*very high confidence*). (Figure SPM.4) {5.4.1.3, Cross-Chapter Box 7 in Chapter 3}
- D.4.4 Mitigation consistent with 1.5°C pathways creates risks for sustainable development in regions with high dependency on fossil fuels for revenue and employment generation (*high confidence*). Policies that promote diversification of the economy and the energy sector can address the associated challenges (*high confidence*). {5.4.1.2, Box 5.2}
- D.4.5 Redistributive policies across sectors and populations that shield the poor and vulnerable can resolve trade-offs for a range of SDGs, particularly hunger, poverty and energy access. Investment needs for such complementary policies are only a small fraction of the overall mitigation investments in 1.5°C pathways. (*high confidence*) {2.4.3, 5.4.2, Figure 5.5}
- D.5 Limiting the risks from global warming of 1.5°C in the context of sustainable development and poverty eradication implies system transitions that can be enabled by an increase of adaptation and mitigation investments, policy instruments, the acceleration of technological innovation and behaviour changes (*high confidence*). {2.3, 2.4, 2.5, 3.2, 4.2, 4.4, 4.5, 5.2, 5.5, 5.6}**
- D.5.1 Directing finance towards investment in infrastructure for mitigation and adaptation could provide additional resources. This could involve the mobilization of private funds by institutional investors, asset managers and development or investment banks, as well as the provision of public funds. Government policies that lower the risk of low-emission and adaptation investments can facilitate the mobilization of private funds and enhance the effectiveness of other public policies. Studies indicate a number of challenges, including access to finance and mobilization of funds. (*high confidence*) {2.5.1, 2.5.2, 4.4.5}
- D.5.2 Adaptation finance consistent with global warming of 1.5°C is difficult to quantify and compare with 2°C. Knowledge gaps include insufficient data to calculate specific climate resilience-enhancing investments from the provision of currently underinvested basic infrastructure. Estimates of the costs of adaptation might be lower at global warming of 1.5°C than for 2°C. Adaptation needs have typically been supported by public sector sources such as national and subnational government budgets, and in developing countries together with support from development assistance, multilateral development banks, and United Nations Framework Convention on Climate Change channels (*medium confidence*). More recently there is a

growing understanding of the scale and increase in non-governmental organizations and private funding in some regions (*medium confidence*). Barriers include the scale of adaptation financing, limited capacity and access to adaptation finance (*medium confidence*). {4.4.5, 4.6}

- D.5.3 Global model pathways limiting global warming to 1.5°C are projected to involve the annual average investment needs in the energy system of around 2.4 trillion USD2010 between 2016 and 2035, representing about 2.5% of the world GDP (*medium confidence*). {4.4.5, Box 4.8}
- D.5.4 Policy tools can help mobilize incremental resources, including through shifting global investments and savings and through market and non-market based instruments as well as accompanying measures to secure the equity of the transition, acknowledging the challenges related with implementation, including those of energy costs, depreciation of assets and impacts on international competition, and utilizing the opportunities to maximize co-benefits (*high confidence*). {1.3.3, 2.3.4, 2.3.5, 2.5.1, 2.5.2, Cross-Chapter Box 8 in Chapter 3, Cross-Chapter Box 11 in Chapter 4, 4.4.5, 5.5.2}
- D.5.5 The systems transitions consistent with adapting to and limiting global warming to 1.5°C include the widespread adoption of new and possibly disruptive technologies and practices and enhanced climate-driven innovation. These imply enhanced technological innovation capabilities, including in industry and finance. Both national innovation policies and international cooperation can contribute to the development, commercialization and widespread adoption of mitigation and adaptation technologies. Innovation policies may be more effective when they combine public support for research and development with policy mixes that provide incentives for technology diffusion. (*high confidence*) {4.4.4, 4.4.5}.
- D.5.6 Education, information, and community approaches, including those that are informed by indigenous knowledge and local knowledge, can accelerate the wide-scale behaviour changes consistent with adapting to and limiting global warming to 1.5°C. These approaches are more effective when combined with other policies and tailored to the motivations, capabilities and resources of specific actors and contexts (*high confidence*). Public acceptability can enable or inhibit the implementation of policies and measures to limit global warming to 1.5°C and to adapt to the consequences. Public acceptability depends on the individual's evaluation of expected policy consequences, the perceived fairness of the distribution of these consequences, and perceived fairness of decision procedures (*high confidence*). {1.1, 1.5, 4.3.5, 4.4.1, 4.4.3, Box 4.3, 5.5.3, 5.6.5}
- D.6 Sustainable development supports, and often enables, the fundamental societal and systems transitions and transformations that help limit global warming to 1.5°C. Such changes facilitate the pursuit of climate-resilient development pathways that achieve ambitious mitigation and adaptation in conjunction with poverty eradication and efforts to reduce inequalities (*high confidence*). {Box 1.1, 1.4.3, Figure 5.1, 5.5.3, Box 5.3}**
- D.6.1 Social justice and equity are core aspects of climate-resilient development pathways that aim to limit global warming to 1.5°C as they address challenges and inevitable trade-offs, widen opportunities, and ensure that options, visions, and values are deliberated, between and within countries and communities, without making the poor and disadvantaged worse off (*high confidence*). {5.5.2, 5.5.3, Box 5.3, Figure 5.1, Figure 5.6, Cross-Chapter Boxes 12 and 13 in Chapter 5}
- D.6.2 The potential for climate-resilient development pathways differs between and within regions and nations, due to different development contexts and systemic vulnerabilities (*very high confidence*). Efforts along such pathways to date have been limited (*medium confidence*) and enhanced efforts would involve strengthened and timely action from all countries and non-state actors (*high confidence*). {5.5.1, 5.5.3, Figure 5.1}
- D.6.3 Pathways that are consistent with sustainable development show fewer mitigation and adaptation challenges and are associated with lower mitigation costs. The large majority of modelling studies could not construct pathways characterized by lack of international cooperation, inequality and poverty that were able to limit global warming to 1.5°C. (*high confidence*) {2.3.1, 2.5.1, 2.5.3, 5.5.2}

- D.7 Strengthening the capacities for climate action of national and sub-national authorities, civil society, the private sector, indigenous peoples and local communities can support the implementation of ambitious actions implied by limiting global warming to 1.5°C (*high confidence*). International cooperation can provide an enabling environment for this to be achieved in all countries and for all people, in the context of sustainable development. International cooperation is a critical enabler for developing countries and vulnerable regions (*high confidence*). {1.4, 2.3, 2.5, 4.2, 4.4, 4.5, 5.3, 5.4, 5.5, 5.6, 5, Box 4.1, Box 4.2, Box 4.7, Box 5.3, Cross-Chapter Box 9 in Chapter 4, Cross-Chapter Box 13 in Chapter 5}**
- D.7.1 Partnerships involving non-state public and private actors, institutional investors, the banking system, civil society and scientific institutions would facilitate actions and responses consistent with limiting global warming to 1.5°C (*very high confidence*). {1.4, 4.4.1, 4.2.2, 4.4.3, 4.4.5, 4.5.3, 5.4.1, 5.6.2, Box 5.3}.
- D.7.2 Cooperation on strengthened accountable multilevel governance that includes non-state actors such as industry, civil society and scientific institutions, coordinated sectoral and cross-sectoral policies at various governance levels, gender-sensitive policies, finance including innovative financing, and cooperation on technology development and transfer can ensure participation, transparency, capacity building and learning among different players (*high confidence*). {2.5.1, 2.5.2, 4.2.2, 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5, 4.5.3, Cross-Chapter Box 9 in Chapter 4, 5.3.1, 5.5.3, Cross-Chapter Box 13 in Chapter 5, 5.6.1, 5.6.3}
- D.7.3 International cooperation is a critical enabler for developing countries and vulnerable regions to strengthen their action for the implementation of 1.5°C-consistent climate responses, including through enhancing access to finance and technology and enhancing domestic capacities, taking into account national and local circumstances and needs (*high confidence*). {2.3.1, 2.5.1, 4.4.1, 4.4.2, 4.4.4, 4.4.5, 5.4.1 5.5.3, 5.6.1, Box 4.1, Box 4.2, Box 4.7}.
- D.7.4 Collective efforts at all levels, in ways that reflect different circumstances and capabilities, in the pursuit of limiting global warming to 1.5°C, taking into account equity as well as effectiveness, can facilitate strengthening the global response to climate change, achieving sustainable development and eradicating poverty (*high confidence*). {1.4.2, 2.3.1, 2.5.1, 2.5.2, 2.5.3, 4.2.2, 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5, 4.5.3, 5.3.1, 5.4.1, 5.5.3, 5.6.1, 5.6.2, 5.6.3}



### Box SPM.1: Core Concepts Central to this Special Report

**Global mean surface temperature (GMST):** Estimated global average of near-surface air temperatures over land and sea ice, and sea surface temperatures over ice-free ocean regions, with changes normally expressed as departures from a value over a specified reference period. When estimating changes in GMST, near-surface air temperature over both land and oceans are also used.<sup>19</sup> {1.2.1.1}

**Pre-industrial:** The multi-century period prior to the onset of large-scale industrial activity around 1750. The reference period 1850–1900 is used to approximate pre-industrial GMST. {1.2.1.2}

**Global warming:** The estimated increase in GMST averaged over a 30-year period, or the 30-year period centred on a particular year or decade, expressed relative to pre-industrial levels unless otherwise specified. For 30-year periods that span past and future years, the current multi-decadal warming trend is assumed to continue. {1.2.1}

**Net zero CO<sub>2</sub> emissions:** Net zero carbon dioxide (CO<sub>2</sub>) emissions are achieved when anthropogenic CO<sub>2</sub> emissions are balanced globally by anthropogenic CO<sub>2</sub> removals over a specified period.

**Carbon dioxide removal (CDR):** Anthropogenic activities removing CO<sub>2</sub> from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage, but excludes natural CO<sub>2</sub> uptake not directly caused by human activities.

**Total carbon budget:** Estimated cumulative net global anthropogenic CO<sub>2</sub> emissions from the pre-industrial period to the time that anthropogenic CO<sub>2</sub> emissions reach net zero that would result, at some probability, in limiting global warming to a given level, accounting for the impact of other anthropogenic emissions. {2.2.2}

**Remaining carbon budget:** Estimated cumulative net global anthropogenic CO<sub>2</sub> emissions from a given start date to the time that anthropogenic CO<sub>2</sub> emissions reach net zero that would result, at some probability, in limiting global warming to a given level, accounting for the impact of other anthropogenic emissions. {2.2.2}

**Temperature overshoot:** The temporary exceedance of a specified level of global warming.

**Emission pathways:** In this Summary for Policymakers, the modelled trajectories of global anthropogenic emissions over the 21st century are termed emission pathways. Emission pathways are classified by their temperature trajectory over the 21st century: pathways giving at least 50% probability based on current knowledge of limiting global warming to below 1.5°C are classified as ‘no overshoot’; those limiting warming to below 1.6°C and returning to 1.5°C by 2100 are classified as ‘1.5°C limited-overshoot’; while those exceeding 1.6°C but still returning to 1.5°C by 2100 are classified as ‘higher-overshoot’.

**Impacts:** Effects of climate change on human and natural systems. Impacts can have beneficial or adverse outcomes for livelihoods, health and well-being, ecosystems and species, services, infrastructure, and economic, social and cultural assets.

**Risk:** The potential for adverse consequences from a climate-related hazard for human and natural systems, resulting from the interactions between the hazard and the vulnerability and exposure of the affected system. Risk integrates the likelihood of exposure to a hazard and the magnitude of its impact. Risk also can describe the potential for adverse consequences of adaptation or mitigation responses to climate change.

**Climate-resilient development pathways (CRDPs):** Trajectories that strengthen sustainable development at multiple scales and efforts to eradicate poverty through equitable societal and systems transitions and transformations while reducing the threat of climate change through ambitious mitigation, adaptation and climate resilience.

<sup>19</sup> Past IPCC reports, reflecting the literature, have used a variety of approximately equivalent metrics of GMST change.







# TAB R



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# Southern Resident Killer Whale: imminent threat assessment

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**Official title:** Southern Resident Killer Whale Imminent Threat Assessment May 24, 2018

This document assessed the threats to the Southern Resident Killer Whale.

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## 1 Background

This document assesses the threats to the Southern Resident Killer Whale (SRKW), using the best available information, with the aim of informing an opinion as to whether or not this species faces imminent threats to its survival or recovery in Canada, as per section 80 of the Species at Risk Act (SARA or 'the Act'). In 2001, COSEWIC designated SRKW as endangered. This

population is listed in Schedule 1 of SARA. This imminent threat assessment has been developed by Fisheries and Oceans Canada (DFO) with Environment and Climate Change Canada (ECCC), Transport Canada (TC), and the Parks Canada Agency (PCA).

Under section 80 of SARA, an emergency protection order (EPO) must be recommended to the Governor in Council (GiC) if the competent minister is of the opinion that a listed wildlife species is facing imminent threats to its survival or recovery. A recommendation for an EPO is not required if the competent minister is of the opinion that equivalent measures have been taken under another act of parliament to protect the species. As the SRKW is found throughout the coastal waters of southern British Columbia including the waters that are part of national park reserves, so both the Minister of Fisheries, Oceans, and the Canadian Coast Guard (MFO), and the Minister responsible for the Parks Canada Agency acting in her role as Minister of the Environment under SARA, are competent ministers for this species.

In January 2018, the Ministers received a letter from EcoJustice, representing World Wildlife Fund, Natural Resources Defence Council, Georgia Strait Alliance, Raincoast Conservation Foundation and the David Suzuki Foundation, asking that the Ministers recommend to the GiC an emergency order to provide for the survival and recovery of the SRKW. EcoJustice requested that the Ministers form the opinion that the species is facing imminent threats from reduced prey availability, physical and acoustic disturbance and environmental contaminants.

According to SARA, the Ministers' opinions are based on an assessment of the potential imminent threats to the listed species; however, imminence is not further defined within the Act. A section 80 Order requires the assessment of threats to both survival and recovery of the species. In the context of this imminent threat assessment (ITA), imminent threat could be considered such that decisions and actions are required to be made on a more expedited timeframe than would ordinarily be required through 'normal' processes. Specifically, 'normal' processes, for example, for the protection of critical habitat, would follow typical legislative timelines and provide time and opportunity for comprehensive consultations on proposed actions. Should it be found that the SRKWs are facing imminent threat to their survival and/or recovery, then action by way of an emergency order would be required. Various factors, including Indigenous rights, are considered when developing an emergency order.

Since recovery actions should be implemented as they are identified, imminence could be considered if survival or recovery of the population requires timely implementation of recovery actions so as to ensure the potential for survival and recovery.

Answers to the following questions will help the Ministers to form their opinion on whether or not the SRKW is facing imminent threat:

1. is the species currently facing threats that might impact survival or recovery of the species?
2. will the effect of the current threats make survival of the species unlikely or impossible?
3. will the effect of the current threats make recovery of the species unlikely or impossible?
4. do the threats require immediate intervention?

This threat assessment considers the population and distribution objectives set out in the final federal recovery strategy for the species. It takes into account information on the biology and ecology of the species, threats to its survival and recovery, and its population and habitat status and trends. An analysis of existing measures that protect the species against threats is also provided.

The information used to develop this ITA has been drawn from DFO publications on SRKW including the Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada (DFO 2011), the COSEWIC Assessment and Update Status Report on the Killer Whale *Orcinus orca* in Canada (COSEWIC 2008), the Action Plan for the Northern and Southern Resident Killer Whale (*Orcinus orca*) in Canada (DFO 2017a), and the Review of the Effectiveness of Recovery Measures for Southern Resident Killer Whales (DFO 2017b). EcoJustice also provided supporting documentation in their letter to the competent ministers dated January 30, 2018. No new science advice was generated specifically to inform the assessment nor was the interpretation of the information or the conclusions reached in the assessment the subject of a scientific peer-review process.

Socio-economic impacts were not considered in the assessment, as they are not relevant to determining whether or not a wildlife species is facing imminent threats. Socio-economic considerations would inform a GiC decision, further to a recommendation by the competent ministers.

Indigenous consultation was not specifically done to support this ITA. However, from October 10 to 12, 2017, Fisheries and Oceans Canada held a Southern Resident Killer Whale symposium in Vancouver. Indigenous groups provided a review of the linkages between threats, and expressed that the complexity and importance of Killer Whales and their relationship to First Nations is fundamental to cultural traditions and teachings.

## 2 Overview of the SRKW

The Killer Whale is the largest member of the dolphin family, Delphinidae. They are long-lived, upper trophic-level predators. Their size, striking black and white colouring and tall dorsal fin are the main identifying characteristics. Killer Whales are mainly black above and white below, with a white oval eye patch, and a grey saddle patch below the dorsal fin. Each Killer Whale has

a uniquely shaped dorsal fin and saddle patch, and most animals have naturally acquired nicks and scars. Individual Killer Whales are identified using photographs of the dorsal fin, saddle patch, and sometimes eye patches (Ford et al. 2000). They are sexually dimorphic. Maximum recorded lengths and weights for male Killer Whales are 9.0 m, and 5568 kg respectively, whereas females are smaller at 7.7 m and 4000 kg (Dahlheim and Heyning 1999). The tall triangular dorsal fin of adult males is often as high as 1.8 m, while in juveniles and adult females it reaches 0.9 m or less. In adult males, the paddle-shaped pectoral fins and tail flukes are longer and broader and the fluke tips curl downward (Bigg et al. 1987).

Three distinct forms, or ecotypes, of Killer Whale inhabit Canadian Pacific waters: Transient, Offshore and Resident. These forms are sympatric but socially isolated and differ in their dietary preferences, genetics, morphology and behaviour (Ford et al. 1998, 2000, Barrett-Lennard and Ellis 2001). Transient Killer Whales feed on marine mammals; particularly Harbour Seals, porpoises, and Sea Lions (Ford et al. 1998). They travel in small, acoustically quiet groups that rely on stealth to find their prey (Ford and Ellis 1999). Offshore Killer Whales are not as well understood as Residents and Transients. They feed primarily on elasmobranchs but have also been documented to prey on teleost fishes, including Chinook Salmon (Heise et al. 2003; Ford et al. 2014). They often travel in large acoustically active groups of 30 or more whales, using frequent echolocation and social calls (Ford et al. 2000).

Resident Killer Whales that share a common range and that associate at least occasionally are considered to be members of the same community or population. There are two communities of Resident Killer Whales in British Columbia, the Northern Residents and the Southern Residents. Despite having overlapping ranges, these two communities are acoustically, genetically, and culturally distinct. The Northern Resident community consists of three clans broken into 16 sub-groups, or pods; and the Southern Resident community consists of one clan and only three pods.

Resident Killer Whales are the best understood of the three ecotypes. They feed nearly exclusively on salmon, predominantly Chinook Salmon, although Chum Salmon are seasonally important in autumn months, and usually travel in acoustically active groups of 10 to 25 or more whales (Ford et al. 2000). The social organization of Resident Killer Whales is highly structured. Their fundamental unit is the matriline, comprising all surviving members of a female lineage. A typical matriline comprises an adult female, her offspring, and the offspring of her daughters. Both sexes remain within their natal matriline for life (Bigg et al. 1990). Social systems in which both sexes remain with their mother for life have only been described in one other mammalian species, the Long-Finned Pilot Whale (*Globicephala melas*; Amos et al. 1993). Bigg et al. (1990) defined pods as groups of closely related matrilineal groups that travel, forage, socialize and rest with each other at least 50% of the time, and predicted that pods, like

matrilines, would be stable over many generations. However, Ford and Ellis (2002) showed that inter-matriline association patterns in the Northern Residents have evolved over the past decade such that some of the pods identified by Bigg et al. (1990) now fail to meet the 50% criterion. Their analysis suggests that pods are best defined as transitional groupings that reflect the relatedness of recently diverged matriline.

### 3 Population status and trends

Individual Killer Whales can be distinguished by scars and variations in pigmentation and dorsal fin shape. Life history parameters for the Resident populations in British Columbia have been estimated based on more than 30 years of photo-identification studies. Maximum longevity is 80 to 90 years for females and 40 to 50 years for males. Females give birth to their first calf between 12 to 17 years of age. The calving interval averages about five years for NRKW and six years for SRKW (unpublished data DFO-CRP). However, the interval is highly variable and ranges from two to 12 years. The generation time is 26 to 29 years. Females on average produce their last calf at age 39, at which point they become post reproductive (Olesiuk et al. 1990). This extended post-reproductive period, which may last up to 40 years (in females that live to 80 years) is extremely unusual in mammals. Resident Killer Whales are also exceptional among mammals in that there is no dispersal of individuals of either sex from the natal group.

Little is known of the historic abundance of Killer Whales, except that they were “not numerous” (Scammon 1874). While there are no population estimates for Killer Whales in British Columbia prior to 1960, the SRKW is likely to be a naturally precarious <sup>1</sup> population in that even prior to significant effects from human activity, the population is likely to have been small. Since the early 1970s, photo-identification studies have provided population estimates for Killer Whales in the near-shore waters of the northeastern Pacific (Washington, British Columbia, Alaska, and California). Population censuses for Killer Whales are now conducted annually using photo-identification of individuals.

The community of SRKW comprises a single acoustic clan, J clan, which is composed of three pods (referred to as J, K, and L) containing a total of 20 matriline (Ford et al. 2000). Although the Southern Resident community was likely increasing in size in the early 1960s, the number of whales in the community dropped dramatically in the late 1960s and early 1970s due to live capture for aquariums (Bigg and Wolman 1975). A total of 47 individuals that are known or likely to have been Southern Residents were captured and removed from the population (Bigg et al. 1990). The population increased 19% (3.1% per year) from a low of 70 after the live-captures ended in 1973 to 83 whales in 1980, although the growth rate varied by pod (Figure 1). From 1981 to 1984 the population declined 11% (-2.7% per year) to 74 whales as a result of



lower birth rates, higher mortality for adult females and juveniles (Taylor and Plater 2001), and lower numbers of mature animals, especially males, which was caused by selective cropping in previous years (Olesiuk et al. 1990). From 1985 to 1995, the number of Southern Residents increased by 34% (2.9% per year) to 99 animals. A surge in the number of mature individuals, an increase in births, and a decrease in deaths contributed to the population growth. Another decline began in 1996, with an extended period of poor survival (Taylor and Plater 2001; Krahn et al. 2002) and low fecundity (Krahn et al. 2004) resulting in a decline of 17% (-2.9% per year) to 81 whales in 2001. Since 2001, the population has fluctuated between 76 and 89 individuals. The number of Southern Residents increased slightly to 85 in 2003 (unpublished data DFO-Cetacean Research Program). The growth was in J and K pods, whereas L pod continued to decline. The population has not shown signs of recovery and consisted of 76 members in 2017 (unpublished data DFO-Cetacean Research Program). Collectively, the small population size and low number of individuals contributing to reproduction (termed the effective population) heighten the impact of any mortality or loss of reproductive potential to the population's survival relative to their northern counterparts.

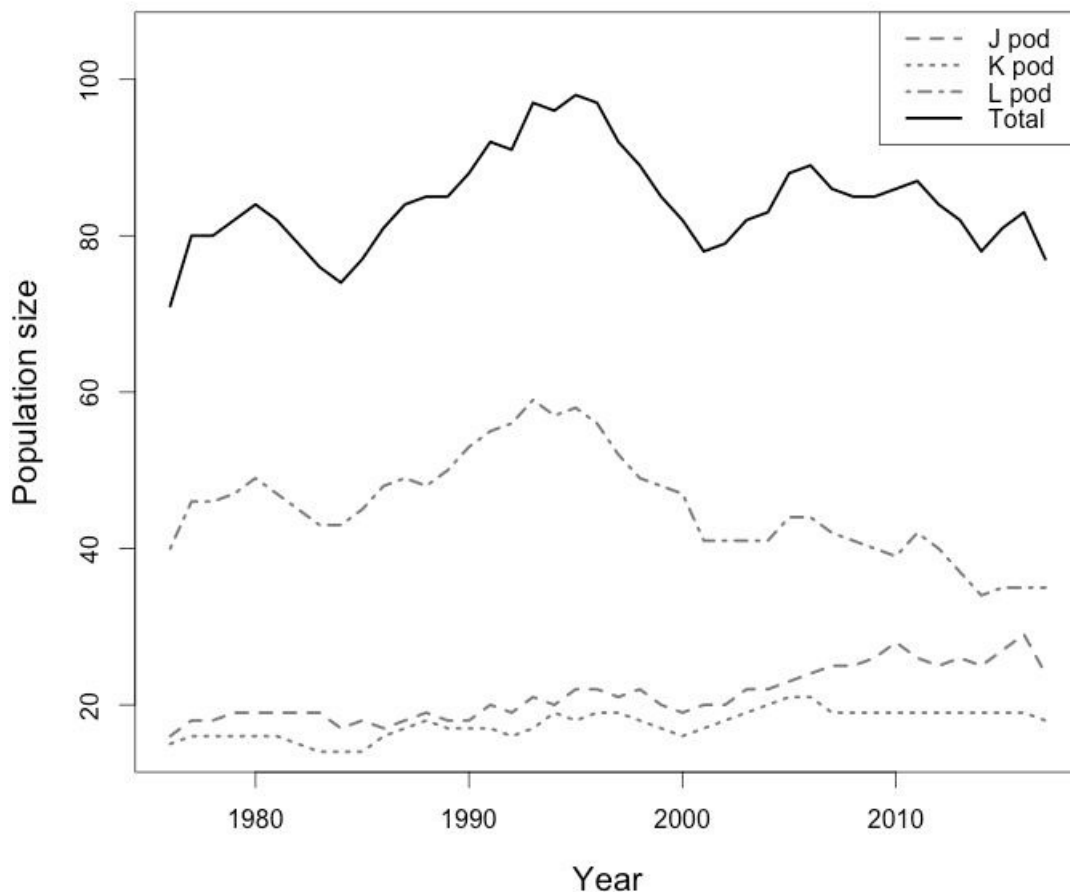


Figure 1. Population size and trends for Southern Resident Killer Whale from 1976 to 2017. Data source: Center for Whale Research (unpublished).

► Long description

The SRKW population demographics have changed since 1979 (Table 1). The number of SRKW post-reproductive females has gone from 12% of the population to only 7%. To translate that to absolute numbers, the 7% represents just five individuals (Table 2). As of 2017, both J and K pods only had one post-reproductive female while L pod had three (DFO-Cetacean Research Program, unpublished data). It is possible that the presence of older females in a group increases the survival of offspring even if such individuals no longer contribute directly to population growth (COSEWIC 2008).

**Table 1: Percent population demographics in 1979 and 2016 for Southern Resident Killer Whale. Data source: Fisheries and Oceans Canada – Cetacean Research Program (unpublished).**

Demographic	1979 (%)	2016 (%)
Reproductive Females (10 y to 42 y)	32	34
Adult Males (> 10 y)	27	18
Post-reproductive Females (> 42 y)	12	7
Juveniles (< 10 y)	38	30

**Table 2: Population demographics from 1980 to 2017 in five year intervals for Southern Resident Killer Whale. Data source: Fisheries and Oceans Canada – Cetacean Research Program (unpublished).**

Year	Total	Reproductive females (10 years - 42 years)	Adult male (> 10 years)	Post-reproductive females (> 42 years)	Juveniles (< 10 years)
2017	Total: 76 <ul style="list-style-type: none"> <li>• J Pod 23</li> <li>• K Pod 18</li> <li>• L Pod 35</li> </ul>	Total: 27 <ul style="list-style-type: none"> <li>• J Pod 10</li> <li>• K Pod 6</li> <li>• L Pod 11</li> </ul>	Total: 24 <ul style="list-style-type: none"> <li>• J Pod 4</li> <li>• K Pod 8</li> <li>• L Pod 12</li> </ul>	Total: 5 <ul style="list-style-type: none"> <li>• J Pod 1</li> <li>• K Pod 1</li> <li>• L Pod 3</li> </ul>	Total: 20 <ul style="list-style-type: none"> <li>• J Pod 8</li> <li>• K Pod 3</li> <li>• L Pod 9</li> </ul>

<b>Year</b>	<b>Total</b>	<b>Reproductive females (10 years - 42 years)</b>	<b>Adult male (&gt; 10 years)</b>	<b>Post-reproductive females (&gt; 42 years)</b>	<b>Juveniles (&lt; 10 years)</b>
2015	Total: 80 • J Pod 27 • K Pod 19 • L Pod 34	Total: 30 • J Pod 12 • K Pod 6 • L Pod 12	Total: 23 • J Pod 5 • K Pod 8 • L Pod 10	Total: 5 • J Pod 1 • K Pod 2 • L Pod 2	Total: 22 • J Pod 9 • K Pod 3 • L Pod 10
2010	Total: 84 • J Pod 26 • K Pod 19 • L Pod 39	Total: 30 • J Pod 10 • K Pod 7 • L Pod 13	Total: 17 • J Pod 4 • K Pod 3 • L Pod 10	Total: 9 • J Pod 2 • K Pod 1 • L Pod 6	Total: 28 • J Pod 10 • K Pod 8 • L Pod 10
2005	Total: 88 • J Pod 24 • K Pod 20 • L Pod 44	Total: 32 • J Pod 8 • K Pod 9 • L Pod 15	Total: 20 • J Pod 4 • K Pod 3 • L Pod 13	Total: 12 • J Pod 2 • K Pod 2 • L Pod 8	Total: 24 • J Pod 10 • K Pod 6 • L Pod 8
2000	Total: 77 • J Pod 19 • K Pod 16 • L Pod 42	Total: 28 • J Pod 6 • K Pod 7 • L Pod 15	Total: 11 • J Pod 1 • K Pod 1 • L Pod 9	Total: 12 • J Pod 2 • K Pod 3 • L Pod 7	Total: 26 • J Pod 10 • K Pod 5 • L Pod 11
1995	Total: 92 • J Pod 20 • K Pod 18 • L Pod 54	Total: 34 • J Pod 10 • K Pod 8 • L Pod 16	Total: 14 • J Pod 3 • K Pod 1 • L Pod 10	Total: 11 • J Pod 2 • K Pod 2 • L Pod 7	Total: 33 • J Pod 5 • K Pod 7 • L Pod 21
1990	Total: 87 • J Pod 18 • K Pod 16 • L Pod 53	Total: 33 • J Pod 9 • K Pod 8 • L Pod 16	Total: 17 • J Pod 4 • K Pod 3 • L Pod 10	Total: 11 • J Pod 2 • K Pod 1 • L Pod 8	Total: 26 • J Pod 3 • K Pod 4 • L Pod 19
1985	Total: 74 • J Pod 17 • K Pod 14 • L Pod 43	Total: 31 • J Pod 7 • K Pod 7 • L Pod 17	Total: 16 • J Pod 3 • K Pod 3 • L Pod 10	Total: 9 • J Pod 2 • K Pod 2 • L Pod 5	Total: 18 • J Pod 5 • K Pod 2 • L Pod 11

<b>Year</b>	<b>Total</b>	<b>Reproductive females (10 years - 42 years)</b>	<b>Adult male (&gt; 10 years)</b>	<b>Post-reproductive females (&gt; 42 years)</b>	<b>Juveniles (&lt; 10 years)</b>
1980	Total: 79 <ul style="list-style-type: none"> <li>• J Pod 18</li> <li>• K Pod 16</li> <li>• L Pod 45</li> </ul>	Total: 25 <ul style="list-style-type: none"> <li>• J Pod 5</li> <li>• K Pod 5</li> <li>• L Pod 15</li> </ul>	Total: 13 <ul style="list-style-type: none"> <li>• J Pod 3</li> <li>• K Pod 4</li> <li>• L Pod 6</li> </ul>	Total: 11 <ul style="list-style-type: none"> <li>• J Pod 3</li> <li>• K Pod 3</li> <li>• L Pod 5</li> </ul>	Total: 30 <ul style="list-style-type: none"> <li>• J Pod 7</li> <li>• K Pod 4</li> <li>• L Pod 19</li> </ul>

### 3.1 SRKW distribution

The known range of this community is from southeastern Alaska to central California (Ford et al. 2017). During summer, its members are usually found in waters off southern Vancouver Island and northern Washington State, where they congregate to intercept migratory salmon. The main area of concentration for Southern Residents is Haro Strait and vicinity off southeastern Vancouver Island (Figure 2), but they are commonly seen in Juan de Fuca Strait, and the southern Strait of Georgia (Ford et al. 2000). Of the three Southern Resident pods, J pod is most commonly seen in inside waters throughout the year, and appears to seldom leave the Strait of Georgia-Puget Sound- Juan de Fuca Strait region in most years (Ford et al. 2000). K and L pods are more often found in western Juan de Fuca Strait and off the outer coasts of Washington State and Vancouver Island. Unlike J pod, K and L pods typically leave inshore waters in winter and return in May or June. Their range during this period is poorly known, but they have been sighted as far south as Monterey Bay, California and as far north as Chatham Strait, southeastern Alaska (Ford et al. 2017).

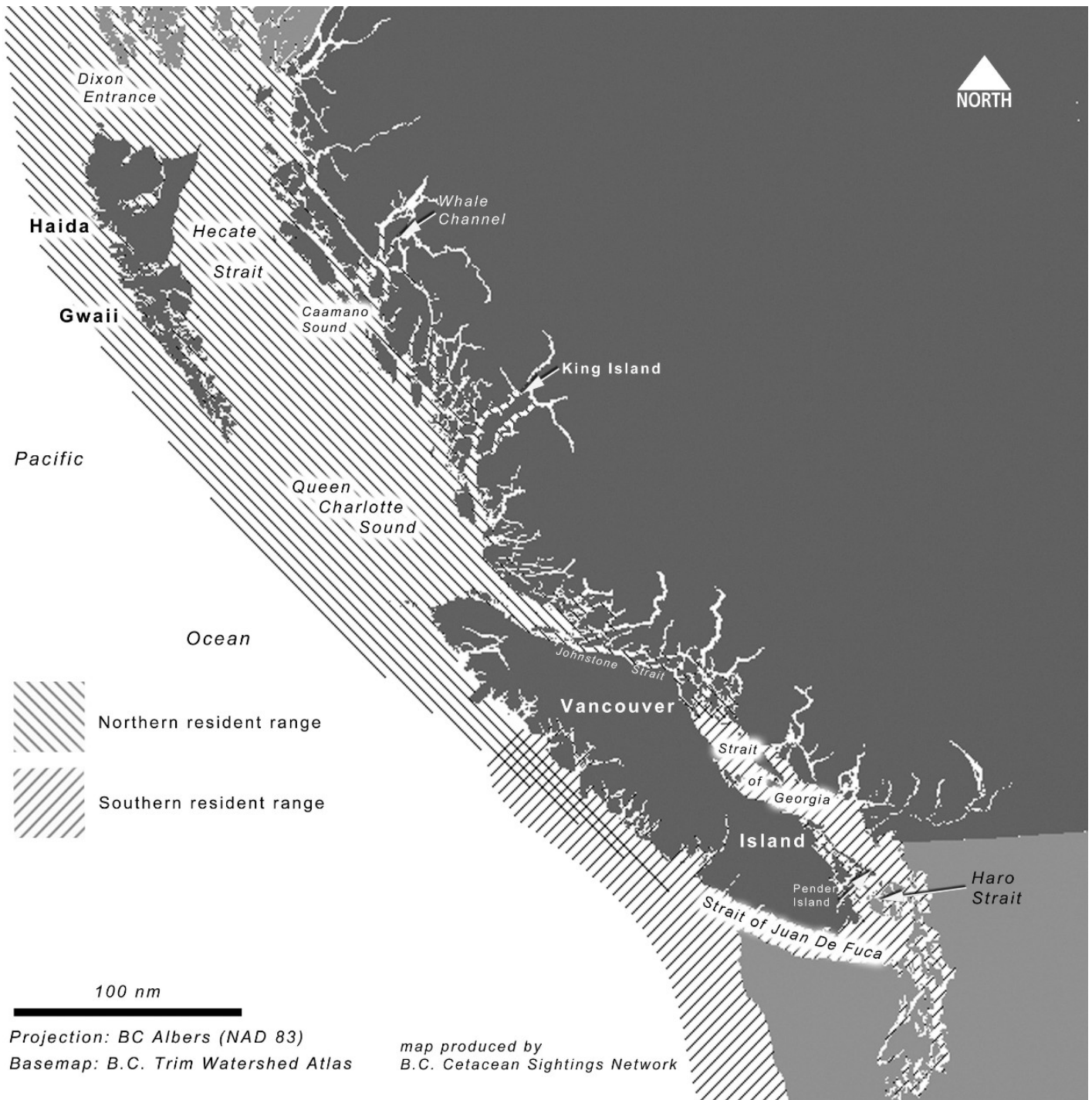


Figure 2. The coast of British Columbia and northwest Washington State showing the general ranges of Northern and Southern Resident Killer Whales.

► Long description

### 3.2 Critical habitat

Critical habitat is defined in SARA (2002) section 2(1) as "...the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a recovery strategy or in an action plan for the species."

SARA defines habitat for aquatic species at risk as "... spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced" [s. 2(1)].

Partial critical habitat was identified for both Northern and Southern Resident Killer Whales in the 2008 recovery strategy. Northern Resident Killer Whale critical habitat included the waters of Johnstone Strait and southeastern Queen Charlotte Strait (Figure 2), while SRKW critical habitat included the transboundary waters in southern British Columbia, including the southern Strait of Georgia, Haro Strait, and Juan de Fuca Strait (Figure 2). A SARA critical habitat order was put in place in 2009 to protect these area of critical habitat. In 2011, the recovery strategy was amended to provide additional clarification regarding this critical habitat.

An additional area was identified for consideration as critical habitat for SRKW in Ford et al. (2017). This area includes the waters on the continental shelf off southwestern Vancouver Island, including Swiftsure and La Perouse Banks . An amendment to the recovery strategy is currently underway to add this area of critical habitat.

The habitat of special importance under consideration as critical habitat off southwest Vancouver Island includes the Canadian portions of Swiftsure Bank, where acoustic monitoring between August 2009 and July 2011 indicated considerable habitat use by both Southern and Northern Resident Killer Whales over much of the year. Additionally, it encompasses several other relatively shallow banks, including La Pérouse Bank which, like Swiftsure Bank, is among the most productive fishing areas for Chinook Salmon on the west coast of North America. During this acoustic monitoring, all three SRKW pods were detected in this area, with L pod being the most frequently documented (Ford et al. 2017). The area is important for SRKW, both during summer, when groups of whales spend time west of the critical habitat area in the transboundary waters in southern British Columbia, and in winter, when whales are mostly absent from the southern British Columbia critical habitat area, but were detected frequently off southwestern Vancouver Island (DFO 2017c).

The transboundary waters of southern British Columbia and Washington State (Figure 3) represent a very important concentration area for SRKW. This area includes waters under both Canadian and U.S. jurisdiction. Analyses of existing data on coast-wide occurrence patterns of SRKW have been completed by NOAA as part of the Endangered Species Act designation of critical habitat in collaboration with DFO (NMFS 2006a). This assessment provided quantitative documentation of the importance of these transboundary areas to these whales and forms, along with previously published information, the basis for the critical habitat identification.

This critical habitat area is utilized regularly by all three Southern Resident pods during June through October in most years (Osborne 1999; Wiles 2004). J pod appears to be present in the area throughout much of the remainder of the year, but two Southern Resident pods, K and L, are typically absent during December through April. This critical habitat is clearly of great importance to the entire Southern Resident community as a foraging range during the period of salmon migration, and thus has been designated as critical habitat under SARA.

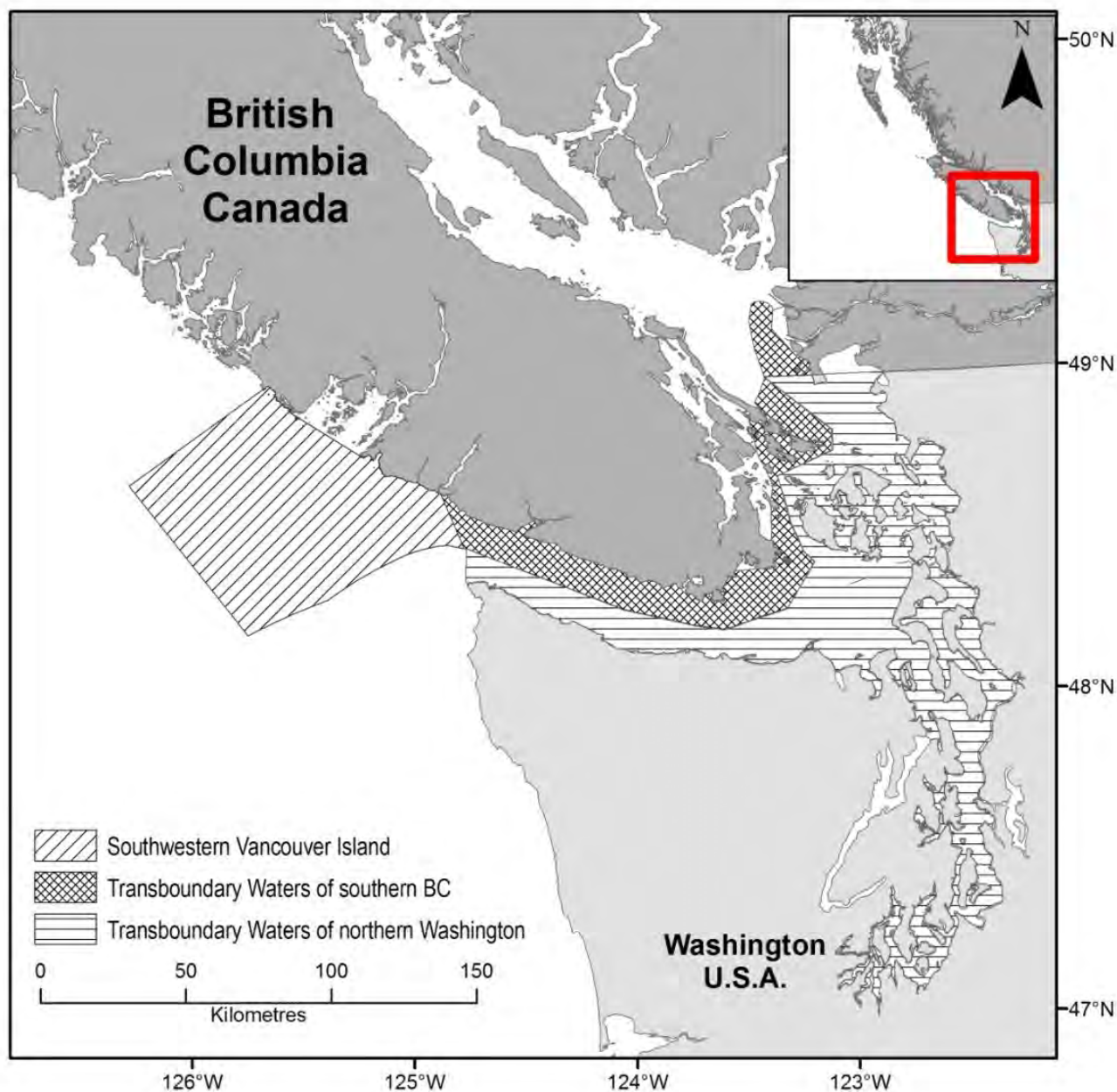


Figure 3: The critical habitat areas for Southern Resident Killer Whale and proposed future areas of critical habitat in Canada and in the transboundary waters of northern Washington. The area identified as southwestern Vancouver Island is the proposed future area of critical

habitat and the existing critical habitat is identified as the Transboundary Waters of southern British Columbia.

► Long description

### 3.3 Recovery goal

The objective established in the recovery strategy for the SRKW set out the basis for achieving a recovered state for the species. Accordingly, the assessment of imminent threat to recovery considers whether any of the threats to SRKW would render its recovery impossible or unlikely without intervention.

The recovery goal for SRKW is to “ensure the long-term viability of Resident Killer Whale populations by achieving and maintaining demographic conditions that preserve their reproductive potential, genetic variation, and cultural continuity.”

Killer Whales are top-level predators, and as such will always be far less abundant than most other species in their environment. In addition, they are segregated into small populations that are closed to immigration and emigration, such as the Northern and Southern Resident communities. Furthermore, their capacity for population growth is limited by a suite of life history and social factors, including late onset of sexual maturity, small numbers of reproductive females and mature males, long calving intervals, and dependence on the cultural transmission of ecological and social information. Unfortunately, little is known concerning the historic sizes of Killer Whale populations, or the factors that ultimately regulate them. Genetic diversity is known to be low in both populations, particularly the Southern Residents. In light of these inherent characteristics and uncertainties, the following were identified as interim measures of recovery success:

1. long-term maintenance of a steady or increasing size for populations currently at known historic maximum levels and an increasing size for populations' currently below known historic maximum levels
2. maintenance of sufficient numbers of females in the population to ensure that their combined reproductive potential is at replacement levels for populations at known historic maximum levels and above replacement levels for populations below known historic maximum levels
3. maintenance of sufficient numbers of males in the population to ensure that breeding females have access to multiple potential mates outside of their own and closely related matriline
4. maintenance of matriline comprised of multiple generations to ensure continuity in the transmission of cultural information affecting survival



### 3.4 Threats

Five threats to the recovery of SRKW were identified in the recovery strategy. These are reduced prey availability, acoustic and physical disturbance, environmental contaminants, oil spills, and incidental mortality in fisheries. Subsequently an additional threat, ship strikes, was identified in the SRKW science-based review (DFO 2017b) conducted under the Oceans Protection Plan. Note that this assessment will focus only on the three main threats to SRKW (reduced prey availability, acoustic and physical disturbance, environmental contaminants).

#### Prey availability

SRKWs are highly specialized predators and prey primarily on Chinook Salmon. This selectivity is particularly evident during the months of May through September in the Salish Sea, when they forage almost exclusively on Chinook Salmon in Juan de Fuca Strait, Puget Sound, the southern Strait of Georgia and off southwest Vancouver Island (Ford et al. 1998; Ford and Ellis 2005, 2006; Ford et al. 2010b; Hanson et al. 2010b; M. Ford et al. 2016; J. Ford et al. 2017). During October and November, SRKWs increase their use of Puget Sound, and feed on migrating Chum Salmon as well as Chinook Salmon. By December, most of the SRKW community have left their summer core areas in the Salish Sea. In particular K and L pods are mostly absent from December to May. Much less is known of SRKW diet in winter and early spring, sightings and acoustic recordings indicate that they range widely along the mainland US coast and off the west coast of Vancouver Island (Wiles 2004; Zamon et al. 2007; Hanson et al. 2013; Ford et al. 2017). Their occurrence off the mouth of the Columbia River and in Monterey Bay, California, appears to be associated with local concentrations of Chinook Salmon (Wiles 2004; Zamon et al. 2007; Hanson et al. 2010b).

The survival and recovery of SRKW appears to be strongly linked to Chinook Salmon abundance. Ford et al. (2010b) showed that mortality rates of both SRKWs and NRKWs were negatively correlated with Chinook Salmon abundance over a 25-year period, from 1979 to 2003. In particular, a sharp decline in Chinook Salmon abundance that persisted for four years during the late 1990s was associated with mortality rates up to 2 to 3 times greater than expected and resulted in population declines in both Resident Killer Whale populations. Ward et al. (2009) demonstrated a significant association between Chinook Salmon abundance and reproductive rates in the SRKW population.

Due to their relatively large size and high lipid content, Chinook Salmon are highly profitable prey for SRKWs and provide a high caloric gain for the energy expenditure of foraging (Ford and Ellis 2005, 2006). They have also been, at least historically, a reliable prey source. Unlike many species of salmon that spend large portions of their lifecycle on the high seas only returning to coastal waters to spawn, Chinook Salmon are available year-round in coastal

waters. Killer Whales appear to preferentially select four to five-year-old Chinook Salmon, which have mean body masses of 8 to 13 kg (Ford and Ellis 2005). These Chinook Salmon are considerably larger than mature Chum Salmon (4.0 to 5.5 kg), which become more prominent in the diet in the fall, and are more than double the size of a typical Coho or Pink Salmon, which are seldom consumed by Resident Killer Whales (Ford et al. 1998).

A 2013, photogrammetry study assessed SRKW body condition in 43 SRKWs and demonstrated a decline in body condition of 11 animals including seven reproductive age females compared to their condition in 2008 when 43 animals were also assessed. In the 2013 study, 12 SRKWs were identified as pregnant, based on breadth measurements from these aerial photos. However, only two of these animals were subsequently seen with a calf, suggesting that poor body condition is a likely factor that contributes to reproductive failure (Fearnbach et al 2015). In 2017, a review of recent research on SRKW was undertaken to detect evidence of poor body condition in the population (Matkin et al. 2017). This review examined evidence from sightings data (photo-identification and mortality), aerial photogrammetry, necropsy data, and fecal hormone analyses. The independent science panel that conducted the review concluded that there were multiple lines of evidence that indicated the presence of poor body condition in SRKW, and that this was associated with loss of fetuses, calves and adults.

### **Acoustic and physical disturbance**

Killer Whales use sound for communication, prey detection, and to acquire information about their environment. They produce a variety of sounds including echolocation clicks for foraging and navigation and pulsed calls and whistles during social interactions. Call production is believed to serve important roles in the social dynamics of groups that travel and forage together (Ford 1989). Resident Killer Whales appear to make extensive use of echolocation to locate and capture prey, though vision may also play a role at close ranges (Ford 1989; Barrett-Lennard et al. 1996). Studies of echolocation click structure and the sound energy content of the clicks in NRKWs suggest that they should be able to detect Chinook Salmon at ranges of about 100 m in average conditions and that these distances decrease as ambient underwater noise increases (Au et al. 2004).

It is estimated that ambient (background) underwater noise levels have increased an average of 15 dB (note a 3dB increase represents a doubling of noise levels) in the past 50 years throughout the world's oceans (NRC 2003). Shipping noise is the dominant source of ambient noise between 10 to 200 Hz but, ships also produce significant amounts of higher frequency noise in the audible range of Killer Whales (600Hz to 114kHz) with the greatest sensitivity in the range of 5kHz to 81kHz (Branstetter et al. 2017). Noise received from ships at ranges less than 3 km in the relatively narrow passage of Haro Strait, an area frequented by SRKWs, extend

upward into frequencies used by SRKWs (Veirs et al. 2015). It is widely recognized that commercial shipping has increased dramatically in recent years. Currently in the Salish Sea one large ship transits the area, on average, every hour of every day of every year, with three transits per hour observed at the busiest times (Erbe et al. 2012 Williams et al. 2014a). Within the Salish Sea, commercial shipping is the dominant source of overall sound energy, but smaller craft (recreational, fishing, whale watching boats) are a substantive contribution in certain sub-areas of the Salish Sea (ECHO 2016).

Whale watching and recreational boating activity has also increased as a result of increasing interest in ecotourism, and a growing human population around the Salish Sea. Commercial whale watching in the Canadian and U.S. portions of the Salish Sea increased from a few boats in the 1970s to about 80 boats in 2003 and in 2016 to 100 boats; this estimate does not include the recreational boaters (Holt 2017). Non-commercial boats include kayaks, sailboats and powerboats. Whale watching activities have the potential to disturb marine mammals through both the physical presence and activity of all types of watercraft, as well as the increased underwater noise levels that boat engines generate (DFO 2011).

Erbe (2002) modelled the noise of whale-oriented boat traffic in the vicinity of SRKWs and showed that the noise of fast boats could mask their calls within 14 km, could elicit a behavioural response within 200 m, and could cause a temporary threshold shift (TTS) in hearing of 5 dB after 30 to 50 min within 450 m. Boat speed was a significant factor in determining the amount of noise generated. Slowing speed, which results in less noise, masked signals at 1 km from the boat. However, there are typically many boats in the vicinity of SRKWs, so modelled noise levels associated with a number of boats around the whales were found to be close to the critical noise threshold assumed to cause a permanent hearing loss over prolonged exposure.

Numerous studies since 2002 have demonstrated behavioural response and changes in acoustic signalling by SRKWs living and foraging in the Salish Sea that strongly suggest an energetic cost and potential stress to SRKWs associated with the increased noise levels. Specifically, SRKWs significantly increased the duration of their calls when boats were present and increased the amplitude of their calls as background noise level increased as a result of the number of vessels nearby (Foote et al. 2004; Holt et al. 2009; 2011).

SRKWs were observed to be within 400 m of a vessel most of the time during daylight hours from May through September, largely as a result of whale-watching oriented vessels approaching and following them. Studies of SRKW behaviour in the vicinity of whale-watching oriented vessels in the Salish Sea showed that SRKWs were significantly less likely to be foraging and significantly more likely to be traveling when boats were around and that SRKWs

were displaced short distances by the presence of vessels (Lusseau et al. 2009). Behavioural responses to close approaches of boats include an increase in surface active behaviour which may have increased energetic costs (Noren et al. 2009).

## **Environmental contaminants**

The threat of environmental contaminants encompasses chemical, particularly bio-accumulating contaminants and biological pollutants. These latter contaminants may be pathogens that enter SRKW habitat from coastal runoff and through wastewater from urban and agricultural areas and possibly through airborne transport. The Salish Sea is surrounded by increasing urban development and industrialization. There are local regional and global inputs of contamination. The issue is also made more complex because Canada and the U.S. have different regulations to address this transboundary threat and an effective solution will require greater collaboration and harmonization.

Killer Whales are vulnerable to accumulating high concentrations of Persistent Organic Pollutants (POPs) because they are long-lived animals that feed high in the food chain and pass on a portion of their contaminant burden to their offspring (Ross et al. 2000, 2002, Rayne et al. 2004, Ross 2006). POPs are persistent, they bio-accumulate in fatty tissues, and are known to affect reproductive and immune function in Killer Whales. Resident Killer Whales prey, primarily on Chinook Salmon and several stocks of importance to SRWKS reside in Salish Sea and in other coastal marine areas for a considerable amount of their life cycle. Chinook Salmon in the range of SKRW are relatively contaminated with POPs due to biomagnification from marine food-webs during their time at sea (O'Neill et al. 1998; Ewald et al 1998).

Biological pollutants, including pathogens and antibiotic-resistant bacteria resulting from human activities, may threaten the health of SRKWs, their habitat or their prey. Due to the small size of the SRKW population and the gregarious social nature of these animals, introduction of a highly virulent and transmissible pathogen has the potential to catastrophically affect the long-term viability of the population through reduced reproductive success and survival (Gaydos et al. 2004). Furthermore, although age may be a confounding factor, it has been suggested that there is an association between cetacean exposure to polychlorinated biphenyls (PCBs) and mortality due to infectious diseases (O'Hara and O'Shea 2001). Pathogens and antibiotic-resistant bacteria can enter the marine environment by means of coastal run-off and wastewater discharges.

## **4 Imminent threat assessment**

The competent minister must recommend the making of an EPO if he or she is of the opinion that a listed wildlife species faces imminent threats to its survival or recovery. A recommendation for such an order is not required if the competent minister is of the opinion that equivalent measures have been taken under another act of parliament to protect the species. In the case of an aquatic species, an EPO may identify habitat that is necessary for the survival or recovery of the species in the area to which the emergency order relates. It may also include provisions requiring the doing of things that protect the species and that habitat, or provisions prohibiting activities that may adversely affect the species and that habitat.

### **Question 1: Is the species currently facing threats that might impact survival or recovery of the species?**

The key threats to SRKW are reductions in the availability or quality of prey, physical and acoustic disturbances, and environmental contaminants. Individually these threats, especially prey availability, have been demonstrated to limit or reverse the recovery of SRKW. The cumulative effect of these threats is unknown but they may work synergistically. Each threat independently impacts the health or the foraging ability of SRKW. Acoustic and physical disturbance, both acute and chronic effects, may affect the success of foraging. The synergistic effects of the combination of threats may exacerbate the impacts of each threat and shorten the timeframe for population impacts.

#### **Summary**

The species is currently facing threats that might be impacting survival and/or recovery.

### **Question 2: Will the effect of the current threats make survival of the species unlikely or impossible?**

COSEWIC assessed the SRKW as endangered because it met criterion C2a(i,ii); D1 (COSEWIC 2008). This means that, when it was assessed in 2006, the population possesses a small number of mature individuals (48) that has been declining over the last 10 to 15 years and was expected to continue to do so in the foreseeable future.

According to the Species at Risk Policies - Policy on Survival and Recovery [Proposed] (2016), a species at risk can be considered more likely to survive when it can be brought to the point where it possesses the characteristics outlined below. The more characteristics the species possesses, the higher its likelihood of continued survival. This means that in order for the SRKW to be considered no longer at risk, the population would need to be:

- stable or increasing over a biologically relevant time frame

- resilient: sufficiently large to recover from periodic disturbance and avoid demographic and genetic collapse
- widespread or has population redundancy: there are multiple (sub) populations or locations available to withstand catastrophic events and to facilitate rescue if necessary
- connected: the distribution of the species in Canada is not severely and unnaturally fragmented
- protected from anthropogenic threats: non-natural significant threats are mitigated
- as appropriate to its specific life history and ecology in Canada, persistence is facilitated by connectivity with populations outside Canada, and/or habitat intervention for species that are naturally below a survival threshold in Canada

### **Population stability**

While the SRKW population may have been stable in the past, at this time it cannot be considered such. In 1974, the first SRKW population census identified 71 individuals. Over the ensuing decades, it has been assessed annually and the population has fluctuated from the low of 71 animals in 1974 to a high of 97 in 1996. Beginning in 1996, an extended period of poor survival (Taylor and Plater 2001; Krahn et al. 2002) and low fecundity (Krahn et al. 2004) resulted in a decline of 17% (-2.9% per year) to 81 whales in 2001. The period of poor survival and low fecundity has been associated with low Chinook Salmon availability (Ford, Ellis and Olesiuk, 2005; Ford et al. 2010). Since 2001, the population has fluctuated between 76 and 89 individuals. From 1974 to 2006 the maximum number of mature individuals (1993) was 72, the minimum number (1985) was 42. When last assessed by COSEWIC in 2008, the population consisted of 87 individuals, including 48 mature individuals, based on 2006 data. In 2017, the population consisted of 76 members including 51 reproductive individuals (see Table 2).

Since 1974 the size of the SRKW population has been quite variable but the fluctuations have been within a certain overall population range. Combining the small population size, small effective populations and poor survival of neonates, heightens the implications of any mortality and resulting loss of reproductive potential. This negatively affects the ability of the population to stabilize and reverse its recent decline. (See Section 2 for more detailed discussion of population status and trends).

### **Resilience**

Although the current population of SRKW is small, fluctuations in the population from 71 individuals in 1974 to a high of 97 in 1996 suggests some degree of population resilience and that it should be capable of increasing its population from the current number of 76, if the demographics and conditions for successful reproduction are present.

In general, small populations have an increased likelihood of inbreeding and lower reproductive rates, which can lead to low genetic variability, reduced resilience against disease and pollution, reduced population fitness, and elevated extinction risks due to catastrophic events. If the population continues to decline, they may be faced with a shortage of suitable mates. Among the Southern Residents, L pod females may be particularly vulnerable to this scenario because of the small number of reproductive males in J and K pod thus reducing the potential for genetic exchange between pods. Even under ideal conditions, the population will recover slowly because Killer Whales calve relatively infrequently (six years for SRKW). Cultural aspects of Killer Whales must also be considered in assessing population resilience. In animals with highly matrilineal societies a breakdown in social structure may occur if the population becomes too small (Williams and Lusseau 2006; Matkin et al. 2008). However, other cultural aspects of the SRKW may contribute to population resilience. Until recently it was believed that Inbreeding would be less of a risk for Resident Killer Whales than might be expected based on the small size of their populations as they may avoid inbreeding and its inherent risks through non-random mate selection by selecting mates from outside their natal pod (Barrett-Lennard and Ellis 2001). However, Ford et al (2018) showed that “only two adult males sired 52% of the sampled progeny born since 1990”, potentially negatively impacting resilience.

### **Population redundancy and connectivity**

The SRKWs are not widespread, nor do they have population redundancy or connectivity with other populations of Killer Whales. There is a single population and they are not known to interbreed with other Killer Whale populations. This is not expected to change in the future owing to their cultural distinctiveness and separation from other Killer Whale populations.

### **Protected from anthropogenic threats**

The three main threats of reduced prey availability, physical and acoustic disturbance, and contaminants are anthropogenic in nature and ongoing. Although actions have been taken, and additional measures are being planned to reduce the impacts of these threats, the threats are not fully mitigated. Even if factors that have caused the decline of a Killer Whale population are reduced or eliminated, the time required for recovery will be long, because on average, females produce a calf only every 5 to 6 years.

### **Predicted population trajectories**

Population viability analyses (PVA) have been used to estimate the extinction risk of SRKW (Taylor and Plater 2001; Krahn et al. 2002, 2004). These models predict that if the mortality and reproductive rates of the 1990s persist, there is a 6 to 100% probability that the population will be extinct within 100 years, and a 68 to 100% risk that the population will be extinct within 300

years. When the mortality and reproductive rates of the entire 1974 to 2000 period are used, the risk of the population going extinct declines to 0 to 55% over 100 years and 2 to 100% over 300 years. Extinction of the Southern Resident population can be regarded as inevitable in these scenarios under the assumptions of the analyses. Catastrophic events, such as oil spills, would hasten its demise. A more recent PVA model predicted survival and recovery rates of SRKW based on sex-structured models and high-quality demographic data that encompassed one Killer Whale generation (25 years; 1987 to 2011). These models predicted an annual decline of 0.91% for this population, with an extinction risk of 49% over a 100-year period (Velez-Espino et al. 2014). Another recently published PVA model indicated that the current population is fragile, with no growth projected under current conditions, and decline expected if new or increased threats are imposed (Lacy, 2017).

## Summary

Given the above considerations, threats to the survival of the SRKW population could be considered imminent.

### **Question 3: Will the effect of the current threats make recovery of the species unlikely or impossible?**

The objective established in the recovery strategy for the SRKW set out the basis for achieving a recovered state for the species. Accordingly, the assessment of imminent threat to recovery considers whether any of the threats to SRKW would render its recovery impossible or unlikely without intervention.

The recovery goal for SRKW is to:

“Ensure the long-term viability of Resident Killer Whale populations by achieving and maintaining demographic conditions that preserve their reproductive potential, genetic variation, and cultural continuity.”

This recovery goal reflects the complex social and mating behaviour of Resident Killer Whales and the key threats that may be responsible for their decline; it is linked to maintenance of the current population and structure.

Killer Whales are top-level predators, and as such will always be far less abundant than most other species in their environment. They can therefore be considered naturally precarious. In addition, they are segregated into small population units that are closed to immigration and emigration. Furthermore, their capacity for population growth is limited by a suite of life



history and social factors, including late onset of sexual maturity, small numbers of reproductive females and mature males, long calving intervals, and dependence on the cultural transmission of ecological and social information.

Unfortunately, little is known concerning the historic sizes of Killer Whale populations, or the factors that ultimately regulate them. Genetic diversity is known to be particularly low in the Southern Resident population. In light of these inherent characteristics and uncertainties, the following were identified as interim measures of recovery success in the recovery strategy:

1. long-term maintenance of a steady or increasing size for populations currently at known historic maximum levels and an increasing size for populations currently below known historic maximum levels
2. maintenance of sufficient numbers of females in the population to ensure that their combined reproductive potential is at replacement levels for populations at known historic maximum levels and above replacement levels for populations below known historic maximum levels
3. maintenance of sufficient numbers of males in the population to ensure that breeding females have access to multiple potential mates outside of their own and closely related matriline
4. maintenance of matriline comprised of multiple generations to ensure continuity in the transmission of cultural information affecting survival

## **Population**

As noted above, the SRKW is small and declining. The population size is very close to the minimum recorded in 1974 of 71 animals; the known historic maximum since surveys began in 1974 is 97, which was in 1996. The presence of poor body condition in SRKW has been associated with the loss of fetuses, calves and adults. A 2013, photogrammetry study assessed SRKW body condition in 43 SRKWs and demonstrated a decline in body condition of 11 animals including 7 prime-age females compared to their condition in 2008 when 43 animals were also assessed. A review of recent research in 2017 concluded that there were multiple lines of evidence that indicated the presence of poor body condition in SRKW.

Given the small population size and low number of individuals contributing to reproduction, poor survival of neonates, it is unlikely the population will increase unless the body condition of the SRKW population improves.

## **Sufficient numbers of reproductive females**

Although the SRKW population is declining, there are as many reproductive females as there were in 1979 (Table 1). In 2017 of the three pods, K pod had the fewest number of reproductive females at 6. In 1980 K pod had just 5 reproductive females and achieved a high of 9 in 2005 (Table 2). This would suggest that there may likely be sufficient females at present to support recovery should conditions permit. It should be noted that this assumes that all females of reproductive age are reproductively viable which may not be the case.

### **Sufficient numbers of adult males**

Although the SRKW population overall is declining, there has been an increase in the number of adult males since 1979 from 18 to 29 (Table 1). This would suggest that there may be sufficient males at present to support recovery should conditions permit. It should be noted that this assumes that all adult males are reproductively viable which may not be the case.

### **Maintenance of matriline**

Small populations are particularly vulnerable to population-level effects from the loss of even one individual. Many of the older individuals from all three pods have died over the last 20 years and the overall percentage of post-reproductive females has gone from 12% to 7%. Both J and K pods have only one post-reproductive female and L pod only has three. Although it is possible that there could still be multiple generations present in the matriline without the post-reproductive females, these few individuals likely play a key role in each pod.

### **Summary**

Given the above considerations, threats to the recovery of the SRKW population could be considered imminent.

### **Question 4: Do the threats require intervention?**

Actions to mitigate threats and support recovery of SRKW have been underway for many years; however, these efforts have yet to result in detectable signs of recovery of the population.

Although the overall population size is still above the low point in 1974, the current demographic distribution of the population does not support the recovery goals identified in the 2011 Recovery Strategy. The complexity of the SRKW social structure requires the presence of older matriarchs. The maximum lifespan of a female Killer Whale is about 80 years but currently there is only one remaining whale born before 1971.

Ongoing and anticipated mitigation to address the ongoing threats

DFO's Science-based whale review (DFO 2017b) confirmed that the main threats to the SRKW population are the lack of prey availability, acoustic and physical disturbance, and bio-accumulation of contaminants. The action plan (2017a) identified numerous management and research oriented recovery measures anticipated to help abate human pressures on this population.

### **Critical habitat**

An additional area was identified as habitat of special importance for SRKW in Ford et al. (2017); an amendment to the recovery strategy is currently underway to add this area of critical habitat. This area includes the waters on the continental shelf off southwestern Vancouver Island, including Swiftsure and La Perouse Banks (Figure 3). The inclusion in a revised recovery strategy of these additional areas as critical habitat should support recovery of SRKW.

### **Prey availability**

DFO's Science-based whale review (DFO 2017b) identified two priority actions to directly abate reduced prey availability:

- plan and manage salmon fisheries in ways that will reduce anthropogenic competition for SRKW prey in important foraging areas during key times (for example, create protected areas; implement fishery area boundary adjustments and/or closures) or when there are indications of population nutritional stress; among other things, this will require the formation and formalization of a transboundary working group of science and management representatives from DFO, National Oceanic and Atmospheric Association (NOAA), and other technical experts to ensure that SRKW prey needs are incorporated consistently in the management of salmon fisheries for transboundary stocks (for example, Canada's Policy for Conservation of Wild Salmon, Pacific Salmon Treaty)
- during years of poor Chinook Salmon returns, implement a more conservative management approach than would be used in typical years to further reduce or eliminate anthropogenic competition for Chinook Salmon and other important prey in key SRKW foraging areas during key times

Current actions to address this threat:

Work has been undertaken to address this threat to the SRKW. Numerous technical science-based workshops have been held by DFO and NOAA since 2011 including: the Independent Science Panel of the Bilateral Scientific Workshop Process to Evaluate the Effects of Salmon Fisheries on Southern Resident Killer Whales (Hillborn et al. 2012) and the follow up joint DFO-NOAA Prey Availability Technical Workshop held at the University of British Columbia in November 2017 (Trites and Rosen 2018). A discussion paper including information on proposed

management measures and areas under consideration for implementation of salmon fishing or finfish closures was released to the public and externally consulted on. The focus of this discussion paper was on salmon fisheries, contained in the Southern Salmon Integrated Fisheries Management Plan (IFMP), and through this process fisheries management measures. The primary objective of these measures is to improve Chinook Salmon availability for SRKW in key foraging areas by decreasing potential fishery competition, as well as minimizing physical and acoustic disturbance to the extent possible. Options are currently being considered by the Minister for action starting in the 2018/19 fishing season.

The effectiveness of the proposed salmon fishery measures will depend upon the broad efforts designed to reduce the physical and acoustic disturbance in key foraging areas to the extent possible. In addition, the potential to increase low Chinook Salmon abundance in SRKW foraging areas may be limited given low exploitation rates in fisheries seaward of SRKW foraging areas and current low returns expected for many Fraser Chinook Salmon populations. The identified key Killer Whale foraging areas are located within the Canadian portion of proposed and existing legally-designated SRKW critical habitat and are therefore protected against destruction. Additional foraging areas have been identified in new areas proposed as SRKW critical habitat, which is in the process of being designated and protected as such.

As these management measures are new, there is no evidence yet available that the efforts will result in successful abatement of the threats associated with prey availability to promote survival and recovery. Consequently, this threat is still considered to be acting on the population and does require the type of intervention that is proposed.

### **Acoustic and physical disturbance**

Measures to address the threat from acoustic and physical disturbance from vessels fall largely under the responsibility of TC but are reliant on science advice and support from DFO.

DFO's Science-based whale review (DFO 2017b) identified four priority actions to directly abate the threat of acoustic and physical disturbance:

- increase the distance between SRKWs and pleasure crafts and whale-watching vessels
- implement area-specific vessel regulations (for example, speed restriction zones, rerouting vessel traffic, altering vessel traffic scheduling to create convoys) that reduce the overall acoustic impact on SRKWs in their habitat, particularly in the Salish Sea
- implement incentive programs and regulations that result in reduced acoustic footprints of the vessels habitually travelling in and near important SRKW habitat (for example, through changes in vessel maintenance, application of quieting technologies) and the elimination of the noisiest vessels

- identify candidate acoustic refuge areas within foraging and other key areas of SRKW habitat, and undertake actions for their creation

Current actions to address this threat:

Measures are being taken to address the threat posed by vessels that approach the whales. The proposed Marine Mammal Regulations (MMR) identify a 100 m minimum approach distance for all marine mammals, and a 200 m approach distance for all Killer Whales. In the interim, the commercial whale watching sector has committed to voluntarily implementing the 200 m minimum approach distance.

TC currently lacks the necessary legislative and regulatory authority to mandate vessel operations for the purpose of protecting marine mammal and ecosystem. TC is proposing legislative amendments to the Canada Shipping Act (CSA) 2001.

The results of the 2017 Haro Strait voluntary vessel slowdown trial, led by the Vancouver-Fraser Port Authority's Enhancing Cetacean Habitat and Observation (ECHO) program, demonstrate important reductions in noise for every knot reduction in speed. Further analysis of the data is currently underway to better inform future actions. TC is currently working with ECHO, and industry stakeholders in support of a voluntary trial for the summer of 2018 to further understand the benefits of any additional actions.

DFO has identified the need for discussions with other sectors, including whale watching, to understand activity levels within key foraging areas and what potential additional voluntary measures may be taken to minimize physical and acoustic disturbance in identified Killer Whale foraging areas to the extent possible. Discussion of potential voluntary measures that align with any implemented fishery area closures in key foraging areas through engagement, communications and stewardship is anticipated. At present, it is unclear whether and if the appropriate federal regulatory tools exist to exclude non-fishing vessel-based activities from feeding areas, or whether authorities exist under provincial jurisdiction. As well, vessel exclusion zones can be difficult to enforce, especially for small recreational crafts.

DFO (2017b) found that source-based mitigation measures, such as ship design and/or retrofit, can have a long-term and global effect but these can only be applied incrementally as ships are modified or replaced. Operation-based mitigation measures, such as vessel slow down and convoys, could improve acoustic environments but there is more uncertainty in the effectiveness of these measures as more knowledge is required on whale behaviour, presence, and distribution. Under the Whales Initiative there may be a recommendation to develop

guidelines for quiet design and retrofits. Requirements could be made mandatory through regulation. This is a long term action since design criteria and/or standards will need to be developed.

In 2017, the Government of Canada released the Oceans Protection Plan and committed to "take action to better understand and address the cumulative effects of shipping on marine mammals such as SRKW....this includes work to better establish baselines for noise and consideration of options to mitigate these effects." DFO has evaluated the scientific evidence related to mitigation measures that could be applied to reduce shipping-related noise within identified and proposed SRKW critical habitat. A range of mitigation measures were evaluated; including source- and operation-based measures (DFO 2017d).

Activities to address the recommendations above are ongoing by the Government of Canada but as with abating threats associated with prey availability, the current actions are relatively new and their success in reducing and eliminating the threats posed by acoustic and physical disturbance have not been evaluated for their effectiveness in promoting survival and recovery for the SRKW. Consequently, this threat is still considered to be acting on the population and does require immediate intervention.

### **Environmental contaminants**

Measures to address the threat from environmental contaminants are part of the legislative responsibility of ECCC. The Whale Review (DFO 2017b) identified four priority actions to directly abate the presence of environmental contaminants (in no particular order):

- adequately enforce Canadian regulations aimed at reducing toxic chemical compound discharges at the source
- accelerate the rate of compliance with the Canadian Wastewater System Effluent Regulation (2012) in wastewater treatment facilities that border the Salish Sea
- review policies and best management practices for ocean dredging and disposal at sea and modify them to include an examination of polybrominated diphenyl ethers (PBDEs) as well as any other necessary modifications to minimize SRKW contaminant exposure
- identify programs that mitigate small scale and/or chronic contaminant spills and leaks and provide support to them ; if none exist, design and implement an ongoing program that focuses on this mitigation

Current and planned actions to abate this threat:

Many of the POPs found in whales, such as dichlorodiphenyltrichloroethane (DDT) and PCBs, are legacy contaminants used historically and now banned. The Chemicals Management Plan (CMP) was created in 2006 to help ensure that substances currently in use, or being considered

for use as new substances, do not become the POPs of the future. ECCC implements the CMP collaboration with Health Canada to assess and manage substances that are toxic to the environment and human health. Under this program the department has put in place regulations to prohibit, restrict, or control toxic substances, including some of those known to affect whales.

For other toxic substances known or suspected to be affecting whales, there are plans to review existing controls and consider how to strengthen them. This will include, for example, further evaluation of prohibitions on the use of flame retardants such as PBDEs, and water, oil and grease repellants such as PFCAs; and, assessing whether to expand regulatory controls for chlorinated alkanes, to include certain types (medium and long chain) which are not addressed in the existing regulations.

Under the Fisheries Act, ECCC administers the Metal Mining Effluent Regulations (MMER) and the Pulp and Paper Effluent Regulations (PPER). These regulations manage threats to fish, fish habitat, and human health from fish consumption by governing the deposit of deleterious substances from mining and pulp and paper mills into waters frequented by fish. ECCC is considering expanding its enforcement activities to specifically target offenders posing the highest risk to whale populations and their prey.

Wastewater releases are a known source of contaminants in the Salish Sea. The Capital Regional District (CRD) plant in Victoria and Vancouver's Lions Gate and Iona Island wastewater treatment plants collectively release about 700 million litres of untreated and under treated effluent every day into the Salish Sea. ECCC's Wastewater System Effluent Regulations require wastewater facilities to upgrade to at least secondary treatment, which can remove approximately 90% of contaminants such as flame retardants (and 95% of conventional pollutants). Victoria (CRD) has until the end of 2020 to stop discharging untreated wastewater, and Metro Vancouver Lions Gate and Iona Island wastewater treatment plants have until the end of 2020 and 2030, respectively.

ECCC will put in place more protective measures under the Disposal at Sea (DaS) regulations to ensure that PCBs in sediment in marine environments do not increase as a result of disposal of dredged materials. This includes increased sampling at DaS sites to help establish protective limits for disposal at sea, to ensure that we do not increase contaminants (specifically PBDEs) in whale habitat.

Specifically regarding spills, under the Ocean Protection Plan, ECCC is supporting the Canadian Coast Guard and Fisheries and Oceans on the development of a legislative and operational framework to permit the use of the most effective response techniques for ship source spills. ECCC is also supporting legislative changes (amendments to the Canadian Shipping Act and

the Canadian Environmental Protection Act, 1999), development of an operational framework on use of alternate response measures, and completing scientific research on the use of response techniques. ECCC is also enhancing its emergency response capacity with new environmental emergency officers on the Pacific and Atlantic coasts, and additional enforcement officers in British Columbia, wildlife biologists, 24/7 oil spill modelling and emergency communications capacity.

While DFO will conduct research to quantify key contaminants founds in whales, ECCC's research efforts will focus on identifying the sources of contaminants and how they are entering aquatic environments, in order to better manage them. This research will include air monitoring to measure concentrations of contaminants in air, and the contribution of air pollution from urban centres to whale habitat; increased freshwater sampling to understand the extent to which the Fraser River and other rivers that discharge directly into SRKW habitat are contributing contaminants that are impacting the whales or their prey; sampling of leachate from landfills located close to critical whale habitat to assess the presence of contaminants. Additionally, contaminants of emerging concern such as recycled plastics containing flame retardants and microplastics will be investigated to understand their effects and potential contribution to contaminants found in whales and their prey. The findings from these various research efforts will be used to assess the effectiveness of existing management measures and to identify potential areas where new actions are required.

Many of the activities to address the recommendations are ongoing by the Government of Canada but others are planned for the future. The success of these actions in reducing contaminants in the environment will require long term monitoring and research. Consequently, this threat is still considered to be acting on the population and does require intervention.

## **Summary**

Despite ongoing and planned mitigation measures, the key threats affecting the SRKW population are, to date, not being fully abated; further, the effectiveness of these actions has not yet been evaluated, which can take many years. Given the long life-span of the species, recovery is a long-term goal and effects of reducing the threats on the population to ensure survival and advance recovery would not occur over the short term.

# **5 Conclusions**



In terms of imminency of threat to species at risk, each case must be considered on its own merit owing to the broad range of species and threats that act on them. The opinion of the Ministers must be formed based on the best available information. What is an imminent threat for one species may not necessarily apply to another. This ITA considered the application of imminent threat to the SRKW population only.

When forming an opinion as to the existence of imminent threats, the Ministers should consider factors including whether the threats are of sufficient proximity, taking into account the recovery objectives identified in the recovery strategy for the species if there is one, and whether the threats to the survival or recovery of SRKW are more than a mere possibility or potential future outcome. The more likely the threats are, the more weight they will merit in the Ministers' assessment of the imminence of the threats. However, the threats need not be guaranteed to materialize and the precautionary principle should guide the Ministers in forming their opinion. The impact of the threats should be considered over a biologically appropriate timescale for SRKW; whether it would render the SRKW recovery or survival impossible or unlikely without intervention should also be considered.

The three primary threats to SRKW that are described in this document are present, have ongoing impacts to this population and must be considered.

Threats acting on the SRKW population are not new and may be considered chronic in that they have been acting on the population for many years and cannot be eradicated by any one action or activity. However, it is recognized that these threats and the impacts they may be having on the population are also likely increasing. At the present time, due to the current status of the population and the criteria established for recovery, the threats, although chronic and not necessarily immediate, can be considered imminent. Intervention (through current and proposed measures and/or through additional measures) is needed now in order to preserve the current population to allow the SRKW the best chance for survival and recovery.

In light of their inherent characteristics, including life history and social factors, the population was likely historically small compared to other cetacean populations, even in the absence of impacts from human activities. However, the current population is considered small, not stable and declining. It does not exhibit population redundancy or connectivity with other Killer Whale populations and it continues to face anthropogenic threats that may be increasing. As described above, there are new measures underway, such as reducing commercial Chinook Salmon harvest and reducing noise, that are expected to help mitigate these threats to SRKW, but the effectiveness of these additional measures in abating the threat and contributing to the survival and recovery of the population will take time to evaluate. The maximum lifespan of a

female SRKW is approximately 50 to 80 years and a generation is considered to be 26 to 29 years; the effectiveness of threat mitigation actions can be expected to take many years to come to fruition.

Therefore, in following the precautionary approach committed to by the Government of Canada, and the information presented above, the following recommendations are made:

### **Imminent threat to survival**

Based on the information reviewed and analysis undertaken as part of this assessment, it is considered that SRKW are likely facing imminent threat to survival. Unless mitigated, the current threats may make survival of the population unlikely or impossible.

### **Imminent threat to recovery**

Based on the information reviewed and analysis undertaken as part of this assessment, it is considered that SRKW are likely facing imminent threat to recovery. Unless mitigated, the current threats may make recovery of the population unlikely or impossible.

## **6 References**

- Adam v. Canada (Environment), [2013] 2 FCR 201, 2011 FC 962 (CanLII).
- Amos, B., C. Schloetterer, and D. Tautz. 1993. Social structure of pilot whales revealed by analytical DNA profiling. *Science* 260: 670-672.
- Au, W.W.L., J.K.B. Ford, and K.A. Newman Allman. 2004. Echolocation signals of free-ranging Killer Whales (*Orcinus orca*) and modeling of foraging for chinook salmon *Oncorhynchus tshawytscha*). *Journal of the Acoustical Society of America* 221: 559-564.
- Baird, R.W. 2001. Status of Killer Whales, *Orcinus orca*, in Canada. *Canadian Field Naturalist* 115:676-701.
- Barrett-Lennard, L.G. and G.M. Ellis. 2001. Population structure and genetic variability in Northeastern Pacific Killer Whales: toward an assessment of population viability. CSAS Res. Doc. 2001/065. 35 pp.
- Barrett-Lennard, L.G., J.K.B. Ford and K. Heise. 1996. The mixed blessing of echolocation: Differences in sonar use by fish-eating and mammal-eating Killer Whales. *Animal Behaviour* 51: 553-565.
- Black, N., R. Ternullo, A. Schulman-Janiger, A.M. Hammers, and P. Stap. 2001. Occurrence, behaviour, and photo-identification of Killer Whales in Monterey Bay, California. In 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, British Columbia. Society for Marine Mammalogy, San Francisco, California.

- Bigg, M.A., G.M. Ellis, J.K.B. Ford, and K.C. Balcomb. 1987. Killer Whales: a study of their identification, genealogy, and natural history in British Columbia and Washington State. Phantom Press, Nanaimo, British Columbia.
- Bigg, M.A., P.F. Olesiuk, G.M. Ellis, J.K.B. Ford, and K.C. Balcomb. 1990. Social organization and genealogy of Resident Killer Whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission Special Issue 12:383-405.
- Bigg, M.A. and A.A. Wolman. 1975. Live-capture Killer Whales (*Orcinus orca*) fishery, British Columbia and Washington, 1962-73. Journal of the Fisheries Research Board of Canada 32: 1213-1221.
- Branstetter, B.K., St Leger, J., Acton, D., Stewart, J., Hauser, D., Finneran, J.J., Jenkins, K. 2017. Killer whale (*Orcinus orca*) behavioural audiograms. J. Acous. Soc. of Amer.
- COSEWIC. 2008. COSEWIC assessment and update status report on the Killer Whale *Orcinus orca*, Southern Resident population, Northern Resident population, West Coast Transient population, Offshore population and Northwest Atlantic / Eastern Arctic population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 65 pp.
- Dahlheim, M.E. and C.O. Matkin. 1994. Assessment of injuries to Prince William Sound Killer Whales. Pages 163-171 in T.R. Loughlin (editor). Marine mammals and the Exxon Valdez. Academic Press, San Diego, California.
- Dahlheim, M.E. and J.E. Heyning. 1999. Killer Whale *Orcinus orca* (Linnaeus, 1758). Pages 281-322 in S. Ridgway and R. Harrison (editors). Handbook of marine mammals, Volume 6. Academic Press, San Diego, California.
- DFO. 2011. Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada. Species at Risk Act Recovery Strategy Series, Fisheries and Oceans Canada, Ottawa, ix + 80 pp.
- DFO. 2017a. Action Plan for the Northern and Southern Resident Killer Whale (*Orcinus orca*) in Canada. Species at Risk Act Action Plan Series. Fisheries and Oceans Canada, Ottawa. v + 33 pp.
- DFO. 2017b. Southern Resident Killer Whale: A science based review of recovery actions for three at-risk whale populations. [accessed February 2018].
- DFO. 2017c. Identification of habitats of special importance to Resident killer whales (*Orcinus orca*) off the west coast of Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/011
- DFO. 2017d. Evaluation of the Scientific Evidence to Inform the Probability of Effectiveness of Mitigation Measures in Reducing Shipping-Related Noise Levels Received by Southern Resident Killer Whales. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/041.

- Donague, M., R. Reeves, and G.S. Andrews. 2002. Report of the Workshop On Interactions Between Cetaceans And Longline Fisheries. Apia, Samoa: November 2002. New England Aquarium Aquatic Forum Series Report 03-1, New England Aquarium, Boston, MA, USA.
- ECHO 2016. Enhancing Cetacean Habitat and Observation (ECHO) Program. Advisory Working Group Meeting Presentation, June 2016.
- Erbe, C. 2002. Underwater noise of whale-watching boats and potential effects on Killer Whales (*Orcinus orca*), based on an acoustic impact model. *Marine Mammal Science* 18:394-418.
- Erbe, C., MacGillivray, A., and Williams, R.. 2012. Mapping cumulative noise from shipping to inform marine spatial planning. *The Journal of the Acoustical Society of America* 132:EL423
- Ewald, G., Larsson, P., Linge, H., Okla, L., and Szarzi, N. 1998. Biotransport of organic pollutants to an inland Alaska lake by migrating sockeye salmon (*Oncorhynchus nerka*). *Arctic* 51:40-47.
- Fearnbach, H., Durban, J.W., Ellifrit, D.K. and Balcomb, K.C., 2015. Individual-based photogrammetric measures of length, growth and shape to infer body condition and reproductive status of Southern Resident Killer Whales. Unpublished report by Center for Whale Research and NOAA, USA.
- Ford, J.K.B. 1989. Acoustic behaviour of Resident Killer Whales *Orcinus orca* off Vancouver Island, British Columbia, Canada. *Canadian Journal of Zoology* 67: 727-745.
- Ford, J.K.B. and G.M. Ellis. 1999. *Transients: Mammal-Hunting Killer Whales*. UBC Press, Vancouver, British Columbia. 96 pp.
- Ford, J.K.B. and G.M. Ellis. 2002. Reassessing the social organization of Resident Killer Whales in British Columbia. Pages 72-75 in the Fourth International Orca Symposium and Workshop, September 23-28, 2002. CEBC-CNRS, France.
- Ford, J.K.B. and G.M. Ellis. 2005. Prey selection and food sharing by fish-eating 'Resident' Killer Whales (*Orcinus orca*) in British Columbia. Canadian Science Advisory Secretariat, Research Document 2005/041.
- Ford, J.K.B. and G.M. Ellis. 2006. **Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. *Marine Ecology Progress Series* 316: 185-199.**
- Ford, J.K.B., G.M. Ellis, and K.C. Balcomb. 2000. *Killer Whales: the natural history and genealogy of *Orcinus orca* in British Columbia and Washington*, second edition. UBC Press, Vancouver, British Columbia. 104 pp.
- Ford, J.K.B., G.M. Ellis, L.G. Barrett-Lennard, A.B. Morton, R.S. Palm, and K.C. Balcomb. 1998. Dietary specialization in two sympatric populations of Killer Whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. *Canadian Journal of Zoology* 76:1456-1471.

- Ford, J.K.B., G.M. Ellis, P.F. Olesiuk. 2005. Linking prey and populations dynamics: did food limitation cause recent declines of 'Resident' Killer Whales (*Orcinus orca*) in British Columbia. Canadian Science Advisory Secretariat, Research Document 2005/042.
- Ford, J.K.B., G.M. Ellis, P.F. Olesiuk, and K.C. Balcomb. 2010. Linking Killer Whale survival and prey abundance: food limitation in the oceans' apex predator? *Biology letters* 6:139–42.
- Ford, J.K.B, E.H. Stredulinsky, G.M. Ellis, J.W. Durban, and J.F. Pilkington. 2014. Offshore Killer Whales in Canadian Pacific Waters: Distribution, Seasonality, Foraging Ecology, Population Status and Potential for Recovery. DFO Canadian Science Advisory Secretariat Research Document 2014/088. vii + 55 p.
- Ford, J.K.B, J.F. Pilkington, A. Reira, M. Otsuki, B. Gisborne, R.M. Abernethy, E.H. Stredulinsky, J.R. Towers, and G.M. Ellis. Habitats of Special Importance to Resident Killer Whales (*Orcinus orca*) off the West Coast of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/035.
- Ford, M.J., K.M. Parsons, E.J. Ward, J.A. Hempelmann, C.K. Emmons, M.B. Hanson, K.C. Balcomb, L.K. Park. Inbreeding in an endangered killer whale population. *Anim Conserv* 21(2).
- Foote, A.D., R.W. Osborne, and A. R. Hoelzel. 2004. Whale-call response to masking boat noise. *Nature* 428: 910.
- Gaydos, J.K., K.C. Balcomb, R.W. Osborne, and L. Dierauf. 2004. Evaluating potential infectious disease threats for Southern Resident Killer Whales, *Orcinus orca*: a model for endangered species. *Biological Conservation* 117: 253-262.
- Geraci, J.R. and D.J. St. Aubin. 1982. *Sea mammals and oil: confronting the risks*. Academic Press, New York, New York.
- Grant, S.C.H. and P.S. Ross. 2002. Southern Resident Killer Whales at risk: toxic chemicals in the British Columbia and Washington environment. Canadian Technical Report of Fisheries and Aquatic Science 2412:1-111.
- Hanson, M.B., R.W. Baird, J.K.B. Ford, J. Hempelmann-Halos, D.M. Van Doornik, J.R. Candy, C.K. Emmons, G.S. Schorr, B. Gisborne, K.L. Ayres, S.K. Wasser, K.C. Balcomb, J.G. Sneva, and M.J. Ford. 2010. Species and stock identification of prey consumed by endangered Southern Resident Killer Whales in their summer range. *Endangered Species Research* 11: 69–82.
- Hanson, M.B., C.K. Emmons, E.J. Ward, J.A. Nystuen, and M.O. Lammers. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. *Journal of the Acoustical Society of America* 134:3486-3495.
- Heise, K., L. G. Barrett-Lennard, E. Saulitis, C. Matkin, and D. Bain. 2003. Examining the evidence for Killer Whale predation on Steller sea lions in British Columbia and Alaska.

Aquatic Mammals 29: 325-334.

- Holt, M.M. 2017. Research Efforts to Address Noise and Vessel Effects on Southern Resident Killer Whales. Presentation made at the DFO-NOAA Strategic Planning of Activities Meeting, March 708, 2017, Seattle, WA.
- Holt, M.M., D.P. Noren, V. Viers, C.K. Emmons, and S. Viers. 2009. Speaking up: killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. *Journal of the Acoustical Society of America* 125(1): 27-32.
- Holt, M.M., Noren D.P., and Emmons, C.K. 2011. Effects of noise levels and call types on the source levels of killer whale calls. *The Journal of the Acoustical Society of America* 130:3100.
- Krahn, M.M., M.J. Ford, W.F. Perrin, P.R. Wade, R.P. Angliss, M.B. Hanson, B.L. Taylor, G.M. Ylitalo, M.E. Dahlheim, J.E. Stein, and R.S. Waples. 2004. 2004 Status review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. U.S. Dept. Commer, NOAA Tech. Memo. NMFSNWFSC- 62, 73 p. [accessed January 2005].
- Krahn, M.M., P.R. Wade, S.T. Kalinowski, M.E. Dahlheim, B.L. Taylor, M.B. Hanson, G.M. Ylitalo, R.P. Angliss, J.E. Stein, and R.S. Waples. 2002. Status review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-54. 133p.
- Lusseau, D., D. Bain, R. Williams, and J. Smith. 2009. Vessel traffic disrupts the foraging behavior of Southern Resident Killer Whales *Orcinus orca*. *Endangered Species Research* 6:211–221.
- Matkin, C.O., G.M. Ellis, E.L. Saulitis, L.G. Barrett-Lennard, and D.R. Matkin. 1999. Killer Whales of Southern Alaska. North Gulf Oceanic Society, Homer, Alaska.
- Matkin, C. O, Moore M. J., and Gulland F.M.D. 2017. Review of Recent Research on Southern Resident Killer Whales (SRKW) to Detect Evidence of Poor Body Condition in the Population. Independent Science Panel Report to the SeaDoc Society. 3 pp. + Appendices. DOI 10.1575/1912/8803
- Matkin, C.O., E.L. Saulitis, G.M. Ellis, P. Olesiuk, and S.D. Rice. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. *Mar. Ecol. Prog. Ser.* 356:269-281.
- NMFS. 2006a. Designation of critical habitat for Southern Resident Killer Whales, biological report, October 2006, 44 pp. [accessed March 2007].
- Noren, D., Johnson A.H., Rehder D., and Larson A.. 2009. Close approaches by vessels elicit surface active behaviors by Southern Resident Killer Whales. *Endangered Species Research* 8:179–192.
- O'Hara, T.M., O'Shea, T.J., 2001. Toxicology. In: Dierauf, L.A., Gulland, F.M.B. (Eds.), *CRC Handbook of Marine Mammal Medicine*, 2nd Edition. CRC Press, Boca Raton, Florida, pp. 309–335.

- Olesiuk, P.F., M.A. Bigg, and G.M. Ellis. 1990. Life history and population dynamics of Resident Killer Whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission Special Issue 12: 209-243.
- O'Neill, S.M., J.E. West, and J.C. Hoeman. 1998. Spatial trends in the concentration of polychlorinated biphenyls (PCBs) in chinook (*Oncorhynchus tshawytscha*) and coho salmon (*O. kisutch*) in Puget Sound and factors affecting PCB accumulation: results from the Puget Sound Ambient Monitoring Program. Puget Sound Research '98:312-328. [accessed January 2005]
- Osborne, R.W. 1999. A historical ecology of Salish Sea "Resident" Killer Whales (*Orcinus orca*): with implications for management. Ph.D. Thesis, University of Victoria, Victoria, British Columbia.
- Pike, G.C. and I.B. MacAskie. 1969. Marine mammals of British Columbia. Bulletin of the Fisheries Research Board of Canada 171: 1-54.
- Rayne, S., M.G. Ikonomou, P.S. Ross, G.M. Ellis, and L.G. Barrett-Lennard. 2004 PBDEs, PBBs, and PCNs in three communities of free-ranging Killer Whales (*Orcinus orca*) from the northeastern Pacific Ocean. Environmental Science and Technology 38: 4293-4299.
- Ross, P.S. 2000. Marine mammals as sentinels in ecological risk assessment. Humans and Ecological Risk Assessment 6: 29-46.
- Ross, P.S. 2002. The role of immunotoxic environmental contaminants in facilitating the emergence of infectious diseases in marine mammals. Humans and Ecological Risk Assessment 8: 277-292.
- Ross, P.S. 2006. Fireproof Killer Whales (*Orcinus orca*): Flame retardant chemicals and the conservation imperative in the charismatic icon of British Columbia, Canada. Canadian Journal of Fisheries and Aquatic Sciences 63: 224-234.
- Scammon, C.M. 1874. The marine mammals of the northwestern coast of North America, together with an account of the American whale fishery. J.H. Carmany and Company, San Francisco, California.
- Taylor, M. and B. Plater. 2001. Population viability analysis for the Southern Resident population of the Killer Whale (*Orcinus orca*). Centre for Biological Diversity, Tucson, Arizona. 30 p.
- Veirs, S., Veirs, V. and Wood, J.D. 2015. Ship noise in an urban estuary extends to frequencies used for echolocation by endangered killer whales. PeerJ 4:e1657
- Vélez-Espino, L.A., Ford, J.K.B., Araujo, H.A., Ellis, G., Parken, C.K., and Balcomb, K.C. 2014. Comparative demography and viability of northeastern Pacific resident killer whale populations at risk. Can. Tech. Rep. Fish. Aquat. Sci. 3084: v + 58 p.

- Ward, E.J., E.E. Holmes, and K.C. Balcomb. 2009. Quantifying the effects of prey abundance on killer whale reproduction. *Journal of Applied Ecology* 46(3): 632-640.
- WDOE (Washington Department of Ecology). 2004. Vessel entry and transit for Washington waters VEAT 2003. WDOE Publication 04-08-002. Olympia Washington. [accessed December 2004].
- Wiles, G.J. 2004. Washington state status report for the Killer Whale. Washington Department of Fish and Wildlife, Olympia. 106 p.
- Williams, R., C. Erbe, E. Ashe, A. Beerman, and J. Smith. 2014. Severity of killer whale behavioral responses to ship noise: A dose-response study. *Marine Pollution Bulletin* 79: 254-260.
- Williams, R., D. Lusseau, and P.S. Hammond. 2006. Estimating relative energetic costs of human disturbance to Killer Whales (*Orcinus orca*). *Biological Conservation* 133: 301-311.
- Zamon, J.E., Guy, T.J., Balcomb, K. and Ellifrit, D. 2007. Winter observations of southern resident killer whales (*Orcinus orca*) near the Columbia River plume during the 2005 spring Chinook salmon (*Oncorhynchus tshawytscha*) spawning migration. *Northwestern Naturalist*, 88:193-198.

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## Footnote

- <sup>1</sup> For species that were historically precarious, recovery will be considered feasible if the extent of irreversible change is such that under the best achievable scenario it is technically and biologically feasible to improve the condition of the species to a point that it is approaching the historical condition. For these species, recovery is deemed not feasible if the extent of irreversible change is so great that it is not technically and biologically feasible to improve the condition of the species to approach the lower end of the historical condition. In such a case, survival of the species may be achieved by ensuring connectivity between the species Canadian population and other populations of the same species in other countries or other populations that are not at risk; and/or by actively intervening with the species and/or its habitat. If recovery is deemed not to be technically and biologically feasible, population and distribution objectives will be set to support survival of the species and the identification of critical habitat to the extent possible, in addition to the other requirements of subsection 41(2) of SARA.

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**Date modified:**

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# TAB S

# SCIENTIFIC REPORTS



OPEN

## Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans

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Understanding cumulative effects of multiple threats is key to guiding effective management to conserve endangered species. The critically endangered, Southern Resident killer whale population of the northeastern Pacific Ocean provides a data-rich case to explore anthropogenic threats on population viability. Primary threats include: limitation of preferred prey, Chinook salmon; anthropogenic noise and disturbance, which reduce foraging efficiency; and high levels of stored contaminants, including PCBs. We constructed a population viability analysis to explore possible demographic trajectories and the relative importance of anthropogenic stressors. The population is fragile, with no growth projected under current conditions, and decline expected if new or increased threats are imposed. Improvements in fecundity and calf survival are needed to reach a conservation objective of 2.3% annual population growth. Prey limitation is the most important factor affecting population growth. However, to meet recovery targets through prey management alone, Chinook abundance would have to be sustained near the highest levels since the 1970s. The most optimistic mitigation of noise and contaminants would make the difference between a declining and increasing population, but would be insufficient to reach recovery targets. Reducing acoustic disturbance by 50% combined with increasing Chinook by 15% would allow the population to reach 2.3% growth.

Conservation science is tasked with quantifying the relative importance of multiple anthropogenic threats to species, both to determine if cumulative impacts exceed sustainable levels and to guide effective recovery plans<sup>1–4</sup>. However, cumulative human impacts are often poorly understood and inadequately addressed in conservation and management<sup>5</sup>. Fundamental research is still needed to integrate information on qualitatively different stressors into comprehensive models that reveal the cumulative impacts on measures of population growth, stability, and resilience<sup>6</sup>. Such work is needed, in part, because threats vary widely in their amenity to mitigation. When regulators require users to forego economic opportunities, it is important to have confidence that management actions will achieve the desired effect<sup>7</sup>. One way to accomplish this is to conduct “population viability analyses” (PVA) that use models of population dynamics to evaluate the relative importance of multiple anthropogenic stressors, singly and in combination, so that conservation can be directed toward efforts most likely to promote species recovery<sup>8</sup>. PVA can be a powerful tool for informing management and conservation decisions. However, the detailed population models used in PVA depend on: availability of estimates for demographic rates (both fecundity and survival and the variability in such rates); confidence that observed past rates are predictors of ongoing demography, or that trends can be foreseen; data for quantifying effects of threats on demographic rates; and a population model that adequately captures the key demographic, social, genetic, and environmental processes that drive the dynamics of the population of concern. Nevertheless, even when data on certain aspects of the population or its threats are not available, we can use PVA models to explore possible outcomes across a plausible range of values, and thereby identify which factors might be important and the target of additional research.

The Southern Resident killer whale (*Orcinus orca*, SRKW) population in the northeastern Pacific Ocean is one of the most critically endangered populations of marine mammals in the USA<sup>9</sup> and Canada<sup>10</sup>. The USA and

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Set	Scenario	Parameters varied	Population growth (r)
Baseline	Baseline	Rates as observed 1976–2015	−0.002
	Sensitivity Tests	See Supplementary Information (S.I.)	See S.I.
Individual Th eats	Current	Chinook = 1.0; Noise = 85%; PCB = 2 ppm/y	−0.001
	Chinook	0.6 to 1.3 × baseline	−0.038 to +0.025
	Noise	0 to 100% of time	+0.017 to −0.004
	PCB	0 to 5 ppm/y	+0.003 to −0.008
Cumulative Th eats	No Anthropogenic Th eats	baseline Chinook; no noise, no PCB; no oil spills; no ship strikes	+0.019
	Low Development	25% decline in Chinook; 92.5% noise; low frequency oil spills and ship strikes (see Table 2)	−0.008
	High Development	50% decline in Chinook; 100% noise; higher frequency oil spills and ship strikes (see Table 2)	−0.017
Demographic Management	Fecundity	1 to 1.5 × baseline	+0.016
	Adult Mortality	1 to 0.5 × baseline	+0.009
	Calf Mortality	1 to 0.5 × baseline	+0.004
Th eat Management	Chinook	1 to 1.3 × baseline	+0.025
	Noise	85% to 0%	+0.017
	PCB	2 to 0 ppm/y	+0.004
	Chinook & Noise	1 to 1.3 × Chinook; 42.5% Noise	+0.036

**Table 1.** Models of viability of the SRKW population for assessing current viability, sensitivity to anthropogenic threats, and responses to management. Population growth rates are mean  $r$  for Baseline, ranges for tests of Individual Th eats, means for Cumulative Th eat scenarios, and maxima for ranges tested in Demographic Management and Th eat Management scenarios.

Canada have listed this transboundary population as Endangered, citing three primary risk factors: lack of the whales' preferred prey, Chinook salmon (*Oncorhynchus tshawytscha*); chronic and acute underwater noise and physical disturbance (e.g., from ferries, commercial ships, whale-watching boats, fishing boats, and recreational traffic) and high levels of contaminants, including polychlorinated biphenyls (PCBs)<sup>10,11</sup>. A recent Status Review<sup>12</sup> highlighted also the potential risk to this small, localized population from catastrophic events such as an oil spill. Governments and non-governmental organizations are currently seeking effective conservation measures for this high-profile population. Fortunately, the biological and environmental data available for SRKWs are rich by the standards of any marine mammal population. Long-term annual censuses, with continuous monitoring since 1976, coupled with the specialized diet, have allowed inference of quantitative relationships between prey and various metrics of fecundity and survival<sup>13,14</sup>. Thus, the prerequisites for a robust PVA suitable for guiding conservation are met.

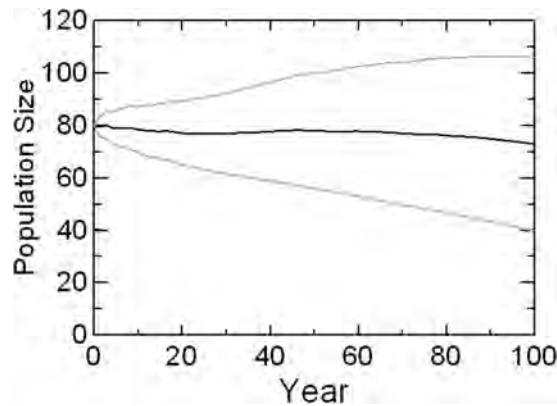
PVA uses demographic models to assess risk to wildlife populations and evaluate the likely efficacy of protection measures, recovery targets, and restoration options<sup>15,16</sup>. We used the Vortex PVA model to examine the dynamics of SRKWs. Vortex<sup>17–19</sup> is a flexible, individual-based simulation that is freely available. Vortex has been used to set recovery goals and guide actions for many threatened species, including the Mexican wolf (*Canis lupus baileyi*)<sup>20</sup>, Florida panther (*Puma concolor coryi*)<sup>21</sup>, and Florida manatee (*Trichechus manatus latirostris*)<sup>22</sup>. Several recent PVAs on the SRKWs have shown how variability in demography<sup>23</sup> or inter-annual variability in Chinook salmon abundance<sup>12,24,25</sup> could affect the population. We extend those approaches to consider also the sub-lethal effects of contaminants and acoustic disturbance, and the cumulative impacts of threats and interactions among them.

We first parameterized a Baseline model with demographic rates observed over 1976 through 2014, and tested the sensitivity of population growth to each demographic parameter. We then constructed one model that quantifies the population consequences of all three anthropogenic threats to SRKWs identified in Canadian<sup>10</sup> and USA<sup>11</sup> recovery plans. We compared the relative importance of each threat by projecting the population growth across the possible range of each threat. Finally, we used the PVA to explore the degree to which threats would have to be mitigated, alone or in combination, to reach a quantitative USA recovery target of sustained 2.3% growth over 28 years<sup>11</sup>.

## Results

Five sets of population models and the scenarios examined in each are listed in Table 1. The Baseline model projects mean population growth over the next 100 years of  $r = -0.002$ , with variation across years of  $SD = 0.045$  (Fig. 1). These projections match very closely to the rate of  $r = 0.002$ , with  $SD = 0.042$ , observed over 1976 to 2014. The marginally lower growth in the model can be accounted for by future accumulation of low levels of inbreeding. After 100 years, the projected mean inbreeding coefficient is 0.067, about the same as results from mating between first-cousins. When inbreeding depression was eliminated from the Baseline model, the projected growth was  $r = 0.002$ , with  $SD = 0.043$  – nearly identical growth and variation in growth to the trend in recent decades, and thereby confirming that the model replicates accurately the recent dynamics of the population.

Sensitivity tests of the influence of each demographic rate in the baseline PVA (Supplementary Information) show that, across the ranges of values tested, variation in fecundity (defined for the model as the mean proportion of adult females giving birth per year) accounts for most (77%) of the uncertainty in population growth rate.



**Figure 1.** The distribution of 10,000 simulated trajectories with means and SD of the population size for northeastern Pacific Ocean SRKW's projected for 100 years, based on demographic rates observed from 1976 through 2014, applied to a starting population as it existed in 2015.

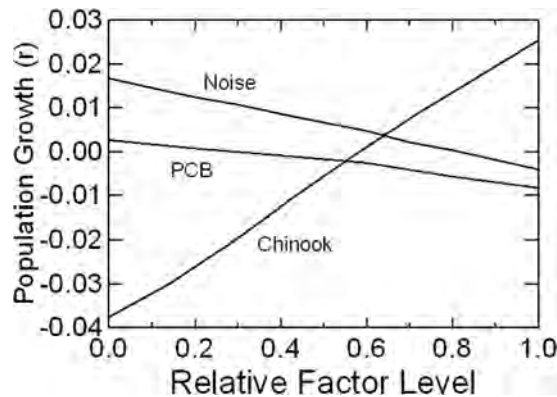
Scenario	Threats modelled					Population projection		
	Chinook trend	Noise	PCB (ppm/y)	Oil spill (big; small)	Ship strikes	Population growth ( $r$ )	Probability extinct	Probability final $N < 30$
No anthropogenic threats	constant	0	0	0	0	0.019	0	0
Current threats	constant	85%	2	0	0	-0.001	0	5%
Low increase	-25% in 100 y	92.5%	2	0.21%; 1.08%	1 per 10 y	-0.008	5%	31%
Higher increase	-50% in 100 y	100%	2	0.42%; 2.16%	2 per 10 y	-0.017	25%	70%

**Table 2.** Measures of viability of the SRKW population over 100 years under scenarios of minimal anthropogenic threats, current threats, and two levels of increased threats due to development. See text for explanation of threats modelled.

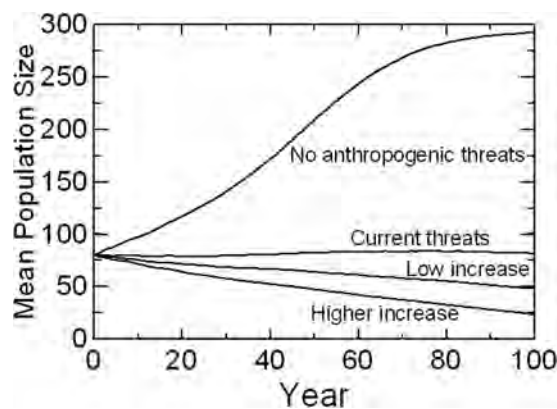
Annual adult mortality has some influence on the population trajectories (6%), but because mortality is already close to 0, there is comparatively less opportunity to improve the value of this parameter. Calf (first year) and juvenile (1 y to 10 y) mortality each accounted for about 3% of variation in population growth. Individual variation in reproductive success and temporal fluctuations (EV) in demographic rates had almost no effect on long-term population growth, as would be expected for a very long-lived species in which short-term fluctuations average out over time. Therefore, although our estimates of annual variation in rates are uncertain, refining the estimates would not change any conclusions about the effects of threats on the viability of the population. Given the small population size, inbreeding depression might cause sufficient adverse impact on population viability (6% of the total variance explained) such that it should not be ignored in assessments of long-term population viability. The impact of inbreeding was exacerbated slightly when we did not include avoidance of very close inbreeding (Supplemental Information).

**Individual Threats.** The set of models that includes estimates for the threats identified in the recovery plans – Chinook prey availability, noise and disturbance, and contaminants – was calibrated so that in the Current Threats scenario the demographic rates at existing threat levels reflect the mean demographic rates observed from 1976 through 2014. Thus, the Current Threats scenario mirrored the simpler Baseline scenario, except that rounding error in estimating effects of threats led to very slight deviation from the Baseline. The levels of these threats were then varied across broad ranges of values to determine which threat would have the greatest impact on population growth. Over the ranges tested, the effects of Chinook prey abundance on fecundity and survival had a greater effect on the population growth rate than did the other two factors (Fig. 2). Noise disturbance acts through decreased feeding efficiency in our model, but has a lesser effect than prey abundance because the maximum impact of boat noise 100% of the time would be to reduce foraging by about 20%. PCB accumulation rates that we tested result in mean levels in adult females of 0 to 132 ppm. Across this range, calf mortality is predicted to rise from about 7% to 50% (see Methods), and this impact shifts population growth from slightly positive to negative.

**Cumulative Threats.** Threats may interact, such that cumulative effects differ from those projected based on the summation of individual impacts. Full exploration of all of the possible interactions among the threats to the SRKW is not warranted at this time because individual threats are not yet well quantified. As more data on the above threats and other threats are acquired, management authorities can use the PVA framework to examine specific interactions of interest or full statistical analysis of all possible interactions<sup>26</sup>. To illustrate how cumulative threats can be assessed within the PVA model, we examined combinations of threat levels that represent the cumulative impacts of multiple threats for a few sample scenarios. We compared the Current Threats to a



**Figure 2.** Effect of Chinook prey abundance (index varied from 0.60 to 1.30), noise and disturbance (boats present from 0% to 100% of time), and PCB contaminants (accumulation rate from 0 to 5 ppm/y) on mean population growth, while holding the other two factors at their baseline levels (1.0 prey index, 85% noise, and 2 ppm/y PCB accumulation). The x-axis is standardized to the range tested for each variable.



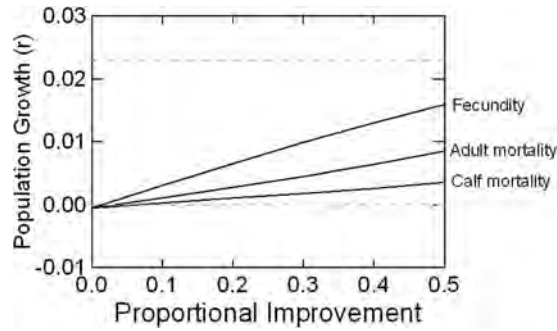
**Figure 3.** Mean projected SRKW population sizes for scenarios with (from top to bottom): no anthropogenic noise or contaminants; current Chinook abundance, noise, and PCBs; reduced Chinook, increased noise, and additional threats of oil spills and ship strikes as estimated for low level impacts of future industrial development; and these increased and additional threats with higher level impacts of development.

scenario with no anthropogenic threats and to scenarios with an increase in current threats and the addition of new threats. Figure 3 compares the population trajectory for the Current Threats with a scenario in which noise and PCB contamination were set to 0, and with two scenarios that describe levels of threat that could occur with proposed further industrial development and climate change. Table 2 shows the mean growth rates, probabilities of decline below 30 animals, and probabilities of extinction within 100 years under these scenarios.

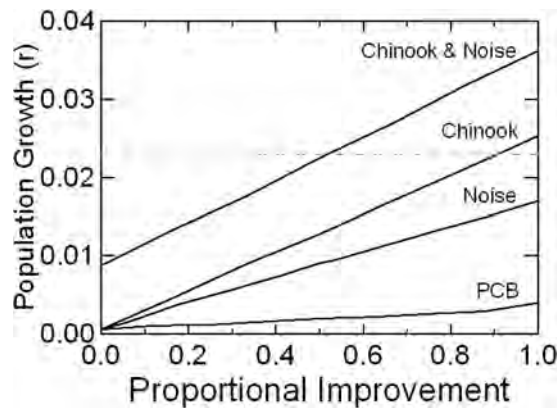
The population could show robust growth if all anthropogenic threats were removed, but has no growth under current threat levels (Fig. 3). The combination of increased and additional threats expected under planned further industrial development in the habitat of the SRKW would cause population decline.

**Demographic Management.** The potential benefits of improvements in the primary demographic rates were examined in a set of Demographic Management scenarios. The demographic analyses indicate that reaching the SRKW recovery target of 2.3% growth is impossible by improving any single rate by a plausible amount, although increased fecundity would have the greatest positive influence on population growth (Fig. 4). To reach the recovery target, sustained mitigation of threats will be necessary to promote both increased fecundity and reduced mortality.

**Threat Management.** Improvements in demographic rates would need to be achieved by management actions that reduce threats or otherwise enhance the environment for SRKW. We therefore examined how population growth would respond to reductions in the levels of current threats. To achieve the recovery goal by increasing Chinook abundance alone would require a return to nearly the highest rates of Chinook abundance observed since 1979 (Fig. 5). If eliminating acoustic disturbance while maintaining current levels of Chinook abundance were possible, annual population growth could reach 1.7%. Removal of PCBs from the habitat would result in marginally positive (0.3%) growth, but the effect is much smaller than the impact of reduced noise and disturbance or increased Chinook abundance. Complete removal of both acoustic disturbance and PCBs is predicted to result in 1.9% growth. Therefore, reaching the recovery target without increasing Chinook salmon



**Figure 4.** Mean population growth for SRKW achieved by improvements in demographic rates. Fecundity was increased from baseline to 1.5x baseline; mortality rates were decreased from baseline to 0.5x baseline. Dashed lines indicate a stated recovery target (2.3% growth) and  $r = 0$ .



**Figure 5.** Mean population growth for SRKW achieved by mitigation of anthropogenic threats. The eat reductions are scaled on the x-axis from no reduction to the maximum reductions tested: Chinook abundance increased up to 1.3x the long-term mean; noise disturbance during feeding was reduced from 85% to 0; and PCBs were reduced from accumulation rates of 2 ppm/y to 0. The top line shows growth rates under a combination of varying levels of improved Chinook abundance plus mitigation of noise to half the current level.

numbers is likely impossible. Reducing acoustic disturbance by 50% and simultaneously increasing Chinook by more than 1.15x would allow the population to reach the 2.3% growth target. Other combinations of mitigation should be explored by management authorities as conservation options are identified.

## Discussion

The SRKW population has experienced almost no population growth during the past four decades, and it declined in the last two decades. Intensive monitoring of the population since 1976 provides the information for construction of a detailed PVA model that closely replicates the observed population dynamics, and thereby provides a basis for projections under scenarios of increased anthropogenic threats or, conversely, increased mitigation actions. Models projecting population changes based on average demographic rates and fluctuations in those rates project that under the *status quo* the population will most likely remain near its current size. However, our use of baseline demographic rates averaged across 38 years of monitoring might give an overly optimistic projection for the SRKW if rates have deteriorated in recent years. A population projection based on demographic rates observed through 2011 projected a 1% annual mean growth<sup>25</sup>, but a recent Status Review<sup>12</sup> projects a decline of 0.65% per year if demographic rates (such as recently lower fecundity) remain as they have been during 2011–2016. If ongoing monitoring indicates that these are not just short-term fluctuations in rates, then assessments of current viability, vulnerability to new or increased threats, and measures needed to achieve recovery will need to be revised.

When examined over ranges that encompass plausible improvements, the demographic parameter that presents the better opportunity for a large benefit to population growth is fecundity, rather than mortality. This finding is similar to a study of two bottlenose dolphin (*Tursiops aduncus*) populations off Australia, which found that variability in reproduction was more important than variability in mortality in driving differences between the populations<sup>27</sup>. There is simply more potential for improving reproduction than for improving adult survival when survival is already close to 1. Even complete elimination of adult mortality in the SRKW (not a biological possibility) would result in a population growth rate of 1.8%, still below the recovery goal of 2.3% growth. Although recovery cannot be achieved solely by improving adult survival, any decline in adult survival caused by new or exacerbated threats could have serious consequences for the population.



The PVA was useful for exploring scenarios representing the three main anthropogenic threats – prey limitation, acoustic and physical disturbance, and PCBs – that might worsen with increased development, or could be mitigated through management. Across the ranges of threat levels that we examined, reduction of the prey base was the single factor projected to have the largest effect on depressing population size and possibly leading to extinction, although either higher levels of noise and disturbance or higher levels of PCB contamination are sufficient to push the population from slow positive growth into decline. If additional threats from proposed and approved shipping developments (such as catastrophic and chronic oil spills, ship strikes, and increased vessel noise) combine with the predicted decline of Chinook due to climate change<sup>28</sup>, then the population could decline by as much as 1.7% annually, have a 70% probability of declining to fewer than 30 animals, and have a 25% chance of complete extirpation within 100 years.

Mitigating multiple anthropogenic threats sufficiently to reach the recovery target will be difficult. The PVA is a useful way for managers to identify priorities for future research, and to focus conversations with ocean users and other special interests about the most pragmatic ways to promote recovery of endangered species. Those discussions must be integrated with considerations of feasibility, cost, societal impact, and timeframe for effective implementation. If a threat cannot be mitigated in a timescale relevant to conservation, or if costs are so high that they are prohibitive, thinking of those intractable problems as “fixed costs” in a cumulative impact management framework<sup>4</sup> might be useful. For example, our model results show that eliminating PCBs would provide less benefit to SRKWs than improving salmon returns or reducing anthropogenic noise and disturbance. This is fortuitous because imagining a way to eliminate PCBs that are persistent in the ecosystem is problematic<sup>29</sup>, even though levels in tissues of SRKWs have been slowly declining in recent decades<sup>30</sup>. Identifying fixed costs that are difficult or impossible to mitigate allows a practical discussion about how to rank recovery actions among the anthropogenic factors that can be managed.

Of the three threats we considered, across wide but plausible ranges of each, salmon abundance is the greatest factor affecting SRKW population dynamics. Previously reported correlations of demographic rates with Chinook abundance<sup>13,14,24</sup> were used to parameterize our model, and Wasser *et al.*<sup>31</sup> recently offered insights into a mechanism that could cause the effect on fecundity: hormone levels indicate that SRKWs experience nutritional stress related to periods of lower abundance of Chinook prey and that this stress results in fewer successful pregnancies. Our PVA model estimated that SRKW recovery cannot be achieved without reaching the highest levels of salmon abundance observed since 1979, which was 30% higher Chinook salmon abundance than the long-term average between 1979 and 2008. This model result allows managers to focus discussions on whether achieving such a high sustained level of salmon abundance is attainable, and if so, how to achieve it. For example, removal of a hydroelectric dam on the Elwha River in the state of Washington is expected to increase spawning habitat for all five wild Pacific salmon species in the Salish Sea, but discussions about dam removal began in the 1960s<sup>32</sup> and the cost was in the hundreds of millions of US dollars. Restoration of spawning and rearing habitat could improve growth and survival of wild, juvenile salmon, but this takes political will, time, and money<sup>33</sup>. Improvement of marine survival of juvenile salmon might be possible by better management of net-pen salmon aquaculture sites that host and amplify viruses and parasites that have the potential to reduce survival of wild salmon<sup>34,35</sup>. Reducing Chinook harvest could provide an interim and strategic opportunity to rebuild depressed wild Chinook salmon runs and increase the number of Chinook available to whales in terminal areas like the Salish Sea<sup>36</sup>. Harvest reductions without longer term rebuilding plans might be an incomplete measure in places where Chinook harvests are already low due to abundance concerns or other constraints<sup>37</sup>.

The SRKW population could be adversely affected by any new threats and further intensified impacts of the anthropogenic threats that we did assess. For example, pollutants other than PCBs might affect the population, and PCBs are known to have adverse effects beyond just reduced infant survival – such as reduced immune function<sup>38</sup>. However, other than calf survival, sufficient data are not yet available on the impacts of PCBs on demographic rates to allow incorporation of those threats in the population model. Moreover, threats to the population likely interact, perhaps in non-linear ways. For example, cetaceans that are food-limited might mobilize more lipids, and this will change the accumulated loads and harmful effects of PCBs and other organic pollutants. Similarly, reduction in foraging success because of boat noise might be of little consequence if prey is abundant, but could be critical if killer whales have difficulty procuring enough prey. If we can obtain data on additional threats and the interactions among threats, such effects could be included in the PVA models. At present, given that only estimates of approximate average effects of some threats are included in the model, inclusion of higher level interactions is premature.

While acknowledging that we examined only the identified primary threats to the SRKWs and that we cannot yet fully assess possible complex interactions among those threats, an important finding from our PVA is that reaching the recovery target will likely require mitigation of multiple threats. For example, the PVA projects that a 50% noise reduction plus a 15% increase in Chinook would allow the population to reach the 2.3% growth target. Noise is a particularly attractive issue to address in a management context, because it is amenable to several possible mitigation scenarios<sup>39,40</sup>. With respect to noise from commercial shipping, preliminary calculations suggest that the distribution of source levels of individual ships follows a power law, implying that quieting the noisiest ships will reduce overall noise levels by a disproportionate amount<sup>41</sup>. Identifying the noisiest ships operating in SRKW critical habitat<sup>42</sup> and creating incentives to reduce their noise outputs through speed restrictions and maintenance might generate considerable reductions in noise levels. The International Maritime Organization and the International Whaling Commission have urged nations to reduce the contribution of shipping to ocean ambient noise, with some countries adopting a pledge to reduce anthropogenic noise levels by 50% in the next decade<sup>43</sup>. However, from the perspective of a foraging killer whale that emits high-frequency (18–32 kHz) echolocation clicks to detect and capture salmon, high-frequency noise from small, outboard vessels that follow whales might cause a greater reduction in a killer whale’s foraging success than low-frequency (<1 kHz) background noise from commercial shipping<sup>44</sup>.

Clearly, even without new or increased external threats, the SRKW population has no scope to withstand additional pressures. The current situation for SRKWs gives little cause for optimism. This is likely to worsen, given the energy-related project proposals already approved for the region<sup>45</sup>, which will increase broadband ocean noise levels and the risk of ship strikes and oil spills<sup>46</sup>. Our models of the additional threats expected with a proposed increase in oil shipping show that these threats will push a fragile population into steady decline. Obviously, countering such additional threats sufficiently to achieve SRKW population recovery would require even more aggressive mitigation actions than if there were no such increasing threats to the population.

The case study we present offers an unusual opportunity to examine multiple anthropogenic threats in a wildlife population that is extremely data-rich by the standard of any marine ecology study<sup>5</sup>. One threat (the impact of prey abundance through the prey-demography link) has been well studied for decades. Another (acoustic disturbance) is relatively well appreciated in that there are documented relationships between higher noise level and reduction in foraging success. However, a conceptual step is required to convert the reduction in foraging to a reduction in prey acquisition. Full consideration of noise impacts would need to include complex interactions among reduced foraging time, reduced detection space, and reductions in prey availability. The third kind of threat (population consequences of PCBs and other persistent pollutants) relies on very few data points to calibrate the effect of the PCBs only on whale calf survival, which underestimates the total population consequences of contaminants in two ways. Lack of concentration-response studies on compounds other than PCBs hinder our ability to model population consequences of PBDEs or other contaminants. Similarly, existing studies do not allow us to predict effects of contaminants on pregnancy rate or adult mortality. This spectrum of data-rich to data-poor steps in predicting population consequences of multiple stressors is ubiquitous in conservation and ecological studies<sup>2,47</sup>. The funding to fill knowledge gaps with empirical data may be lacking, or in the case of critically endangered species, time to wait for science to fill data gaps may be insufficient<sup>48</sup>. Some authors use expert elicitation<sup>49,50</sup> to fill data gaps. Expert opinion or examination of hypothetical, but plausible scenarios should be used to augment rather than replace the available data.

The case study presented here illustrates the use of PVA as a method to inform difficult conservation decisions, by simulating across plausible ranges of uncertainty. For example, sensitivity analyses revealed that some factors (e.g., individual variability in breeding success) have no effect, and such knowledge gaps should not be a barrier to management action. Given our inability to manage some insidious threats, such as persistent organic pollutants that are already in the environment, it is reassuring that the model predicts that this stressor has the smallest adverse impact on the population, at least via the pathway of reduced calf survival. The PVA can focus priority research on questions that make a practical difference. Studies of foraging efficiency under varying levels of anthropogenic disturbance are needed only because the population is prey-limited. If doubling Chinook salmon numbers were possible, and returning them to levels seen in the 1920s<sup>51</sup>, consideration of other anthropogenic impacts on the whales' foraging efficiency might not be necessary. Alas, this is not a realistic scenario, and the model therefore points to the importance of including both improvement in prey abundance and reduction in noise as the more effective mitigation pathway.

Unfortunately, focus on only the immediate, tractable threats is all too common in conservation. For example, conservation of grizzly bears (*Ursus arctos horribilis*) in the continental United States focuses on roads and development activities, but the primary concern is that the species has been absent from most of its range since the 1800s<sup>52</sup>. Similarly, the current small size of the SRKW population was not caused by lack of salmon. The whales' depleted status is due in large part to the legacy of an unsustainable live-capture fishery for display in aquariums<sup>53</sup>. Salmon, noise, and contaminants are important factors that can prevent recovery. Many policies, including the US National Environmental Policy Act, require regulators to consider the effect of a proposed activity "which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR § 1508.7)." Allocating impacts among multiple ocean user sectors may be difficult, but in the case study we present, the population is sufficiently imperilled that it has little or no scope for tolerating additional stressors.

## Methods

The SRKW population is closed to immigration and emigration, every individual in the population is known, and the population has been censused annually for decades<sup>11</sup>. Individuals were identified by their unique fin shapes, saddle patches, and the presence of any nicks or scratches, and sexed using distinctive pigmentation patterns around the genital slits. Male and female offspring remain within the natal, matrilineal unit, although mating occurs within and between these pods. The term "resident" refers to their residency in inshore waters of southern British Columbia (Canada) and Washington state (USA) in the summer months, when they feed almost exclusively on Chinook salmon<sup>13,14,54,55</sup>. Given that there is no dispersal from the population<sup>56</sup>, mortality was recorded if an individual's matriline was observed in the population within a year but the individual did not appear.

We used values of demographic parameters calculated from the census data to build the population model in the Vortex PVA program<sup>17,18</sup>. We included temporal variation in demographic rates ("environmental variation"), based on inter-annual variability in parameters observed since 1976, and we included individual variation in age of maturity and probability of reproductive success. The Vortex simulation model of possible future population trajectories includes demographic stochasticity (binomial variation in individual fates); random assignment of sex and a bi-sexual mating system, resulting in fluctuations in sex ratio and mate availability that can affect small populations; and projections of loss of genetic diversity, allowing for inclusion of inbreeding depression. We quantified population growth as the mean exponential rate of increase ( $r = \ln[N_{t+1}/N_t]$ ).

Modelling was conducted in stages. First, a "Baseline" model was developed to represent the population trajectories if demographic rates remain the same as have been observed in recent decades. We confirmed this Baseline model by comparing simulated dynamics with recent population trends. Secondly, we conducted sensitivity tests on uncertain demographic rates in the model to determine which parameters had large effects on the projected



population growth. Thirdly, we used a set of models of Individual Threats that tested ranges of values for the primary threats identified in the recovery plans to determine which would have the greatest effects on population projections. Fourthly, we examined Cumulative Threats scenarios to project the fate of the population if further industrial development increases existing threats and adds new ones. A set of Demographic Management scenarios was then examined to determine the population growth that could be achieved by improvements in demographic rates. Finally, we explored Threat Management scenarios to assess the plausibility of reaching sustained annual population growth of 2.3% given various options for increasing salmon abundance, reducing ocean noise levels, or reducing contaminant levels. The following section describes key parameter estimates used in the model. More detailed description of the modelling methods is presented in Supplementary Information. The input files for the Vortex project are available at <http://www.vortex10.org/SRKW.zip> and from the Dryad Digital Repository at <https://doi.org/10.5061/dryad.46vq7>.

**Baseline PVA.** We started the simulations with the ages, sexes, and pod membership of the killer whales living in 2015. We specified the mother of each animal, where known (for 76 of 80 living animals)<sup>57</sup>. Based on previous genetic data on paternity<sup>58</sup>, we specified in the simulation that females would not mate with their father, a son, or a maternal half-sibling. What effect lower levels of inbreeding or the inevitable accumulated inbreeding in a closed population will have on any cetacean is unknown. We modelled inbreeding depression as being caused by recessive lethal alleles, with 6.29 “lethal equivalents” (the negative of the slope of log(recruitment) against the inbreeding coefficient), the mean combined effect of inbreeding on fecundity and first-year survival in a survey of impacts on wild species<sup>59</sup>.

Demographic rates were calculated from individual animal histories compiled by the Center for Whale Research<sup>57</sup>, using data collected from 1976 through 2014. The time series begins when the population was depleted by live-captures for display in aquariums<sup>60</sup>. The time series therefore includes periods of moderate population growth (1976 to 1993), subsequent decline, and approximate stability. Demographic rates were estimated for the age-class groupings used in recent models<sup>24,61</sup>, except that we set an upper limit for female breeding at 45 y rather than 50 y, because no females in the population have been documented to produce calves at older ages. Thus, we calculated survival and (for adult females) fecundity rates for calves (first year), juveniles (defined as from 1 y through 9 y of age), young mature females (10–30 y), older reproductive females (31–45 y), post-reproductive females (46 y and older), young mature males (10–21 y), and older males (22 y and older). Killer whales can survive many years after reproductive senescence, but estimating maximum longevity is difficult in such a long-lived species<sup>62</sup>. We set an upper limit of age to 90 y in our models, although only about 2% of females would be expected to reach this age, and only about 2% of males (with higher mortality) would be expected to exceed 50 y. Females stop breeding long before the maximum age, so the long-term population growth would not be affected by the upper age limit unless post-reproductive females benefit the pod in ways other than through their own reproduction.

Mortality for each age-sex class was averaged across the 39 years of data to obtain mean annual rates. We did not try to partition observed mortality into presumed causes of death. The use of these historic data for our Baseline model makes the implicit assumption that the frequency of deaths due to the various causes remains the same as has been observed across recent decades. The variation in mortality observed across years has two components: 1) environmental variation (fluctuations in the probability of survival), and 2) demographic stochasticity (binomial variation in individual fates). To determine how much of the observed variation was due to environmental variation, the variance due to demographic stochasticity can be calculated from the expectation for a binomial process, and then subtracted from the total variation across years. Calculated annual mortality rates (and environmental variation) ranged from a low of 0.97% (SD = 0) for young adult females to 17.48% (SD = 17.96) for calves. Although the lack of evidence for annual variation in the mortality adult females beyond that expected from random sampling of a constant probability might seem optimistic, for long-lived species a low level of annual variation in rates would have negligible effect on long-term population trajectories. We confirmed through sensitivity tests (Supplementary Information) that the environmental variation entered into the population model has no effect on our results.

The breeding system is polygamous, with some males able to obtain multiple mates, females mating with different males over their lifetimes, and mating between and within pods. Males become sexually mature (actively breeding, which may occur several years after they are physiologically capable of breeding) from 12 to 18 y of age. Thus, in the model, each male was assigned an age of sexual maturity by randomly selecting a value from 12 to 18. Variance in reproductive success among individual females and males will cause genetic diversity to be depleted faster and inbreeding to accumulate faster than would occur if mating was assumed random. Information is available on male mating success<sup>51</sup>, and we incorporated variation in male and female reproductive success in the model (Supplementary Information). Our models project an effective population size that is 37% of the total size, close to an estimate obtained from genetic data<sup>58</sup>.

Breeding rates, expressed as the proportion of the females of an age class that produce a calf each year, were calculated from annual census data. Rates ranged from 0% for post-reproductive females (age >45 y), to 7.88% (SD = 4.15) for older adult females (age 31–45 y), to 12.04% (SD = 3.54) for young adult females (age 10–30 y).

The upper limit on population size was set to 300, so that carrying capacity (K) would not restrict future population growth except under the best conditions tested. In the projections of current or expected conditions, the SRKW populations never reached this limiting size, and rarely exceeded 150 animals in any of the independent iterations of each simulation. Population recovery was assessed by the mean growth rate each year calculated before any carrying capacity truncation. Thus, the growth rate reflects the demographic potential and is not affected by the limit on population size in the model.

The SRKW population was projected for 100 years. For the initial exploration of parameter uncertainty, the simulation was repeated in 10,000 independent iterations to obtain high precision in mean and variance estimations. For comparisons among alternative management scenarios, less iteration is needed to obtain the relative influence of input values, and tests were run with 1,000 iterations. Sensitivity tests were conducted by varying each basic demographic rate (life table values for fecundity and mortality) over a range of  $\pm 10\%$  around the baseline value. For several model variables that describe other aspects of the population dynamics and are also very uncertain, a wider range of values was tested (see Supplementary Information).

**Individual Threats.** We explored the effects of three threats identified in the recovery strategies. For each of prey abundance, noise disturbance, and PCB contaminants, we scaled impacts such that the estimated current level of the threat resulted in the mean demographic rates reported over recent decades. Effects of prey limitation were modelled using published relationships linking inter-annual variability in Chinook salmon to inter-annual variability in calf and adult mortality<sup>63</sup> and fecundity<sup>13,61</sup>. A prey index was calculated by dividing the total salmon abundance in each year by its average abundance over the 1979–2008 period<sup>63</sup>. The relationship of mortality to prey abundance was modelled with a multiplier of baseline mortality that is a linear function scaled to 1 when salmon abundance was at the mean observed level over period of observation:  $\text{MortalityFactor} = 3.0412 - 2.0412 * \text{PreyIndex}$ . The relationship of birth rate to prey was modelled with logistic functions, with the intercept scaled to yield the observed birth rates for young females (12.04%) and older females (7.88%) when  $\text{PreyIndex} = 1$ . For relationships of form  $\text{BirthRate} = \exp(A + B * \text{PreyIndex}) / [1 + \exp(A + B * \text{PreyIndex})]$ , the function parameters were  $A = -3.0$  and  $B = 1.0$  for young females, and  $A = -3.46$  and  $B = 1.0$  for older females. (See Supplementary Information for more details on these relationships.) To explore the impacts of prey abundance across a range of plausible values, we varied the prey index from approximately the lowest level (0.60) reported since 1978 to approximately the highest level (1.30).

Effects of noise on demography were modelled using the approach outlined in previous analyses of loss of acoustic communication space<sup>4,64</sup>. We used summertime observations to estimate the proportion of time boats were present (during daylight hours) while the whales were foraging and the reduction in foraging expected with that amount of acoustic disturbance. We calibrated the model of noise impacts so that the mean Baseline demographic rates are obtained at the reported level of disturbance. We then simulated the relative change in foraging time and consequently demographic rates across the spectrum from no noise impact at all, to the upper limit expected if boat disturbance increased from current, already high, levels to 100% of time. We do not have data on the amount of acoustic disturbance in the winter feeding areas, but the modelling based on observed summertime disturbance provides a means to project a range of population consequences if changes in disturbance overall mirror those that are possible in the summertime habitat. Land-based observations have shown that SRKWs reduce their time spent feeding in the presence of boats by 25%<sup>65</sup>. Vessels are present 85% of the daytime, and SRKWs are foraging in the presence of vessels an estimated 78% of that time. Thus, for the 85% current (baseline) exposure to vessels, feeding is expected to be reduced by 16.6% ( $= 85\% \times 78\% \times 25\%$ ) due to disturbance by boats. To translate the reduction in feeding into its demographic consequences, we multiplied the prey index by a factor of  $(1 - 0.195 * \text{Noise}) / (1 - 0.166)$  to obtain the proportional availability of prey. This proportion is thus 1 in the current, baseline conditions ( $\text{Noise} = 0.85$ ), 0.965 when vessels are always present ( $\text{Noise} = 1.00$ ), and 1.20 assuming no disturbance from vessels. The noise-modified index of prey availability was then used to determine the consequent mortality and fecundity rates. We recognize that anthropogenic noise can also have less direct effects on wildlife, including disruption of social behaviours and even impeding responsiveness to other sensory modalities<sup>66</sup>.

Our model of accumulation, depuration, and impact on calf survival of PCBs was based on the approach described by Hall *et al.*<sup>67,68</sup> with modifications in rates for SRKW<sup>69</sup>. Calves obtain their initial load of contaminants from their dams through gestation and lactation, and females producing calves thereby depurate an estimated 77% of their contaminants<sup>67</sup>. Otherwise, males and non-breeding females accumulate PCBs in the blubber of at a rate that we varied from 0 to 5 ppm/y in our tests. Few data are available on PCBs in the SRKW population with which to calibrate the model of PCB bioaccumulation, and the levels of PCBs reported in SRKW might have been dropping slowly in recent years. Reported levels in adult female SRKW range from  $55 \pm 19$  ppm sampled in 1993–1996,  $37 \pm 42$  ppm sampled in 2004–2007, and  $30 \pm 31$  ppm sampled in 2008–2013<sup>30</sup>. Our population model generates a mean 28, 55, and 81 ppm PCBs in adult females when bioaccumulation rate is 1, 2, and 3 ppm/y, respectively. Effects of maternal PCB load on calf mortality were modelled using a logistic response function ( $\text{survival} = \exp(2.65 - 0.02 * \text{PCB}) / [1 + \exp(2.65 - 0.02 * \text{PCB})]$ ), fitted to the two observed data points for SRKW ( $\text{survival} = 0.8252$ ) and the nearby northern resident killer whales ( $\text{survival} = 0.9218$ )<sup>24</sup>, with the mean PCB levels (55.4 ppm and 9.3 ppm, respectively)<sup>70</sup> reported from the time period in the middle of the span over which mortality rates were calculated. If we use the more recent, lower estimates of PCB loads in SRKW to estimate the impacts, our response function would have a steeper slope. There are not yet sufficient data on effects of PCBs on other demographic rates to allow inclusion of any other effects of PCBs (or other contaminants) in our PVA model.

**Cumulative Threats.** We modelled two scenarios to represent the cumulative impacts of possible increases in threats, based in part on a recent environmental impact assessment submitted to Canada National Energy Board<sup>45</sup> evaluating effects of a proposed oil pipeline and associated tanker traffic. For the purposes of this PVA, projected increases in anthropogenic threats are not meant to mimic any one industrial development, but rather a general process of industrialization reflecting the number of port expansions, pipeline proposals, and liquefied natural gas terminal proposals pending for the BC coast<sup>4</sup>. For a low level scenario, we used the catastrophe option in Vortex to add the possibility of large ( $>16,500 \text{ m}^3$ ) and smaller ( $>8,250 \text{ m}^3$ ) oil spills. The frequencies of a big spill (0.21% chance per year) and a smaller spill (1.08%) were based on an industry projection of the likelihood of

such spills caused by proposed increase in tanker traffic<sup>71</sup>. Based on the percent overlap of oil coverage and critical habitat, we estimate that if a large oil spill were to occur, about 50% of the SRKWs would be killed due to direct exposure to the oil. We estimate that 12.5% of the SRKWs would be killed by exposure to oil from a smaller spill. For a scenario with higher level impacts of development, we doubled the frequency of oil spills.

These energy development scenarios also included an increase in vessel noise and disturbance of feeding, with the current vessel presence of 85% of time increased to 92.5% in the low level scenario and to 100% in the high level scenario. We also included a probability of additional deaths of killer whales due to ship strikes, with one death per decade in the low level and two deaths per decade in the high level scenario. Although some persistent organic pollutants might increase under increased industrial activity in the SRKW habitat, PCBs have been phased out of production and are in decline in at least some fish species in low-development basins<sup>72</sup>. Lacking data on likely long-term trends in the contaminant loads of SRKW prey, we did not include any change in such pollutants in these scenarios.

Climate change is projected to cause a decline in Chinook abundance<sup>28</sup>, and we modelled this possibility with a projected 25% (low scenario) or 50% (high scenario) decrease in Chinook over the next 100 years.

**Demographic Management and Threat Management scenarios.** We used the PVA to simulate how much improvement in demographic parameters or how much reduction in anthropogenic threats, singly or in combination, would be required to reach a stated recovery objective of sustained annual population growth of 2.3% for 28 years<sup>41</sup>. In calculating the growth for these models, we started the tally 20 years into the simulation to avoid short-term demographic fluctuations as the age structure adjusts to new demographic rates, and growth was tallied over the subsequent 28 years. For the set of Demographic Management scenarios, we assessed the relationship between improved demography and population growth. Birth rate was incremented by 1.1x, 1.2x, 1.3x, 1.4x, and 1.5x, whereas calf mortality and adult mortality were decreased by 0.9x, 0.8x, 0.7x, 0.6x, and 0.5x. Next, in Threat Management scenarios, we modelled the effects of reduced threats, with the consequences resulting from the functional relationships to demography. We increased salmon abundance (up to the highest level of the Chinook index observed between 1979 and 2008, namely 1.3 times the long-term average). We simulated the improved demography if acoustic disturbance were reduced or eliminated. We considered the population consequences of improved calf survival resulting from reduction of PCBs, testing rates of future accumulation in SRKW from the estimated current 2 ppm/y to down to 0 ppm/y. Finally, we tested scenarios that both reduced acoustic disturbance by half and increased salmon abundance up to 1.3x.

## References

1. Wright, A. J. & Kyhn, L. A. Practical management of cumulative anthropogenic impacts with working marine examples. *Conserv. Biol.* **29**, 333–340 (2014).
2. Côté, I. M., Darling, E. S. & Brown, C. J. Interactions among ecosystem stressors and their importance in conservation. *Proc. Biol. Sci.* **283**, 20152592, <https://doi.org/10.1098/rspb.2015.2592> (2016).
3. National Academy of Sciences. *Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals* (The National Academies Press, Washington, DC, 2016) <https://doi.org/10.17226/23479>.
4. Williams, R., Thomas, L., Ashe, E., Clark, C. W. & Hammond, P. S. Gauging allowable harm limits to cumulative, sub-lethal effects of human activities on wildlife: A case-study approach using two whale populations. *Mar. Policy* **70**, 58–64 (2016).
5. Maxwell, S. M. *et al.* Cumulative human impacts on marine predators. *Nat. Commun.* **4**, 2688, <https://doi.org/10.1038/ncomms3688> (2013).
6. Lacy, R. C. *et al.* Metamodels for transdisciplinary analysis of population dynamics. *PLoS ONE* **8**, e84211, <https://doi.org/10.1371/journal.pone.0084211> (2013).
7. Agardy, T., Di Sciara, G. N. & Christie, P. Mind the gap: addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Mar. Policy* **35**, 226–232 (2011).
8. Boyce, M. S. Population viability analysis. *Annu. Rev. Ecol. Syst.* **23**, 481–506 (1992).
9. Reynolds, J. E. III, Marsh, H. & Ragen, T. J. Marine mammal conservation. *Endang. Species Res.* **7**, 23–28 (2009).
10. Fisheries and Oceans Canada. *Action Plan for the Northern and Southern Resident Killer Whale (Orcinus orca) in Canada*. Species at Risk Act Action Plan Series. (Fisheries and Oceans Canada, Ottawa, 2017).
11. National Marine Fisheries Service. *Recovery Plan for Southern Resident Killer Whales (Orcinus orca)* (National Marine Fisheries Service Northwest Region, Seattle, 2008).
12. National Marine Fisheries Service. *Southern Resident Killer Whales (Orcinus orca) 5-Year Review: Summary and Evaluation*. (National Marine Fisheries Service West Coast Region, Seattle, 2016) [http://www.westcoast.fisheries.noaa.gov/publications/status\\_reviews/marine\\_mammals/kw-review-2016.pdf](http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/marine_mammals/kw-review-2016.pdf).
13. Ward, E. J., Holmes, E. E. & Balcomb, K. C. Quantifying the effects of prey abundance on killer whale reproduction. *J. Appl. Ecol.* **46**, 632–640 (2009).
14. Ford, J. K. B., Ellis, G. M., Olesiuk, P. F. & Balcomb, K. C. Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator? *Biol. Lett.* **6**, 139–142 (2010).
15. Shaffer, M. L. Population viability analysis. *Conserv. Biol.* **4**, 39–40 (1990).
16. Beissinger, S.R. & McCullough, D.R. (eds). *Population Viability Analysis* (University of Chicago Press, Chicago, 2002).
17. Lacy, R. C. Structure of the VORTEX simulation model for population viability analysis. *Ecol. Bull.* **48**, 191–203 (2000).
18. Lacy, R.C. & Pollak, J.P. *Vortex: A Stochastic Simulation of the Extinction Process*. Version 10.0. (Chicago Zoological Society, Brookfield, Illinois, 2014) [www.vortex10.org/Vortex10.aspx](http://www.vortex10.org/Vortex10.aspx).
19. Lacy, R.C., Miller, P.S. & Traylor-Holzer, K. *Vortex10 User's Manual* (IUCN SSC Conservation Breeding Specialist Group, and Chicago Zoological Society, Apple Valley, Minnesota, 2014).
20. Carroll, C., Fredrickson, R. J. & Lacy, R. C. Developing metapopulation connectivity criteria from genetic and habitat data to recover the endangered Mexican wolf. *Conserv. Biol.* **28**, 76–86 (2014).
21. Maehr, D.S., Lacy, R.C., Land, E.D., Bass, O.L. Jr. & Hootor, T.S. Evolution of population viability assessments for the Florida panther: a multiperspective approach. In *Population Viability Analysis* (eds. Beissinger, S. R. & McCullough, D.R.) 284–311 (University of Chicago Press, Chicago, 2002).
22. Marmontel, M., Humphrey, S. R. & O'Shea, T. J. Population viability analysis of the Florida manatee (*Trichechus manatus latirostris*), 1976–1991. *Conserv. Biol.* **11**, 467–481 (1997).

23. Krahn, M.M. *et al.* 2004 Status review of Southern Resident killer whales (*Orcinus orca*) under the Endangered Species Act. NOAA Tech. Memo. NMFSNWFC-62 (U.S. Dept. Commerce, Washington, DC, 2013) [https://www.nwfsc.noaa.gov/assets/25/6377\\_02102005\\_172234\\_krahnstatusrevtm62fi\\_al.pdf](https://www.nwfsc.noaa.gov/assets/25/6377_02102005_172234_krahnstatusrevtm62fi_al.pdf).
24. Vélez-Espino, L. A. *et al.* Comparative demography and viability of northeastern Pacific resident killer whale populations at risk. *Canadian Technical Report of Fisheries and Aquatic Sciences* **2014**, 3084 (2014).
25. Ward, E.J. *et al.* Estimating the impacts of Chinook salmon abundance and prey removal by ocean fishing on Southern Resident killer whale population dynamics. NOAA Tech. Memo. NMFS-NWFSC-123. (U.S. Dept. Commerce, Washington, DC, [https://www.nwfsc.noaa.gov/assets/25/4647\\_08132013\\_113012\\_ImpactsOnSRKW'sTM123WebFinal.pdf](https://www.nwfsc.noaa.gov/assets/25/4647_08132013_113012_ImpactsOnSRKW'sTM123WebFinal.pdf) 2013).
26. Prowse, T. A. A. *et al.* An efficient protocol for the sensitivity analysis of complex ecological models. *Ecosphere* **7**, e01238, <https://doi.org/10.1002/ecs2.1238> (2016).
27. Manlik, O. *et al.* The relative importance of reproduction and survival for the conservation of two dolphin populations. *Ecol. Evol.* **6**, 3496–3512 (2016).
28. Muñoz, N. J., Farrell, A. P., Heath, J. W. & Neff, B. N. Adaptive potential of a Pacific salmon challenged by climate change. *Nat. Clim. Change* **5**, 163–166 (2014).
29. Hickie, B. E., Ross, P. S., Macdonald, R. W. & Ford, J. K. B. Killer whales (*Orcinus orca*) face protracted health risks associated with lifetime exposure to PCBs. *Environ. Sci. Technol.* **41**, 6613–6619 (2007).
30. Mongillo, T.M. *et al.* Exposure to a Mixture of Toxic Chemicals: Implications for the Health of Endangered Southern Resident Killer Whales. NOAA Tech. Memo. NMFS-NWFSC-135 (U.S. Dept. Commerce, Washington, DC, 2016) <https://doi.org/10.7289/V5/TM-NWFSC-135>.
31. Wasser, S. K. *et al.* Population growth is limited by nutritional impacts on pregnancy success in endangered Southern Resident killer whales (*Orcinus orca*). *PLoS ONE* **12**, e0179824 (2017).
32. Witze, A. Let the river run: Removing two dams from the Elwha is a can't-miss restoration experiment. *Science News* **187**, 22–26 (2015).
33. Sommer, T. R., Nobriga, M. L., Harrell, W. C., Batham, W. & Kimmerer, W. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. *Can. J. Fish. Aquat. Sci.* **58**, 325–333 (2001).
34. Krkošek, M. *et al.* Declining wild salmon populations in relation to parasites from farm salmon. *Science* **318**, 1772–1775 (2007).
35. Miller, K. M. *et al.* Genomic signatures predict migration and spawning failure in wild Canadian salmon. *Science* **331**, 214–217 (2011).
36. Williams, R. *et al.* Competing conservation objectives for predators and prey: estimating killer whale prey requirements for Chinook salmon. *PLoS ONE* **6**, e26738, <https://doi.org/10.1371/journal.pone.0026738> (2011).
37. Hilborn, R. *et al.* The Effects of Salmon Fisheries on Southern Resident Killer Whales: Final Report of the Independent Science Panel (ESSA Technologies, Vancouver, BC, 2012).
38. Desforges, J.-P. W. *et al.* Immunotoxic effects of environmental pollutants in marine mammals. *Environment International* **86**, 126–139 (2016).
39. Williams, R., Erbe, C., Ashe, E., Beerman, A. S. & Smith, J. C. Severity of killer whale behavioral responses to ship noise: A dose-response study. *Mar. Pollut. Bull.* **79**, 254–60 (2014).
40. Williams, R., Erbe, C., Ashe, E. & Clark, C. W. Quiet(er) marine protected areas. *Mar. Pollut. Bull.* **100**, 154–161 (2015).
41. Leaper, R. & Renilson, M.R. A review of practical methods for reducing underwater noise pollution from large commercial vessels. *Trans. RINA* **154** (A2) (2012).
42. Veirs, S., Veirs, V. & Wood, J. D. Ship noise in an urban estuary extends to frequencies used for echolocation by endangered killer whales. *PeerJ* **4**, e1657, <https://doi.org/10.7717/peerj.1657> (2016).
43. Malakoff, D. A push for quieter ships. *Science* **328**, 1502–1503 (2010).
44. Silber, G. K., Vanderlaan, A. S. M., Arceredillo, A. T. & Johnson, L. L. The role of the International Maritime Organization in reducing vessel threat to whales: process, options, action and effectiveness. *Mar. Policy* **36**, 1221–1233 (2012).
45. Canada National Energy Board. *National Energy Board Report. Trans Mountain Expansion Project* (National Energy Board, Calgary, Alberta.). [https://docs.neb-one.gc.ca/ll-eng/llisapi.dll/2969681/National\\_Energy\\_Board\\_Report\\_-\\_OH-001-2014\\_-\\_A5A9H1.pdf](https://docs.neb-one.gc.ca/ll-eng/llisapi.dll/2969681/National_Energy_Board_Report_-_OH-001-2014_-_A5A9H1.pdf) 2016
46. Gaydos, J. K., Thixon, S. & Donatuto, J. Evaluating threats in multinational marine ecosystems: a Coast Salish First Nations and tribal perspective. *PLoS ONE* **10**, e0144861, <https://doi.org/10.1371/journal.pone.0144861> (2015).
47. King, S. L., Schick, R. S. & Donovan, C. An interim framework for assessing the population consequences of disturbance. *Method. Ecol. Evol.* **6**, 1150–1158 (2015).
48. González-Suárez, M., Lucas, P. M. & Revilla, E. Biases in comparative analyses of extinction risk: mind the gap. *J. Anim. Ecol.* **81**, 1211–1222 (2012).
49. Donlan, C., Wingfield, D. K., Crowder, L. B. & Wilcox, C. Using expert opinion surveys to rank threats to endangered species: a case study with sea turtles. *Conserv. Biol.* **24**, 1586–1595 (2010).
50. Teck, S. J., Halpern, B. S. & Kappel, C. V. Using expert judgment to estimate marine ecosystem vulnerability in the California Current. *Ecol. Appl.* **20**, 1402–1416 (2010).
51. Irvine, J. R. & Fukuwaka, M. A. Pacific salmon abundance trends and climate change. *ICES J. Mar. Sci.* **68**, 1122–1130 (2011).
52. Noss, R. F., Quigley, H. B., Hornocker, M. G., Merrill, T. & Paquet, P. C. Conservation biology and carnivore conservation in the Rocky Mountains. *Conserv. Biol.* **10**, 949–963 (1996).
53. Bigg, M. A. & Wolman, A. A. Live-capture killer whale (*Orcinus orca*) fishery, British Columbia and Washington, 1962–73. *J. Fish. Res. Board Can.* **32**, 1213–1221 (1975).
54. Hanson, M. B. *et al.* Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. *Endang. Species Res.* **11**, 69–82 (2010).
55. Ford, M. J. *et al.* Estimation of a killer whale (*Orcinus orca*) population's diet using sequencing analysis of DNA from feces. *PLoS ONE* **11**, e0144956, <https://doi.org/10.1371/journal.pone.0144956> (2016).
56. Olesiuk, P. F., Bigg, M. A. & Ellis, G. M. Life history and population dynamics of resident killer whales (*Orcinus orca*) in coastal waters of British Columbia and Washington State. *Rep. Int. Whal. Comm.* **12**, 209–243 (1990).
57. Center for Whale Research. *Southern Resident Orca Survey. Review Copy. 20150320 update.* (Center for Whale Research, Friday Harbor, Washington, 2015).
58. Ford, M. J. *et al.* Inferred paternity and male reproductive success in a killer whale (*Orcinus orca*) population. *J. Hered.* **102**, 537–553 (2011).
59. O'Grady, J. J. *et al.* Realistic levels of inbreeding depression strongly affect extinction risk in wild populations. *Biol. Conserv.* **133**, 42–51 (2006).
60. Williams, R. & Lusseau, D. A killer whale social network is vulnerable to targeted removals. *Biol. Lett.* **2**, 497–500 (2006).
61. Vélez-Espino, L. A. *et al.* Relative importance of Chinook salmon abundance on resident killer whale population growth and viability. *Aquat. Conserv.* **25**, 756–780 (2015).
62. Ward, E. J., Parsons, K., Holmes, E. E., Balcomb, K. C. I. I. I. & Ford, J. K. B. The role of menopause and reproductive senescence in a long-lived social mammal. *Front. Zool.* **6**, 4, <https://doi.org/10.1186/1742-9994-6-4> (2009).
63. Ford, J.K.B., Wright, B.M., Ellis, G.M., & Candy, J.R. Chinook Salmon Predation by Resident Killer Whales: Seasonal and Regional Selectivity, Stock Identity of Prey, and Consumption Rates. (Fisheries and Oceans Canada, Nanaimo BC, 2009).



64. Williams, R., Clark, C. W., Ponirakis, D. & Ashe, E. Acoustic quality of critical habitats for three threatened whale populations. *Anim. Conserv.* **17**, 174–185 (2014).
65. Lusseau, D., Bain, D. E., Williams, R. & Smith, J. C. Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*. *Endang. Species Res.* **6**, 211–221 (2009).
66. Morris-Drake, A., Kern, J. M. & Radford, A. N. Cross-modal impacts of anthropogenic noise on information use. *Curr. Biol.* **26**, 2697–2840 (2016).
67. Hall, A. J. *et al.* Population consequences of polychlorinated biphenyl exposure in bottlenose dolphins – an individual based model approach. *Environ. Health Perspect.* **114**(Suppl. 1), 60–64 (2006).
68. Hall, A. J. *et al.* Assessing the population consequences of pollutant exposure to cetaceans using an individual based modelling framework. Tech. Rep. of International Whaling Commission, Tromsø, Norway, SC63–E5 (2011).
69. Hall, A. J. & Williams, R. The potential effect of PCBs on Killer whales – using the ‘SPOC’ individual based pollution model approach to estimate impacts on population growth. IWC SC meeting document SC/66a/E/2 (2015).
70. Ross, P. S., Ellis, G. M. & Ikonomou, M. G. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: Effects of age, sex and dietary preference. *Mar. Pollut. Bull.* **40**, 504–515 (2000).
71. Det Norske Veritas (USA). *Termopol 3.15 – General Risk Analysis and Intended Methods of Reducing Risks. Trans Mountain Expansion Project.* <https://apps.neb-one.gc.ca/REGDOCS/File/Download/2393696> and <https://apps.neb-one.gc.ca/REGDOCS/File/Download/2393360> (2013).
72. West, J. E., O’Neill, S. M. & Ylitalo, G. M. Time trends of persistent organic pollutants in benthic and pelagic indicator fishes from Puget Sound, Washington, USA. *Arch. Environ. Contam. Toxicol.* **73**, 207–229 (2017).

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## Author Contributions

P.P. coordinated the project. K.C.B. and D.A.G. provide the core census and demographic database. R.W., E.A., L.J.N.B., C.W.C., D.P.C., P.P., and M.M. provided data on threats. R.C.L. built the population model and conducted the simulations. R.W., R.C.L. and P.P. led the writing. All authors contributed to and reviewed the manuscript.

## Additional Information

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# TAB T



# Assessing Cumulative Environmental Effects under the Canadian Environmental Assessment Act, 2012

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## Interim Technical Guidance

March 2018

Version 2

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## Document Information

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## Updates

This document may be reviewed and updated periodically. To ensure that you have the most up-to-date version, please consult the [Policy and Guidance page](#) of the Canadian Environmental Assessment Agency's website.

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This document is also available in Adobe's [Portable Document Format \(1.9 MB \(megabytes\)\)](#).

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# List of Abbreviations and Acronyms

## **ATK (Aboriginal Traditional Knowledge)**

Aboriginal Traditional Knowledge

## **Agency**

The Canadian Environmental Assessment Agency

## **CEAA (Canadian Environmental Assessment Act) 2012**

Canadian Environmental Assessment Act, 2012

## **EA (environmental assessment)**

Environmental Assessment

## **EIS (environmental impact statement)**

Environmental Impact Statement

## **GIS**

Geographic Information System

## **OPS**

Operational Policy Statement

## **Project**

A designated project under CEAA (Canadian Environmental Assessment Act) 2012 for which the Agency is the responsible authority

## **Project EA (environmental assessment)**

EA (environmental assessment) of designated projects conducted under CEAA (Canadian Environmental Assessment Act) 2012 for which the Agency is the responsible authority

## **TLU**

Traditional Land Use

## **VC (Valued Component)**

Valued Component

## **ZOI**

# Introduction

## Context

The Canadian Environmental Assessment Act, 2012 (CEAA (Canadian Environmental Assessment Act) 2012) aims to protect components of the environment that are within federal legislative authority from significant adverse environmental effects caused by a project, including cumulative environmental effects.

In addition, CEAA (Canadian Environmental Assessment Act) 2012 ensures that a project is considered in a careful and precautionary manner to avoid significant adverse environmental effects, when the exercise of a power or performance of a duty or function by a federal authority under any Act of Parliament, other than CEAA (Canadian Environmental Assessment Act) 2012, is required for the project to be carried out.

CEAA (Canadian Environmental Assessment Act) 2012 requires that each environmental assessment (EA (environmental assessment)) of a project take into account any cumulative environmental effects that are likely to result from the project in combination with the environmental effects of other physical activities that have been or will be carried out.

Throughout the guidance, the term “environmental effects” refers to environmental effects as described in section 5 of CEAA (Canadian Environmental Assessment Act) 2012 (see description and examples below). In addition, the term “cumulative effects” refers to cumulative environmental effects as mentioned in paragraph 19(1)(a) of CEAA (Canadian Environmental Assessment Act) 2012.

Under CEAA (Canadian Environmental Assessment Act) 2012, the “environmental effects” to be considered are those in areas of federal jurisdiction as described in section 5, which include:

1. effects on fish and fish habitat, shellfish and their habitat, crustaceans and their habitat, marine animals and their habitat, marine plants, and migratory birds;
2. effects on federal lands;
3. effects that cross provincial or international boundaries;
4. with respect to Aboriginal peoples, effects of any changes to the environment on health and socio-economic conditions, physical and cultural heritage, the current use of lands and resources for traditional purposes, or any structure, site or thing that is of historical, archaeological, paleontological or architectural significance;
5. changes to the environment that might result from federal decisions as well as any associated effects on health and socio-economic conditions, matters of historical, archaeological, paleontological or architectural interest, or other matters of physical or cultural heritage.

**Examples of cumulative effects:**

**Fish & Fish Habitat:** destruction of habitat of the same fish population from multiple physical activities.

**Aquatic Species:** shoreline destruction from multiple physical activities resulting in the removal of several patches of a marine plant.

**Socio-Economic Conditions:** environmental effects from multiple physical activities resulting in the decline of a bivalve population on which an Indigenous group depends as a source of income.

**Physical and Cultural Heritage:** damage caused to sites associated with the creation of legends, ceremonial functions, personal vision quests etc. as a result of multiple physical activities.

**Current Use of Lands and Resources:** effects on use of traditional fishing grounds owing to decreased fish population which results from multiple physical activities.

**Archaeology:** disturbance of an archaeologically significant site due to construction activities associated with multiple physical activities.

Please refer to Basics of Environmental Assessment and the Practitioners Glossary for Environmental Assessment of Designated Projects under the Canadian Environmental Assessment Act, 2012 for additional information on the EA (environmental assessment) process and key terms under CEAA (Canadian Environmental Assessment Act) 2012.

## Purpose

The Operational Policy Statement on Assessing Cumulative Environmental Effects under CEAA (Canadian Environmental Assessment Act) 2012 (OPS) clarifies CEAA (Canadian Environmental Assessment Act) 2012 requirements related to cumulative effects and provides core guidance to ensure that these requirements are met in project EAs where the Agency is the responsible authority, and when the EA (environmental assessment) is conducted by a review panel.

This technical guidance document provides methodological options and considerations to support the implementation of CEAA (Canadian Environmental Assessment Act) 2012 and the approach outlined in the OPS in a way that achieves high quality EA (environmental assessment).

This document informs the preparation of directives by the Agency, such as the Environmental Impact Statement (EIS (environmental impact statement)) Guidelines, and supports proponents in the development of an EIS (environmental impact statement). It also provides guidance to Agency employees in their interactions with those engaged in federal EA (environmental assessment), such as proponents, federal authorities, other jurisdictions, Indigenous groups, and the public.

## Application

This technical guidance informs the assessment of cumulative effects undertaken as part of the EA (environmental assessment) of designated projects conducted under CEAA (Canadian Environmental Assessment Act) 2012 for which the Agency is the responsible authority. CEAA (Canadian Environmental Assessment Act) 2012 requires that an EA (environmental assessment) of a designated project take into consideration any cumulative environmental effects, which includes greenhouse gas (GHG) emissions associated with projects. This technical guidance does not apply to the assessment of cumulative effects of GHG emissions. Methodological approaches and considerations for cumulative effects assessment of GHG emissions continue to evolve. EA (environmental assessment) practitioners seeking direction on the cumulative effects assessment of GHGs under CEAA (Canadian Environmental Assessment Act) 2012 are encouraged to contact the nearest Agency regional office.

In this document, the term “project” refers to designated projects conducted under CEAA (Canadian Environmental Assessment Act) 2012 for which the Agency is the responsible authority, and “project EA (environmental assessment)” refers to the EA (environmental assessment) of designated projects conducted under CEAA (Canadian Environmental Assessment Act) 2012 for which the Agency is the responsible authority

For such a project EA (environmental assessment), this technical guidance replaces the 1999 guide entitled “Cumulative Effects Assessment Practitioners Guide”. The 1999 guide will continue to apply for EAs initiated under the former Canadian Environmental Assessment Act that are still being conducted pursuant to the transitional provisions of CEAA (Canadian Environmental Assessment Act) 2012.

When the National Energy Board (NEB) is the responsible authority, direction and guidance can be found in the NEB filing manual. Applicants seeking guidance on nuclear projects should refer to the Canadian Nuclear Safety Commission’s regulatory framework.

This technical guidance should be used in conjunction with other Agency policy and guidance instruments. For an EA (environmental assessment) by a review panel, additional guidance and direction may be provided in the Terms of Reference or Joint Review Panel Agreement.

## **General Approach**

The practice of EA (environmental assessment) calls for examining potential effects of a project on valued components (VCs). In the context of CEAA (Canadian Environmental Assessment Act) 2012, VCs are selected to enable identification or analysis of environmental effects as described in section 5 of CEAA (Canadian Environmental Assessment Act) 2012. This technical guidance therefore proposes a VC (Valued Component)-centered approach for the assessment of cumulative effects.

The OPS outlines the five-step EA (environmental assessment) framework as it relates to cumulative effects assessment (see Figure 1). This document focusses primarily on steps 1 and 2, scoping and analysis. Practitioners



should refer to the [OPS](#) for further guidance on steps 3-5 and also consult the Policy and Guidance page of the Agency's website for updated information as it is developed.

## **OPS Approach**

All cumulative effects assessments should include the five steps described below - scoping, analysis, mitigation, significance, and follow up.

### **Figure 1. Environmental Assessment Framework and Cumulative Effects Assessment**

#### **Step 1: Scoping**

Step 1 defines the scope of the assessment. This includes identifying VCs for which residual environmental effects are predicted, determining spatial and temporal boundaries to capture potential cumulative effects on these VCs, and examining the relationship of the residual environmental effects of the designated project with those of other physical activities. Scoping helps determine which VCs should be carried forward to Step 2 analysis.

#### **Step 2: Analysis**

Step 2 considers how the physical activities examined during Step 1 may affect the VCs identified for further analysis in Step 1. Step 2 addresses those VCs within spatial and temporal boundaries determined for the assessment of cumulative effects.

#### **Step 3: Mitigation**

Step 3 aims to identify technically and economically feasible measures that would mitigate adverse cumulative effects. Mitigation may include elimination, reduction or control or, where this is not possible,

restitution measures such as replacement, restoration or compensation should be considered.

#### **Step 4: Significance**

Step 4 is concerned with determining the significance of any adverse cumulative environmental effects that are likely to result from a designated project in combination with other physical activities, taking into account the implementation of mitigation measures.

#### **Step 5: Follow-up**

Step 5 involves the development of a follow-up program that addresses both project-specific environmental effects and cumulative effects. A follow-up program verifies the accuracy of the EA (environmental assessment) and determines the effectiveness of any mitigation measures that have been implemented.

The detailed approach to the assessment of cumulative effects is established on a case-by-case basis taking into account:

1. the project-specific EIS (environmental impact statement) guidelines, direction provided by the Agency, or, for an EA (environmental assessment) by review panel, any additional guidance provided in the Terms of Reference or Joint Panel Agreement;
2. the requirements of CEAA (Canadian Environmental Assessment Act) 2012 and core guidance set in the OPS; and
3. the technical options and considerations presented in this guidance.

### **Timing for conducting the cumulative effects assessment**

This guidance is consistent with the general practice that calls for first examining the environmental effects of the project in isolation (project-specific environmental effects) before moving to the consideration of other physical activities (for more information on other physical activities, see section 1.4 of this document). This allows practitioners to first consider mitigation measures for the project and determine if there are residual effects after these mitigation measures have been considered. Identifying such residual effects is one of the ways in which a practitioner can orient and focus the assessment of cumulative effects.

Nonetheless, practitioners may sometimes find it useful to conduct the assessment of cumulative effects at the same time as they are addressing the project-specific environmental effects. As a minimum, information and data needed for the cumulative effects assessment should be considered from the outset of the EA (environmental assessment) for planning purposes.

Scoping (Step 1) for the cumulative effects assessment can therefore be started during or after the assessment of potential project-specific environmental effects. In either case, as the EA (environmental assessment) advances and additional information is gained, it may become clearer which VCs should be carried forward to Analysis (Step 2). Scoping is therefore iterative, and adjustments can be made at different points during the EA (environmental assessment) process.

## **Scope and Organization**

Most of the guidance in this document relates to the first two steps of the framework presented in the OPS. Section 1 covers scoping and Section 2 covers analysis. To facilitate future updates of this guide, each section is

organized into stand-alone guidance sheets (e.g., guidance sheet 1.0, entitled “Overview and Outcomes of Scoping”, is the first guidance sheet dealing with Step 1).

Additional technical background is provided in appendices as follows:

1. Appendix 1 provides information on the source-pathway-receptor model that can be used to identify the source of an environmental change, what the source may affect (receptor), and how the source may reach the receptor (pathway).
2. Appendix 2 provides examples of types of cumulative effects to support the consideration of cumulative effects on VCs.
3. Appendix 3 provides a brief introduction to some of the methods that may be used in conducting Step 1 (scoping) or Step 2 (analysis).

In this technical guidance, a methodology refers to a technical approach and related considerations for use in the conduct of an EA (environmental assessment). In addition, a methodology generally frames the implementation of various methods. A “method” is a specific tool, technique, or procedure used as part of implementing the chosen methodology.

## **1.0 Overview and Outcomes of Scoping**

As the first step in a cumulative effects assessment, scoping serves to orient and focus subsequent steps. Its overall outcome is a list of VCs that should be carried forward into the Step 2 analysis, as well as a rationale for VCs considered in scoping that are not carried forward. Scoping documents the scientific evidence and advice, as well as feedback from the public and Indigenous groups used to determine if further assessment of the VCs is warranted.

## Methodologies

Figure 2 summarizes the recommended generic approach to scoping. The information in the following paragraphs provides an overview of the methodologies that can be used for the scoping step, starting with a description of the generic approach.

As per Figure 2, a cumulative effects assessment generally starts with addressing VCs for which residual environmental effects are predicted, after consideration of mitigation measures, regardless of whether those residual environmental effects are predicted to be significant.

For each of these VCs:

1. gather information on the VC (Valued Component) of particular relevance to the cumulative effects assessment (e.g., comments from the public, Indigenous groups, experts, government and non-governmental organizations);
2. determine the spatial boundaries within which the potential for cumulative effects will be examined and, if appropriate, analyzed;
3. determine the temporal boundaries within which the potential for cumulative effects will be examined and, if appropriate, analyzed;
4. identify the other physical activities that will be considered in the cumulative effects assessment; and
5. identify the VCs that will be carried forward to Step 2, based on the scoping.

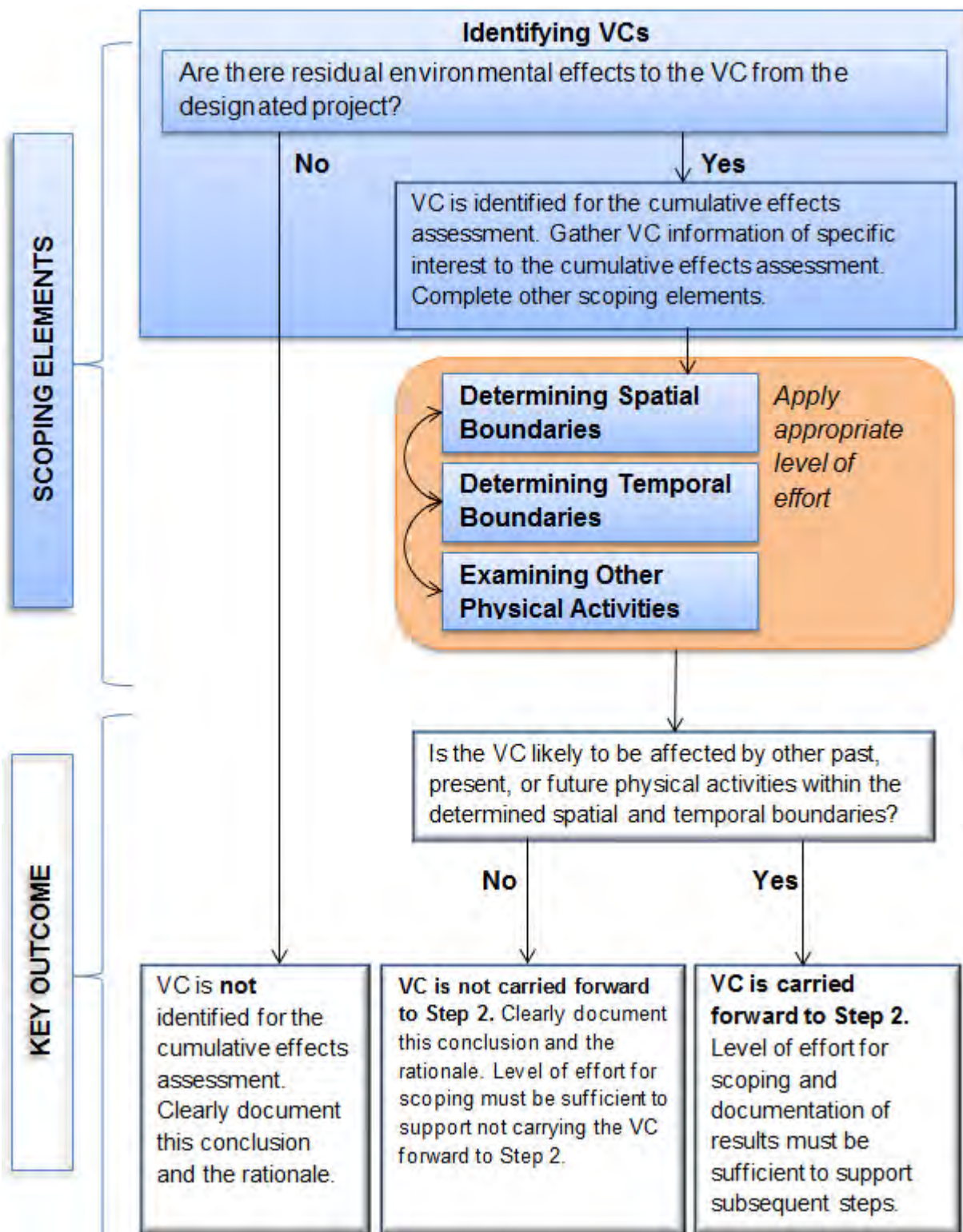
Scoping for the cumulative effects assessment can be started during or after the assessment of potential project-specific environmental effects. With the former approach, project-specific scoping activities inform the selection of VCs by considering, concurrently, how the project and other physical activities may affect VCs. With the latter approach, the determination of which VCs to carry forward for the cumulative effects

assessment can also be informed by the results of the detailed analysis of the environmental effects of the project. In either case, as the EA (environmental assessment) advances and additional information is gained, it may become clearer which VCs should be carried forward to Step 2.

The scoping elements (identifying VCs, determining spatial boundaries, determining temporal boundaries, and examining other physical activities) outlined in Figure 2 are complementary, allowing for considerations in each to inform integrated decision making on which VCs to carry forward to Step 2. VCs that are likely to be affected by other past, present, or future physical activities within set spatial and temporal boundaries should be carried forward.

A decision may be made not to carry a VC (Valued Component) forward to Step 2 (analysis) for the purposes of the cumulative effects assessment. However, for the purposes of the project-specific assessment, that VC (Valued Component) would still be considered in Steps 3-5 (mitigation, significance, and follow-up), noting that there are not likely cumulative effects on that VC (Valued Component).

Figure 2. Generic Approach to Scoping for Cumulative Effects Assessment



## Considerations

A reasonable approach should be taken to ensure that the cumulative effects assessment is undertaken at an appropriate level of effort that supports defensible conclusions. In completing the scoping step, practitioners should take into account the following considerations.

## 1. Existing Sources of Information

The public, Indigenous groups, experts, stakeholders, government and non-government organizations, as well as existing literature, can be important sources of information.

This information may include Aboriginal traditional knowledge (ATK (Aboriginal Traditional Knowledge)), community knowledge and scientific knowledge, or simply an expression of concern regarding potential cumulative effects to a particular VC (Valued Component). Collection and use of ATK (Aboriginal Traditional Knowledge) is addressed in the Agency's reference guide, Considering Aboriginal traditional knowledge in environmental assessments conducted under the Canadian Environmental Assessment Act, 2012.

Example: Noise from the project could be identified by an Indigenous group as an issue of concern relative to wildlife in the context of traditional use of lands. There may be concern that existing noise in the area due to existing physical activities may already be at a level of concern and that the project would result in cumulative effects. This concern would typically result in the "noise" VC (Valued Component) being identified for further consideration in scoping.

Where a cumulative effects assessment gathers information useful to understanding the historical context of past impacts on Aboriginal rights, practitioners should keep in mind that, in the context of consultation and accommodation, such information will also help in understanding potential impacts to Aboriginal rights.

## 2. Data limitations and associated uncertainties



VCs should not be omitted from being carried forward to Step 2 based on a lack of readily available data. Where data about a VC (Valued Component) are not readily available, practitioners may use one of the following approaches, and document associated uncertainties:

1. use surrogate data or model output within comparable environmental conditions;
2. undertake new studies and/or collect traditional or community knowledge; or
3. make inferences based on an appropriate body of knowledge (e.g., scientific and traditional knowledge about how the VC (Valued Component) may be affected and to what extent)

Data and information gathered from the analysis of environmental effects of the project (leading to the identification of VCs that have residual environmental effects) will be available to practitioners.

## **Level of Effort for Scoping**

In addition to the level-of-effort considerations outlined in the OPS, the following considerations should be taken into account for the scoping step:

1. Where a VC (Valued Component) is not carried forward to Step 2, the level of effort for scoping including the documentation of results must be sufficient to support not carrying the VC (Valued Component) forward.
2. Where a VC (Valued Component) is carried forward to Step 2, the level of effort for scoping, including the documentation of results, must be sufficient to support subsequent steps of the cumulative effects assessment.

Additional considerations related to level of effort in scoping can be found in Subsections 1.1 to 1.4 of this document.

## OPS Approach

The approach and level of effort applied to assessing cumulative environmental effects in a project EA is established on a case-by-case basis taking into consideration: the characteristics of the project; the risks associated with the potential cumulative environmental effects; the state (health, status, or condition) of valued components (VC (Valued Component)s) that may be affected by the cumulative environmental effects; the potential for mitigation and the extent to which mitigation measures may address potential adverse environmental effects; and the level of concern expressed by Indigenous groups or the public.

## Outcome Documentation

Documentation of the scoping step can take the form of two lists of VCs: those that are carried forward to Step 2, and those that are not carried forward, supported by a rationale.

There should be clear, well-supported documentation of the:

1. description or definition of VC (Valued Component)s, especially if the identified VC (Valued Component) differs from any identified in the project-specific EIS (environmental impact statement) Guidelines or from those considered so far in the EA (environmental assessment) of the project;
2. rationale for decision made on each VC (Valued Component); and
3. any other relevant information that helps justify the choice of VCs (e.g. public or concerns from Indigenous groups).

See also other outcome documentation in Subsections 1.1 to 1.4 of this document.

# 1.1 Identifying Valued Components

Identification of VCs is one of four elements of the scoping step (see Figure 2). The four elements of scoping are complementary, allowing for the considerations in each to inform integrated decision-making.

VCs refer to environmental features that may be affected by a project and that have been identified to be of concern by the proponent, government agencies, Indigenous people, the scientific community or the public. The value of a component not only relates to its role in the ecosystem, but also to the value people place on it. For example, it may have been identified as having scientific, social, cultural, economic, historical, archaeological, or aesthetic importance.

## **OPS Approach**

Identification of VC (Valued Component)s for the project EA (environmental assessment) is made in relation to section 5 of CEAA (Canadian Environmental Assessment Act) 2012 and takes into account direction provided by the Agency. Analysis is then undertaken to identify which of these VC (Valued Component)s will be considered for the cumulative environmental effects assessment.

The cumulative environmental effects assessment should consider those VC (Valued Component)s for which residual environmental effects are predicted after consideration of mitigation measures, regardless of whether those residual environmental effects are predicted to be significant.

## **Methodologies**

Identification of VCs is based on the assessment of environmental effects of the project. Where residual environmental effects from the project are expected, those VCs are identified for consideration in the cumulative effects assessment.

## Considerations

When identifying VCs at any point in the EA (environmental assessment), practitioners should take into account the following considerations.

### 1. Gathering data and information on VCs of interest

Data and information sources to aid in gathering VC (Valued Component) information of specific interest to the cumulative effects assessment include, but are not limited to:

- the Project Description filed by the proponent to initiate the EA (environmental assessment);
- scientific and science-based literature;
- legislation;
- completed or in-progress EAs (federally or any other jurisdiction);
- available mapping (e.g., historical air photos, geomorphological data, hydrological data, vegetation mapping, or topographical maps);
- government websites (e.g., for land use plans, development strategies, or open data);
- regional studies conducted under CEAA (Canadian Environmental Assessment Act) 2012;
- other regional studies (e.g., conducted by a province);
- monitoring information, status assessments, or management plans from resource management agencies;
- input from the public, Indigenous groups, the scientific community, and government agencies;

- baseline studies; and
- information on wildlife species listed under the Species at Risk Act (e.g., recovery plans, management strategies) or other wildlife of conservation concern.

These sources can be used to understand the current state of knowledge on VCs and related issues, or to identify known regional issues of concern.

## 2. Characterizing VCs for Cumulative Effects Assessment

A practitioner has flexibility in characterizing a VC (Valued Component) to provide the best insights into the nature and extent of cumulative effects related to environmental effects as defined in section 5 of CEAA (Canadian Environmental Assessment Act) 2012 by defining it either broadly or narrowly. If the VC (Valued Component) is defined narrowly, consideration should be given to whether the result of the analysis on the narrow VC (Valued Component) is relevant to any broader VC (Valued Component). Conversely, while the EA (environmental assessment) of the project in isolation may look at a broadly defined VC (Valued Component), it may be necessary in the cumulative effects assessment to focus on a narrowly defined VC (Valued Component) such as particular species in danger of losing important habitats as a result of the project and other physical activities. The final choice may be affected by the available information.

Example: A VC (Valued Component) may be defined broadly, such as “terrestrial vegetation” (e.g. where this VC (Valued Component) is relevant under paragraph 5(1)(c) or 5(2)(a) of CEAA (Canadian Environmental Assessment Act) 2012); more narrowly as “forests”; or even more specifically as a species of particular ecological importance due to its rarity, ecological or social value, or vulnerability to the environmental effects likely caused by the project.

The state (health, status, or condition) of a species may be monitored because it is seen as an indicator species (i.e. a reflection of the state of the environment on a chosen scale). In an EA (environmental assessment), it may be used as a surrogate to predict environmental effects on other species or another ecologically justifiable group if it provides a reasonably accurate prediction of effects and response on those other species/ groupings. While such an EA (environmental assessment) approach is reasonable and often used, it is important to recognize that one species or different species' metric (e.g., population distribution, or density; birth, death, fertility rates; longevity; habitat suitability; linear density; etc.) may have a different degree of sensitivity to disturbances than others.

Example: Grizzly bear, a culturally important species to Indigenous groups in a project area, might prove to be a good indicator VC (Valued Component) to represent other culturally important terrestrial animal species if it is known to respond similarly to the perturbations of projects and physical activities.

In characterizing the state of the VC (Valued Component), care must be taken in choosing one or more measurable variables that are directly or sufficiently indicative of the health, status, or condition of the VC (Valued Component). Reliance on an inadequate indicator (i.e., a measurable variable chosen to represent the state of a component) may lead to the premature exclusion of a VC (Valued Component) from further consideration in the cumulative effects assessment.

Example: A bird species, selected as a VC (Valued Component) under paragraph 5 (1) (c) of CEAA (Canadian Environmental Assessment Act) 2012 due to its use by Aboriginal peoples, may be affected by the availability and quality of its habitat. However, the status, health, and

condition of the bird may also be affected by other factors. An indicator which reflects **population** abundance may yield a very different level of concern than an indicator defined in terms of **habitat**. Even though the local habitat may not yet be under pressure, a review of population data might show that the species is under pressure due to other factors, such as the loss of habitat used by that population in another country.

Beyond examining changes to the environment (such as fish under subsection 5(1)(a)), practitioners also need to consider effects of changes to the environment (such as changes to Aboriginal peoples use of lands and resources for traditional purposes, subsection 5(1)(c)). For example, while there may be no biophysical cumulative effects on a species, there could be cumulative effects on individuals that depend on that species in a particular locale.

Example: A project may affect only a small proportion of a regional deer habitat, while leaving ample habitat to support the deer population. After examining other physical activities, it is determined that cumulative effects to the deer population are unlikely. In this case, it is reasonable to document the evidence and conclude that the VC (Valued Component) deer will not be carried forward for further analysis (Step 2). At the same time, however, the effect of the project on the small proportion of the deer' regional habitat may result in a residual cumulative effect to Aboriginal peoples hunting practices (e.g., effects on site-specific locations and times of year for hunting). As a result, the VC (Valued Component) deer relating to Aboriginal peoples hunting practices (paragraph 5 (1) (c) of CEAA (Canadian Environmental Assessment Act) 2012) should be carried forward to Step 2.

### 3. Using Benchmarks

Benchmarks help define what would be considered a significant adverse environmental effect on a VC (Valued Component). In some cases, it may be possible to identify established or generally accepted benchmarks. These may be in the form of standards, guidelines, targets, or objectives. Benchmarks are used to:

- aid in understanding where a VC (Valued Component)'s state (health, status, or condition) stands in relation to multiple stressors;
- provide information on relevant tangible measurements of environmental consequences for a VC (Valued Component); and
- provide an indication of which VCs are of regional concern (i.e., if a benchmark for a VC (Valued Component) has been established at a regional level).

## **Level of Effort for Identifying VCs**

Given that identifying VCs with residual environmental effects is typically the result of previous phases of the EA (environmental assessment), the level of effort for identifying VCs is the one adopted and justified for previous phases of the EA (environmental assessment). Establishing the appropriate level of effort for gathering VC (Valued Component) information of specific interest to the cumulative effects assessment should consider the criteria in the OPS (see Section 1.0 of this document for OPS level-of-effort considerations).

## **Outcome Documentation**

The outcome of this scoping element should be clear, well-supported documentation of the:

- list of VCs with and without residual environmental effects from the project (note that the documentation supporting this list is provided



through the documentation of other phases of the EA (environmental assessment)); and

- information on VCs of specific interest to the cumulative effects assessment.

## 1.2 Determining Spatial Boundaries

Determining spatial boundaries is one of four elements of the scoping step (see Figure 2). The four elements of scoping are complementary, allowing for the results of each to inform integrated decision making on scoping.

### OPS Approach

Spatial boundaries should be identified and justified clearly, and be set taking into account direction provided by the Agency.

To consider the environmental effects of existing and future physical activities, the spatial boundaries need to encompass the potential environmental effects on the selected VC of the designated project, in combination with other physical activities that have been or will be carried out.

### Methodologies

One of the following methodological options, or a combination of them, should be used to determine spatial boundaries. Spatial boundaries must support the consideration of cumulative effects for each VC (Valued Component) identified for the cumulative effects assessment.

#### 1. VC (Valued Component)-centered spatial boundaries

Under this approach, spatial boundaries of a cumulative effects assessment are based primarily on the VC (Valued Component)'s geographic range and the zone of influence (ZOI) of the project for the VC (Valued Component). (The ZOI sets a spatial limit beyond which the residual environmental effects of the designated project and other physical activities on a given VC (Valued Component) are not detectable). For example, spatial boundaries for a migratory species may take into account seasonal migration paths, regardless of jurisdictional boundaries.

This option is generally recommended, as it allows for the most meaningful spatial boundaries to be drawn for the VCs identified for the cumulative effects assessment.

Example: A caribou herd that is hunted by local Indigenous groups ranges within a 5,000 km<sup>2</sup> area. This full area would be the primary basis for the spatial boundary for the VC (Valued Component). The population is predicted to be directly affected by the residual effect (habitat loss) of the project within a 3 km radius of the project. This would occur in the southern part of the caribou population's range. The caribou herd is also being affected by transport roads and seismic lines that are being cut in the northern part of its range. Effects may include loss of habitat, decreased access to habitat due to caribou avoidance of crossing the seismic lines and increased potential for interaction with predators when crossing seismic lines. As well, in the future the herd could be affected by noise from a proposed new remote airport just outside of the herd's range. Noise from the future airport could limit the use of habitat in proximity to the airport. The spatial boundaries should be designed to allow for consideration of the cumulative effects of all of these physical activities.

In considering the caribou herd in the context of the “current use of lands and resources for traditional purposes” VC (Valued Component), practitioners should consult with potentially affected Indigenous groups to understand if accessing hunting opportunities in other parts of the herd’s range is an option for them or not. This information should be considered in setting the spatial boundaries for the “current use of lands and resources” VC (Valued Component) separately from the biophysical caribou VC (Valued Component).

## 2. Ecosystem-centered spatial boundaries

In some cases, the current understanding of an ecosystem’s boundaries and processes allow practitioners to take an ecosystem-centered approach. For example, the geographic extent of the VC (Valued Component) may be dependent on ecosystem features such as topography, climate, soils, or geology. Spatial boundaries under this approach are therefore based on knowledge of the ecosystem and where the VC (Valued Component) fits in it. This option requires a good understanding of ecosystem boundaries and processes. Ecological boundaries (e.g. a watershed) may define the geographic range of a VC (Valued Component) (e.g., a population of a fish species). If a sufficient knowledge base is available, the setting of VC (Valued Component)-specific spatial boundaries is done relative to the system in which the VC (Valued Component) occurs. For example, an aquatic species could be examined across its distribution in a watershed, thus allowing practitioners to take into account the availability of habitat and the success of recruitment processes across the watershed.

Understanding the ecological setting of a project can inform the setting of spatial boundaries. For example, ecological land classification (e.g., ecoregions) can be very helpful in the identification of spatial boundaries for VCs, particularly for VCs that occur at the landscape level. It can also be

useful at a smaller scale for VCs that are an ecotype (i.e., a genetically distinct variety, population, or race of a species adapted to specific environmental conditions). In some circumstances, ecotypes are at great risk due to their rarity or loss of their habitat from other physical activities. In such circumstances, the area of distribution of an ecotype may be the area of key concern for cumulative effects assessment, and it could then be selected as the spatial boundary rather than the larger ecoregion comprising complexes of flora and fauna on which it is nested.

Because of the potential large scale and complexity of ecosystems, an ecosystem-centered approach may be best suited when regional data are available, such as through a regional study, regional EA (environmental assessment), or ecosystem-based planning.

### **3. Activity-centered spatial boundaries**

With this approach, spatial boundaries in a cumulative effects assessment are based on the distribution of physical activities in the vicinity of the project (e.g., mining or forest resources harvesting where they might comprise the principal land use). This approach is generally not recommended, because it may fail to encompass all environmental effects acting on the VC (Valued Component) and may not fully consider the VC (Valued Component) under study (e.g., the type of VC (Valued Component) and its geographic range). EA (environmental assessment) practitioners are encouraged to consult the Agency when contemplating use of this option.

### **4. Administrative, political, or other human-made spatial boundaries**

Under this approach, administrative, political, or other human-made boundaries are established as the spatial boundaries. This may be particularly useful for socio-economic and cultural VCs. For example, spatial boundaries could be based on provincial, municipal, or statistical

boundaries (e.g., census tracts), or the traditional territory of an Indigenous group for VCs such as current use of lands and resources, recreational tourism, health, or fisheries.

Administrative spatial boundaries can also apply to biophysical VCs. For example, wildlife information and management often occurs in defined management areas that may be useful spatial boundaries for cumulative effects assessment. Similarly, at times boundaries like ecological reserves, parks, or other protected areas may also be useful if, for example, they reflect biophysical conditions of relevance to the EA (environmental assessment).

However, administrative, political, or other human-made boundaries may not take into account the spatial pattern of ecosystems, which typically consist of community gradients where attributes adjust progressively. Additionally, such boundaries may not reflect the spatial distribution of a mobile species.

Where a VC (Valued Component)'s state (health, status, or condition) is managed within administrative, political, or other human-made boundaries, the collection of data and integrated implementation of mitigation measures may be most effective if considered in the context of these boundaries. Nevertheless, the use of such boundaries must be appropriate in the context and support the assessment of cumulative effects on specific VCs. EA (environmental assessment) practitioners are encouraged to consult the Agency when contemplating use of this option.

## **5. Any other option**

If any other option is selected, it should be fully justified in the context of the project. It must also take into account the OPS, and enable the completion of an EIS (environmental impact statement) that meets the

information requirements of the project-specific EIS (environmental impact statement) Guidelines and the legal requirements of CEAA (Canadian Environmental Assessment Act) 2012. Discussion with Agency staff prior to implementing any other option is recommended.

## Considerations

Practitioners should take into account the following considerations in determining spatial boundaries.

### 1. Considering geographic scale as the EA (environmental assessment) progresses

The scale of the chosen boundary may lead to over- or under-predicting the importance of the predicted cumulative effects. With this in mind, practitioners must be aware of how cumulative effects are interpreted as the scale of boundaries change:

- Adopting a large spatial area may lead to misinterpreting the incremental cumulative effects of the project as being insignificant relative to everything else that is affecting the VC (Valued Component) in the region, i.e., a small drop in a large bucket.
- Adopting a small spatial area may result in exaggerating the incremental cumulative effects of a project, i.e., a large drop in a small bucket.

An iterative approach to setting spatial boundaries should be followed. Practitioners should be prepared to adjust the spatial boundaries (for example, by covering a larger or smaller geographic extent for a VC (Valued Component)) during the assessment process if new information suggests this is warranted.

### 2. Considering the designated project's zone of influence and effects pathways

The ZOI sets a spatial limit beyond which the residual environmental effects of the designated project on a given VC (Valued Component) are not detectable. The ZOI should be considered in setting spatial boundaries, for example, when:

- environmental effects of the project may extend over a far reaching area (e.g., long-range transport of pollutants in air sheds or waterways, far-ranging wildlife); or
- exposure to environmental effects of the project may result in a mobile VC (Valued Component) moving into the ZOI of another physical activity.

Setting the ZOI should be informed by the nature of pathways that result in cause-effect relationships between the project and the selected VCs (e.g., effluent from a project in a river resulting in contamination of fish tissue which is then consumed by humans and wildlife).

Example: In the case of fish that may be affected by a change in water quality, the ZOI of the project may be determined by considering how far downstream the concentration of a particular contaminant can be detected at levels greater than background levels, and what geographic range of fish populations this may affect. Effects pathways would be considered to determine how the water contaminant could affect fish and would also inform whether the ZOI extends to other fish-bearing water bodies by transport of the contaminant through groundwater or other means.

### **3. Considering the influence of other physical activities**

Effects pathways specify the cause-effect relationship among the project, the selected VCs and other physical activities. The selection of other physical activities to include in the cumulative effects assessment is

covered in Section 1.4: Examining physical activities that have been and will be carried out.

Physical activities will generally not be the primary factor in establishing spatial boundaries for the cumulative effects assessment. Spatial boundaries should be based on the geographic range of the VC (Valued Component) and the ZOI of the project and other physical activities. An understanding of land use is required to establish if other physical activities are likely to affect the same VC (Valued Component) and to identify the ZOI for those other physical activities. Particular care is required when considering mobile or wide-ranging VCs.

Other physical activities located outside of the spatial boundary may still affect a VC (Valued Component) within the spatial boundary. This does not mean that the spatial boundary needs to extend to include a physical activity outside the spatial boundary. The key point is that the environmental effects within the spatial boundary, whether they come from physical activities within or outside of the spatial boundary, should be considered for inclusion.

Example: A caribou herd hunted by local Indigenous groups ranges within a 5,000 km<sup>2</sup> area. This full area would be the spatial boundary for the VC (Valued Component) if the spatial boundary is set solely based on the geographic range of the VC (Valued Component) provided that the ZOI of the project (either completely or in part) falls within the geographic range of the herd. However, the herd could be affected by noise from a proposed new remote airport just outside of the range. Noise from the future airport could limit the use of habitat within the range in proximity to the airport and should therefore be considered in the cumulative effects assessment. While this physical activity and its



noise impact would then be included in the cumulative effects assessment, the VC (Valued Component)-specific spatial boundaries would not need to be extended.

There are circumstances where the spatial boundaries may be adapted in light of examination of other physical activities, as demonstrated in the following example.

Example: A sedentary aquatic species with a patchy distribution within an entire watershed is identified as a VC (Valued Component) for the cumulative effects assessment due to the residual release of a particular contaminant by the project. Pathways of effects indicate that the ZOI for release of the contaminant from the project extends to the watershed level. Further scoping using pathways reveals that only one other physical activity would also affect this aquatic species within a small ZOI nested in the watershed. The spatial boundaries could then be adjusted to focus on effects in this small ZOI, rather than cover the entire watershed.

#### **4. Considering the availability and quality of spatial data**

The availability and quality of the spatial data should be clearly described for each VC (Valued Component) under study. The quality and quantity of the available spatial data, the level of effort that would be required to augment existing data, and information required to enable EA (environmental assessment) decisions will influence whether to collect more data. The decision regarding the collection of additional data should be clearly stated and justified. If no additional data is collected, a valid

reason should be given. For example, a geo-database containing detailed species information for the past 20 years would likely be adequate to identify its spatial boundaries.

Practitioners should keep the following considerations in mind:

- The ability to set spatial boundaries may be enhanced for specific VCs in a well-studied watershed, along a well-known migration path, or where relevant remote sensing imagery is available;
- VC (Valued Component)-specific field studies can help define the spatial boundaries of some VCs for which limited or inadequate information is available. However, additional detailed studies will not necessarily be required if there is sufficient information to make a decision on whether the VC (Valued Component) should be carried forward to Step 2; and
- The study of multiple VCs at once may be particularly useful if the spatial distribution of the VCs under investigation is linked through, for example, predator-prey relationships, food webs, or natural barriers (e.g., on an island or in a mountain valley).

## **Level of Effort for Setting Spatial Boundaries**

Spatial and temporal boundaries are set in light of other elements of scoping, including an understanding of how physical activities had, continue to, or will have an environmental effect on VCs.

The environmental effects of a physical activity on a VC (Valued Component) must occur within the spatial and temporal boundaries set for the cumulative effects assessment (using the approaches outlined in this guidance) in order for that physical activity and its environmental effects to be considered in the cumulative effects assessment.

In addition to the overall level-of-effort considerations outlined in the OPS (see Section 1.0 of this document for OPS level-of-effort considerations), the level of effort needed to establish spatial boundaries will increase with the uncertainty regarding:

- the geographic extent of residual environmental effects from the project;
- the geographic extent of residual environmental effects of past, present, and future physical activities;
- the geographic range of the VC (Valued Component); and
- the quality of available spatial data.

The level of effort put into setting spatial boundaries must be sufficient to allow for full consideration of the environmental effects acting on a VC (Valued Component) from all physical activities, and for the justification of the spatial boundaries in relation to each VC (Valued Component).

## **Outcome Documentation**

The outcome of this scoping element should be clear, well-supported documentation of the:

- methodology and considerations used in determining the spatial boundaries; and
- spatial boundaries to be used in assessing the potential cumulative effects for each VC (Valued Component) and the rationale for their boundaries.

The outcome documentation should be commensurate with the level of effort established. For example, the outcome documentation may be maps with explanatory text which rationalizes the chosen spatial boundary for each identified VC (Valued Component).

Information and data necessary for documenting the spatial boundaries may include maps (geographic information systems), remote sensing or aerial imagery, expert opinions, community knowledge and/or ATK (Aboriginal Traditional Knowledge), thresholds, indicators, and land-use plans.

## 1.3 Determining Temporal Boundaries

Determining temporal boundaries is one of four elements of the scoping step (see Figure 2). The four elements of scoping are complementary, allowing for the results of each to inform integrated decision-making on scoping.

### **OPS Approach**

Temporal boundaries should be identified and justified clearly, and be set taking into account direction provided by the Agency.

Temporal boundaries for assessing a selected VC should take into account past and existing physical activities, as well as future physical activities that are certain and reasonably foreseeable. They should also take into account the degree to which the environmental effects of the physical activities overlap those predicted from the designated project.

### **Methodologies**

Practitioners should endeavour to understand the nature of the perturbation and the persistence of potential cumulative effects in setting temporal boundaries. Time horizons for the project or selected physical activities should include timelines associated with construction, operation, decommissioning and abandonment.

One of the following methodological options, or a combination of them, should be used to determine temporal boundaries for the cumulative effects assessment. Temporal boundaries must support the consideration of cumulative effects for each VC (Valued Component) identified for the cumulative effects assessment.

### **1. VC (Valued Component)-centered temporal boundaries**

Determining temporal boundaries according to each selected VC (Valued Component) enables an examination of the unique characteristics of environmental effects on VCs and takes into account the VC (Valued Component)'s natural variation over time. This option can focus temporal boundaries to account for the duration of the residual environmental effects of the project in combination with environmental effects of other physical activities on the same VC (Valued Component). In establishing temporal boundaries, the identification of past, present, and future physical activities is integral to understanding the cumulative effects on the selected VCs over time.

Example: A VC (Valued Component)-centered approach could be used for a situation associated with a hydroelectric project where there was an increase in mercury in fish consumed by an Indigenous group. For the VC (Valued Component) "Indigenous Health", a practitioner would take into account the mercury contamination associated with effluents from a pulp mill that is no longer operating and future effects from flooding to create a reservoir (which leads to conversion and circulation of mercury already present in plants and soil into the water).

In this case, the temporal boundaries would relate to the environmental effects of increased mercury in fish from the decommissioned pulp mill which may still be affecting fish body burdens. If the mill operated for 50

years and was decommissioned 25 years ago, the past temporal boundary might extend back 75 years.

The future boundary would reflect the likely duration of the presence of increased mercury in the reservoir and fish due to flooding. If mercury levels were expected to decline to levels acceptable for human consumption in some 30 years, and the pulp mill residual environmental effects were predicted to decline in the same period of time, then the future temporal boundary could then be set to 30 years from the time of flooding.

## **2. Ecosystem-centered temporal boundaries**

Using an ecosystem-centered approach, VCs are considered in the context of the current understanding of an ecosystem state and processes. Physical activities are then considered in terms of how they affect ecosystem processes and VCs, and for how long. For example, available information on the evolution of the ecosystem over time may help identify particular events in the history of the VC (Valued Component) that could be useful in setting temporal boundaries for the VC (Valued Component). The information might also reveal a trend in the state (health, status, or condition) of the VC (Valued Component) that could help predict a suitable point for a future temporal boundary. This option is better suited to circumstances where a reasonable understanding of the ecosystem and its processes is available or can be reasonably obtained.

It may also be useful if key VCs have been strongly influenced by historical drivers or shifts in ecosystem processes – for example, with historical changes in land use (e.g., past forested ecosystems having been converted into agricultural lands). This can help in two ways: providing evidence of the time scale at which change occurs relative to the natural or human drivers,

and providing evidence of past shifts in ecosystem processes to assist with predictions of potential effects. Practitioners may also find that the effects of past and existing physical activities are reflected in current ecosystem processes. In some circumstances, it may be important to also understand natural cycles within ecosystems such as predator-prey cycles, and examine the recovery of VCs in relation to the variability of natural cycles of change in ecosystems.

### **3. Activity-centered temporal boundaries**

This option may inform the setting of temporal boundaries, but should not be used in isolation. Focusing purely on physical activities for setting temporal boundaries may create a number of issues:

- time horizons of physical activities may not align well with consequential environmental effects on VCs (i.e., the lag time it might take a VC (Valued Component) to respond to or recover from an environmental effect may extend beyond the phases of physical activities);
- this approach may not reflect natural variation in the VC (Valued Component) over time, or its continuing evolution in response to effects from current or past physical activities; and
- temporal boundaries could stretch too far into the past or future, requiring extra effort to support the analysis, or may require information that cannot be obtained, as uncertainty generally increases the farther into the future the temporal boundary is extended.

Nevertheless, some environmental effects will occur in close association with the phases of a project or physical activity (e.g., noise associated with operation).

## 4. Any other option

If any other option is selected, it should be fully justified in the context of the project. It must also take into account the OPS, and enable the completion of an EIS (environmental impact statement) that meets the information requirements of the project-specific EIS (environmental impact statement) Guidelines and the legal requirements of CEAA (Canadian Environmental Assessment Act) 2012. Discussion with Agency staff prior to carrying forward any other option is recommended.

## Considerations

Practitioners should take into account the following considerations in setting temporal boundaries.

### 1. Setting a past temporal boundary with a VC (Valued Component)-centered approach

Baseline conditions refer to present-day conditions, prior to implementation of the project. These conditions may not be fully representative of the variations in natural conditions, due to natural variability, historical shifts, or effects from other human activity. Therefore, as a standard practice a description of the past state (health, status, or condition) of a VC (Valued Component) should be included in the baseline description of each VC (Valued Component). This description should demonstrate how the state of the VC (Valued Component) has evolved over time.

Setting a past temporal boundary allows for gathering of past data and information that will provide a more meaningful picture of the VC (Valued Component), allowing the practitioner to credibly state whether the baseline condition is representative or is at a particular point in a cycle.



Relevant past information includes scientific, ATK (Aboriginal Traditional Knowledge) and/or community knowledge about natural variability, drivers of change, and historical shifts. This description of the past can take various forms, such as a narrative of the evolution of the VC (Valued Component) from the past point in time to the present, a “pre-industrial case”, or a series of “past temporal snapshots” showing the evolution of the VC (Valued Component).

Example: In assessing the environmental effects to the VC (Valued Component) “current use of lands and resources for traditional purposes by Aboriginal people” as per subparagraph 5(1)(c)(iii) of CEAA (Canadian Environmental Assessment Act) 2012, Aboriginal traditional land use (TLU) and ATK (Aboriginal Traditional Knowledge) studies may be undertaken. These studies typically document historical and current Indigenous land- and resource-use activities that can inform project planning and the development of mitigation strategies. These studies may indicate the lifetimes of study participants as the temporal boundary and/or can include information about the cultural history and identity before industrial development took place. This information, along with other information sources (e.g., EIS (environmental impact statement) of another physical activity), could be used to describe the past state of the VC (Valued Component) and a narrative of its evolution.

The past temporal boundary would be set to a point in the past where a description of the past state of the VC (Valued Component) is useful to understanding cumulative effects. Possible points in time that could serve as boundaries are:

- when a certain land-use designation was made;

- when environmental effects on the VC (Valued Component) first occurred;
- when land use changed (e.g., the commencement of mechanized forest resources harvesting); and
- a point in time when the VC (Valued Component) was in a less disturbed condition, especially if the assessment includes determining to what degree past physical activities have affected the VC (Valued Component).

Example: Gathering baseline data reveals that, 50 years ago, a particular migratory bird species (the VC (Valued Component), as the project has potential effects on federal lands inhabited by the species) habitat covered 10,000 km<sup>2</sup>, as opposed to the present day 1,000 km<sup>2</sup>. The decrease in habitat was due to development in the area. In this case, the past temporal boundary of the VC (Valued Component) could conceivably be set to 50 years ago. However, the availability of historical data on the population of the migratory bird species dating back 50 years may be severely restricted, making this an unreasonable temporal boundary. It may be necessary to rely upon more recent data (e.g., forest management plans and associated migratory bird monitoring that have been in place over the preceding 25 years) and a shorter temporal boundary. Alternatively, practitioners could use surrogate data or modelling to attempt to fill the gap in data.

## 2. Setting a future temporal boundary with a VC (Valued Component)-centered approach

As a standard practice, boundaries should be extended long enough into the future to take into account when cumulative effects may occur. This means that boundaries should consider the planning horizon and expected

life cycle of the project, as well as future certain and reasonably foreseeable physical activities that will be assessed.

Practitioners should consider the temporal dynamics of VCs in response to the environmental effects of the project and other physical activities, which can result in delays in observing environmental effects on VCs in the field. For example, there might be lag time before effects on individuals are observable (e.g., chronic exposure resulting in effects over a long period of time).

It may also take several generations before environmental effects at the population level of a species become fully apparent. A VC (Valued Component) may also take generations to stabilize to a new state, or to recover from the perturbations of the project and/or physical activities.

The point at which the project ceases to contribute to cumulative effects may refer to a point in time when the VC (Valued Component) is predicted to have recovered to the baseline or another acceptable target, and the state of the VC (Valued Component) can now be considered stable relative to environmental conditions and natural variability.

Example: In a highly transformed landscape like agricultural land in the prairies, it may not be reasonable to expect conditions to return to pre-European conditions of native prairie. In such cases, the future temporal boundary may be established by a return to current or pre-project or pre-disturbance conditions. For example, a project which includes a right-of-way on agricultural land in an area of former prairie would set a future temporal boundary for when the right-of-way is expected to be returned to agricultural production with its inherent pre-disturbance, ecological, and land-use condition, not to pre-European conditions.

Illustrating the temporal overlap among physical activities is recommended to help identify when their environmental effects may overlap. This can be done by creating a diagram that provides the major project phases and predicted duration of the project's effects on a timeline with other physical activities included in the cumulative effects assessment. However, the timelines of the project need not overlap with other physical activities for cumulative effects to occur.

Information on the environmental effects of past or existing physical activities may also be of value to setting future temporal boundaries. For example:

- the environmental effects of past or existing physical activities on a specific VC (Valued Component) may help predict the environmental effects of a project if the same or similar type of physical activity already had an environmental effect on a VC (Valued Component); or
- future decommissioning of an existing physical activity could affect the future condition of a specific VC (Valued Component).

### **3. Setting a temporal boundary using various methodologies**

Applying the VC (Valued Component)-centered approach to setting temporal boundaries can be supplemented by other approaches, such as methodologies centered on an ecosystem or on physical activities.

Understanding the contribution of each approach and adding supplemental information from other approaches can assist in understanding complex system interactions. A way to integrate these methodologies can be to develop scenarios.

It may be helpful to build scenarios reflecting, for example, past conditions, current status, or expected evolution with or without the project. Scenario-building is well-suited when regional data are available, for example,

through a regional study, regional EA (environmental assessment), or ecosystem-based planning, such as in the following example, in the context of a forest management plan.

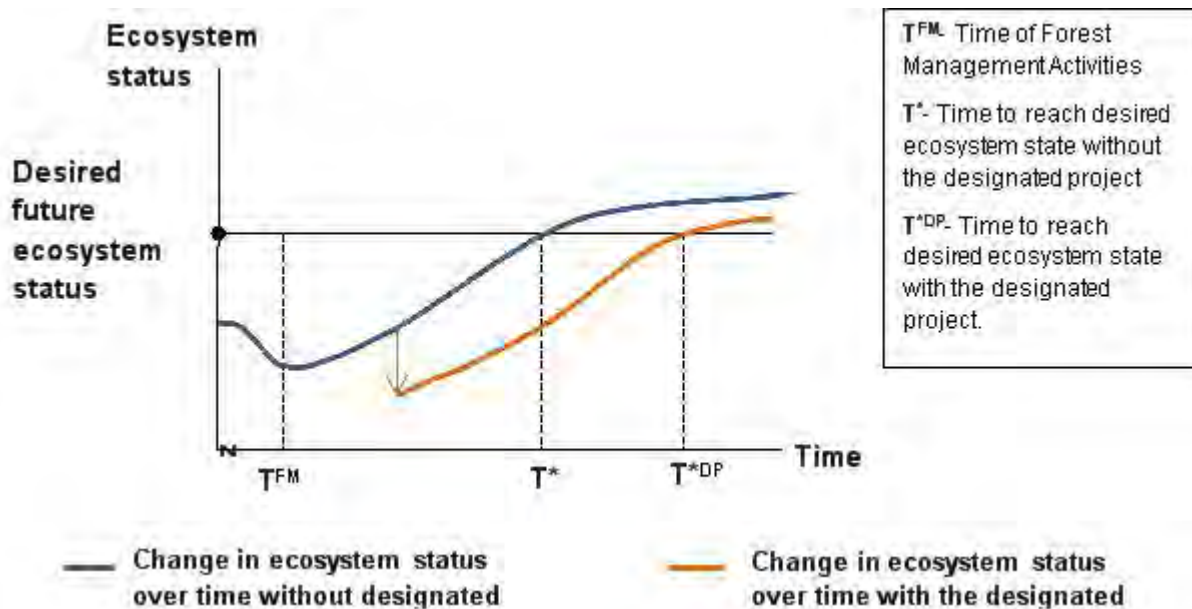
Example: Historical logging or mechanized forest resource harvesting may have progressively changed the status of an ecosystem in the past. These changes were then influenced by forest management activities aimed at reversing some of the effects (initiated at  $T^{FM}$  in Figure 3).

Where a project is proposed in such an area, the future duration of the environmental effects of the project, in combination with those related to forest management, can support the selection of an appropriate future temporal boundary. This boundary would be set as the point in time in the future when the ecosystem can be restored to a certain condition or status.

As shown graphically in a simplified depiction in Figure 3, the desired future ecosystem state would have been reached at  $T^*$  if the project had not been proposed. However, if the project goes ahead, the adverse environmental effects lead to a delay in when the ecosystem can reach the desired state. This occurs at  $T^{*DP}$ , and could serve as the future temporal boundary for VCs within the ecosystem. Where data are available, the setting of past temporal boundaries can also be informed by knowledge of the ecosystem state at specific points in time.

Monitoring of the state of an ecosystem can be done over time using one or more indices (an index is an aggregation of measurable variables, see Appendix 3). For example, the measured variable can be associated with a key indicator species, such as a bird species known to be representative of the state of that particular forest ecosystem.

Figure 3. Future Scenario



## Level of Effort for Setting Temporal Boundaries

Spatial and temporal boundaries are set in light of other elements of scoping, including an understanding of how physical activities had, continue to, or will have an environmental effect on VCs.

The environmental effects of a physical activity on a VC (Valued Component) must occur within the spatial and temporal boundaries set for the cumulative effects assessment (using the approaches outlined in this guidance) in order for that physical activity and its environmental effects to be considered in the cumulative effects assessment.

In addition to the overall level-of-effort considerations in the OPS (see Section 1.0 of this document for OPS level-of-effort considerations), the level of effort needed to establish temporal boundaries will vary with the:

- nature of the residual environmental effects, in terms of their measurability and scale or magnitude;
- time horizon of residual environmental effects of the project;
- time horizon of residual environmental effects of other past, present, and future physical activities; and
- selected temporal resolution(s) (i.e., years or decades).

## Outcome Documentation

The outcome of this scoping element should be clear, well-supported documentation of:

- the methodologies and considerations used in the determination of temporal boundaries, including descriptions and rationale for scenarios if this approach is taken;
- the chosen past temporal boundary for the consideration of cumulative effects for each VC (Valued Component);
- the future temporal boundary for the cumulative effects assessment for each VC (Valued Component); and
- how the chosen temporal boundaries will adequately capture the expected cumulative effects.

The outcome documentation should be commensurate with the level of effort established. The documentation could involve a narrative description of each determined temporal boundary, or a table listing the VC (Valued Component) with its chosen temporal boundary, accompanied by explanatory text.

## 1.4 Examining Physical Activities that have been and will be carried out

Physical activities to be considered in a cumulative effects assessment are not restricted to those listed in the Regulations Designating Physical Activities and those designated in an order made by the Minister of the Environment under subsection 14(2) of CEAA (Canadian Environmental Assessment Act) 2012.

Examining physical activities that have been and will be carried out is done as part of the scoping step (see Figure 2). The four elements of scoping are complementary, allowing for the results of each to inform integrated decision-making.

Examples of physical activities are numerous, and include agricultural development, management of a forested area, dredging a water body, hunting, fishing, remediation of a brownfield site, construction of a pulp mill, or operation and decommissioning of a mine. Practitioners should keep in mind that predicting cumulative effects to a VC (Valued Component) will tend to be more accurate when all sources of environmental effects to that VC (Valued Component) have been reasonably considered.

### **OPS Approach**

The cumulative environmental effects assessment must consider other physical activities that have been carried out up to the time of the analysis, or will be carried out in the future, provided that these physical activities are likely to have an environmental effect on the same VCs that would be affected by residual environmental effects of the designated project.

## **Methodologies**

### **1. Identifying Future Physical Activities**

The OPS sets the methodology to be used for identifying future physical activities, by indicating that they are to be included in the cumulative effects assessment if they are certain and should generally be included if



they are reasonably foreseeable. Some doubt about whether the physical activity will proceed is acceptable. The level of certainty may not be as high as for the project itself.

### **OPS Approach**

A cumulative environmental effects assessment of a designated project must include future physical activities that are certain and should generally include physical activities that are reasonably foreseeable.

A future physical activity would be considered certain to proceed, and would be included in a cumulative effects assessment if one or more of the following criteria are met:

- The physical activity has received approval in whole or in part, such as:
  - environmental assessment approval;
  - pre-development approval for early works, permits for exploration, or collection of baseline data; or
  - some other regulatory approval from a province.
- The physical activity is under construction;
- The site preparation is being undertaken.

A future physical activity could be considered reasonably foreseeable and should generally be included in the cumulative effects assessment if one or more of the following criteria are met:

- The intent to proceed is officially announced by a proponent. This information could be found in news media, the proponent's website or via an announcement from the proponent directly to regulatory agencies.
- The physical activity is under regulatory review (i.e., the application is in process). This can be known, for example, if information about the

review or application is available on a government website, or an EA (environmental assessment) notice has been made public.

- The submission for regulatory review is imminent. This could be known if the collection of data has already commenced, regulatory authorities have been contacted about information requirements, or through an announcement from the proponent.
- The physical activity is identified in a publically available development plan that is approved or for which approval is anticipated (e.g., a wastewater treatment plant in a city's long term development plan).
- The physical activity supports – or is consistent with – the long-term economic or financial assumptions and engineering assumptions made for the project's planning purposes.
- A physical activity is required in order for the project to proceed (e.g., rail or port transportation facilities, or a transmission line).
- The economic feasibility of the project is contingent upon the future development.
- The completion of the project would facilitate or enable the future development.

The criteria in the last three preceding bullets often relate to what is described as “induced development”. If the induced development is certain or reasonably foreseeable, it should be considered in the cumulative effects assessment. Examples of induced development include housing development that could arise due to the approval of the project.

## **OPS Approach**

Here is how the concepts of ‘certain’ and ‘reasonably foreseeable’ are defined:

- **Certain:** the physical activity will proceed or there is a high probability that the physical activity will proceed, e.g. the proponent

has received the necessary authorizations or is in the process of obtaining those authorizations.

- Reasonably Foreseeable: the physical activity is expected to proceed, e.g. the proponent has publicly disclosed its intention to seek the necessary EA or other authorizations to proceed.

## 2. Identifying Past and Existing Physical Activities

The following methodological options, or a combination of them, should be used to determine which past and existing physical activities to include in the cumulative effects assessment.

### a) Using direct evidence relating to past and existing physical activities with VCs

Reasonable effort should be made to identify past and existing physical activities based on direct evidence available from the historical record and other reliable sources, such as reports, community knowledge or ATK (Aboriginal Traditional Knowledge).

#### **OPS Approach**

Present-day environmental conditions reflect the cumulative environmental effects of many past and existing physical activities.

Data and information on physical activities that occurred in the distant past is often limited. The challenge generally increases as the study extends into the past. In such circumstances, the information may still provide some insight into VC (Valued Component) response.

Example: It may be known that early settlers cleared land for agriculture in the 19<sup>th</sup> century but then gradually abandoned part of the land due to changing lifestyles, or due to other factors such as declining fertility or

drought. The abandoned portion of land may have naturally regenerated to its current condition of a forest or prairie. The available information may be anecdotal, but can still provide a defensible understanding of the environmental effects of agriculture, and informs the predictions of VC (Valued Component) response to removal of the stressors.

Data and information on existing physical activities, or those that occurred in the recent past, are much easier to find. Sources include recent EA (environmental assessment) reports and land-use planning documents.

Example: A new coal mine is proposed in a watershed where there is an existing coal mine that releases selenium in the water that could potentially lead to cumulative effects on fish and fish habitat. The environmental effects of the existing mine in relation to fish and fish habitat must be understood in order to assess the cumulative effects of the new mine in the same region. Furthermore, any other past physical activity that has affected the watershed in relation to fish and fish habitat should be included.

In some cases, information on past or existing physical activities may help identify appropriate mitigation measures. Information on existing physical activities should cover their full lifecycle, particularly if decommissioning is certain or reasonably foreseeable.

#### **b) Using present-day VC (Valued Component) conditions to represent past and existing physical activities**

This approach is used to address past and existing physical activities when a practitioner has only limited data and information, and needs a reliable means of making inferences about their effects on VCs. For example, it may be well-known that the current environmental conditions in a forested area

exist in response to forest resource harvesting dating back to a distant past, but information on how the harvesting occurred and its effects over time may no longer be available.

In using this option, the practitioner first needs to consider whether the observed present-day VC (Valued Component) conditions are indeed representative of the environmental effects of past and existing physical activities in the study area. Efforts are then focused on describing how past and existing activities may have contributed to the current state of VCs.

The practitioner should also attempt to evaluate whether the current VC (Valued Component) condition is stable or whether it is still changing in response to past and existing physical activities. For example, an understanding of recovery stages after clear-cuts in similar environments may be helpful in determining whether the present-day VC (Valued Component) condition is likely to remain stable or what its future state might be. This helps establish if present-day VC (Valued Component) conditions are adequate surrogates for representing past and existing physical activities.

### **3. Any other option**

If any other option is selected to identify past, existing, or future physical activities, it should be fully justified in the context of the project. It must also take into account the OPS, and enable the completion of an environmental impact statement that meets the information requirements of the project-specific EIS (environmental impact statement) Guidelines and the legal requirements of CEAA (Canadian Environmental Assessment Act) 2012. Discussion with Agency staff prior to carrying forward any other option is recommended.

## **Considerations**

Practitioners should take into account the following considerations in deciding which physical activities to include.

## **1. Appropriate information to gather about physical activities**

As a general rule, the amount of information that can be obtained for future physical activity is usually proportional to the degree of certainty about it proceeding. For a past activity, there is generally more information available for projects that occurred in the recent past.

Each physical activity that is examined should be described in adequate detail to allow potential environmental effects to be characterized for later assessment. Key pieces of information to note about other physical activities may include:

- location, physical size (e.g., area covered, volume of process throughput), and spatial distribution of components (i.e., site specific, randomly dispersed, travel corridors);
- components (e.g., main plant, access roads, waste disposal site) and supporting infrastructure (e.g., waste treatment, power lines);
- expected life or period of activity (including start date), and phasing involved (e.g., exploration, construction, standard operations, later plans for upgraded or expanded operations, decommissioning, and abandonment);
- variations in seasonal operation (e.g., winter closures);
- frequency of use (for intermittent activities – e.g., helicopter use);
- transportation routes and mode of transport (e.g., roads, railways, shipping lanes);
- processes used (for industrial activity – e.g., open pit mining);
- emissions, discharges, and wastes that are likely to be released, and where;
- approvals received (e.g., permit and license conditions in effect); and

- duration of any in-place or planned follow-up program.

Where a scenario of future development is being employed, data surrogates for key pieces of information may be established by referencing typical development characteristics.

## 2. Information constraints

Information about a physical activity may not be readily available if, for example:

- proprietary technology or confidential production records are involved;  
or
- the design of the physical activity is too preliminary to provide enough useful information.

Information from similar physical activities at other locations (known as surrogate information) may be useful. It could be used in a case where future physical activities are reasonably foreseeable, but there is little information available.

Example: The development of a future gold mine may be considered reasonably foreseeable, but little information is available. Information on the environmental effects of a surrogate mine could be used. For example, the physical activity would probably include an open pit, mill, tailings storage facility, and water treatment facility. Caution in the use of this surrogate information would be required since the mine in question may have different geology or chemistry, processes, and tailings-management issues.

## 3. Pathways and categories of environmental effects

Pathway diagrams may assist in identifying and assessing environmental effects of other physical activities on the VCs identified (see [Appendix 1: Source-pathway-receptor model](#)).

The use of broad categories to assess physical activities in a generic way may be appropriate, for example, when little detail is available beyond the type of physical activities (e.g., forest resources harvesting), or when there are too many physical activities (e.g., in an urban area or along a highway) to characterize individually. Categories may be established in recognition of the similar patterns in the environmental effects they may cause. Examples include:

- shape (e.g., linear, aerially dispersed, areal point);
- sector type (e.g., resource extraction, power generation, urban infrastructure);
- industry type (e.g., mining, forest resource harvesting, municipal infrastructure); or
- transportation type (e.g., aircraft, boats, road traffic).

This information will be helpful when conducting the Step 2 analysis described in this document.

## **Level of Effort for Examining other Physical Activities**

Spatial and temporal boundaries are set in light of other elements of scoping, including an understanding of how physical activities had, continue to, or will have an environmental effect on VCs.

The environmental effects of a physical activity on a VC (Valued Component) must occur within the spatial and temporal boundaries set for the cumulative effects assessment (using the approaches outlined in this guidance) in order for that physical activity and its environmental effects to be considered in the cumulative effects assessment.



In addition to the level-of-effort considerations outlined in the OPS (see Section 1.0 of this document for OPS level-of-effort considerations), the level of effort needed to identify past, present, and future physical activities will vary with the:

- number of VCs under consideration;
- spatial boundaries selected;
- temporal boundaries selected;
- number of potential physical activities (past, present and future);
- land-use planning and/or applicable management plan information available;
- sensitivity of VCs to the perturbations of various physical activities;
- status of developments; and
- environmental and regulatory review applications for physical activities.

## **Outcome Documentation**

The outcome of this scoping element should be clear, well-supported documentation of the:

- methodology used in the selection of physical activities;
- physical activities considered for inclusion which may include a map depicting the location of the physical activities in relation to the project and the VC (Valued Component) under consideration; and
- physical activities considered for inclusion that will not be carried forward for analyzing cumulative effects.

A table or matrix format (as shown in Figure 4 below) may be useful for presenting information regarding the rationale for including each physical activity identified and the VCs that they may affect. It may also be used to categorize physical activities as past, existing, or future (certain or

reasonably foreseeable). Where there is evidence that certain or reasonably foreseeable physical activities can be seen as induced development, it should be noted. Where scenarios are used to reflect future or past activities, it should also be noted.

The outcome documentation should be commensurate with the level of effort established. For example, in identifying past physical activities, the availability and use of an extensive historical record would require more documentation than in the case of a more limited historical record.

**Figure 4. Example of a Matrix Structure for Outcome Documentation**

<b>Past, Existing, and Future Physical Activities in a Largely Undeveloped Area</b>	<b>Valued Components</b>				
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>Description</b>

Physical	✓	✓			This future physical activity is reasonably
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Activity A				<p>foreseeable, since it is currently under regulatory review. It has the potential of affecting <u>VC (Valued Component)#1</u> &amp; <u>VC (Valued Component)#2</u>, given the nature of the physical activity and predicted effects pathways within the spatial boundaries established for these VCs. Furthermore, such effects on <u>VC (Valued Component)#1</u> &amp; <u>VC (Valued Component)#2</u> are likely to occur within the same timeframe as the potential effects of the project on the same VCs. The effects of Physical Activity A and those of the project therefore both fall within the established temporal boundaries for <u>VC (Valued Component)#1</u> and <u>VC (Valued Component)#2</u>. The environmental effects of Physical Activity A on these two VCs will be considered further in the Step 2 analysis.</p>
Physical Activity B	✓	✓	✓	<p>This is a past activity that will yield useful information about potential future effects on <u>VC (Valued Component)#1</u>, <u>VC (Valued Component)#2</u> and <u>VC (Valued Component)#3</u>.</p>

Physical Activity C			✓	✓	<p>This is a certain future physical activity</p>
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Activity C					with potential effects on <u>VC (Valued Component)#3</u> and <u>VC (Valued Component)#4</u> . In the context of the area, it can be considered induced development.
Physical Activity X					This activity is not expected to affect any of the VCs identified for the cumulative effects assessment, therefore it is not included.

## 2.0 Overview and Outcomes of the Analysis

Step 2 of the framework is analysis of cumulative effects (see Figure 1).

This step builds on the results of scoping (Step 1) and considers how all physical activities identified during the scoping stage may affect the VCs within the spatial and temporal boundaries determined for the assessment of cumulative effects.

Step 2 analysis focuses on understanding the cumulative effects for each VC (Valued Component) retained for further analysis.

### OPS Approach

The methodologies used to predict cumulative environmental effects must be clearly described. With this information, reviewers of the EIS (environmental impact statement) will be able to examine how the analysis was conducted and what rationale supports the conclusions reached. Any assumptions or conclusions based on professional judgment should be clearly identified and described.

## Methodologies

Assessment of cumulative effects requires an understanding of both the estimated cumulative effects on VCs and the contribution of the project to cumulative effects.

The source-pathway-receptor model (see [Appendix 1: Source-pathway-receptor model](#)) can be used to depict the relationship between the project and other physical activities (as sources of an environmental change) and the VC (Valued Component) (as the receptor affected by the change).

Baseline information serves as a point of reference – before a project is developed – against which cumulative effects can be predicted and assessed. In order to analyze cumulative effects, it is essential to understand the state of the receiving environment into which a project is entering. This means that, for each selected VC (Valued Component) subject to analysis, information should be gathered on its state within the determined spatial and temporal boundaries.

One of the following options, or a combination of them, can be adopted to analyze cumulative effects on each VC (Valued Component).

### **1. Comparison using reference case(s)**

Data from other areas with comparable conditions, or from a reference case, can be used to analyze or understand potential cumulative effects. Comparable conditions can include similar environments, or environments that are experiencing similar environmental effects as a result of similar physical activities. Some past physical activities may be included as a reference because they provide the best source of information for understanding past environmental conditions.

Example: An open pit metal mine in an area of boreal forest with many fish bearing streams could be a reference case for an open pit mine in a similar environment in a different part of the country.

The results of monitoring and follow-up of other similar physical activities that have similar receiving environments can be one source of information. This method is useful only when the reference case is comparable. The EA (environmental assessment) should include a rationale for the use of a reference case and explain its relevance, limitations, and assumptions for assessing the cumulative effects of the project.

When considering use of a reference case for a VC (Valued Component) related to Aboriginal peoples as per section 5 (1)(c) of CEAA (Canadian Environmental Assessment Act) 2012, it is important to recognize that each Aboriginal group is unique and there may be specific considerations not addressed by the reference case.

## **2. Comparison using models**

Predictive models can generate information that supplements available data or simulates existing and future conditions in those cases where data are limited or difficult to attain. Models can also estimate the response of a VC (Valued Component) to cumulative effects.

Models can be qualitative (e.g., a conceptual model, typically less data-intensive) or quantitative (e.g., a numerical model, typically more data-intensive). The most common use of quantitative models is to predict the state of a physical condition or chemical constituent by using a computer-based application to assess various indicators or parameters such as air and water quality, species condition or response, water volume flows, airborne deposition on soils and vegetation, and habitat condition.

Qualitative models can include descriptive narratives or graphic representations that illustrate the conceptual relationships between the environment and human activities.

Example: To model changes to groundwater flow linked to a Navigation Protection Act authorization (for the dewatering of a navigable water that would lead to changes in groundwater flow) under section 5 (2) of CEAA (Canadian Environmental Assessment Act) 2012, two types of models may be considered. A conceptual model would illustrate how groundwater flow may be affected by a project and other physical activities. A computer simulation of groundwater flow may predict the potential numerical quantity and quality of groundwater under a range of future conditions (e.g., future phases of the project or different mitigation measures), with or without the project.

Where models are used, it is necessary to provide the rationale for the chosen methodology, the assumptions involved in its use, and the limitations of the predicted data, including uncertainty on data interpretation, and statistical error and confidence.

### **3. Any other option**

If any other option is selected, it should be fully justified in the context of the project. It must also take into account the OPS, and enable the completion of an EIS (environmental impact statement) that meets the information requirements of the project-specific EIS (environmental impact statement) Guidelines and the legal requirements of CEAA (Canadian Environmental Assessment Act) 2012. Discussion with Agency staff prior to carrying forward any other option is recommended.

## **Considerations**

Practitioners should take into account the following considerations in conducting the analysis.

Environmental effects of other physical activities can interact with those of the project in various ways. For example, some effects may be simply additive, while others may result in effects greater than if they had occurred on their own (for more information, see [Appendix 2: Types of Cumulative Effects](#)).

Changes in the state of a VC (Valued Component) may therefore be attributable to different changes to the environment resulting from the project and other physical activities that are acting together on the VC (Valued Component) in various ways. In considering how various physical activities may interact to affect a VC (Valued Component), practitioners may find it helpful to compare the predicted future environmental state of the VC (Valued Component), both with and without the project.

The methodologies describe general ways that cumulative effects can be analyzed. Regardless of the methodology, a range of methods can be used. For more information about the types of methods that can be used, see [Appendix 3: Methods for Cumulative Effects Assessment](#)

## **Level of Effort for the Analysis**

In addition to the overall level-of-effort considerations outlined in the [OPS](#) (see [Section 1.0](#) of this document for [OPS](#) level-of-effort considerations), the level of effort needed to undertake the analysis of cumulative effects will vary depending on the:

- sensitivity of the VC (Valued Component) to the environmental effects of the project;
- likely contribution of the project to cumulative effects;



- complexity of a VC (Valued Component)'s response to multiple environmental stressors;
- state (health, status, or condition) of a VC (Valued Component) with regard to known thresholds, standards or benchmarks;
- past or existing disturbance levels and extent of other physical activities that are or may contribute to cumulative effects on the VC (Valued Component); and
- selected methods used for the assessment.

## Outcome Documentation

The outcome of the analysis should be a clear, well-supported documentation of the:

- methodological approach and methods used and the rationale for their use;
- estimated cumulative effects on VCs resulting from the project in combination with the environmental effects of other physical activities that have been or will be carried out, including the analysis conducted and rationale supporting the conclusions reached; and
- contribution of the project to the cumulative effects, considering past, existing, and future physical activities, to facilitate the identification of appropriate mitigation.

The outcome documentation should be commensurate with the level of effort established. Outcome documentation may include VC (Valued Component) specific descriptions of the methods used to analyze each VC (Valued Component) and the results of analysis. The level of detail contained in each respective section should be consistent with the level of effort required to analyze the corresponding VC (Valued Component).

# 2.1 Analyzing Various Types of Data and Information

Having access to data and information related to other physical activities and traditional and community knowledge is critical for conducting the Step 2 analysis.

To make decisions about which data is to be collected or generated, practitioners should have a clear understanding of how the data and information will be used in the assessment, how to establish a proper scale of analysis, and what methodologies and specific methods will be employed for their analysis.

## OPS Approach

Data collection and/or generation are important components of a cumulative environmental effects assessment. At times, it may be challenging to obtain or generate data to support the analysis.

## Methodologies

The methodological options presented here orient the analysis of various types of data and information frequently used in a cumulative effects assessment.

### 1. Using information about current and past environmental conditions

#### OPS Approach

A description of past environmental conditions can improve the understanding of cumulative environmental effects for a specific VC (Valued Component).

The OPS recognizes that a description of past environmental conditions can improve the understanding of cumulative effects for a specific VC (Valued Component). As such, practitioners should make reasonable efforts to understand the extent to which past and present physical activities are responsible for baseline conditions.

Baseline data can be compared to past conditions to reveal spatial or temporal patterns or trends so that predictions can be made. Information on past environmental conditions may also help establish if present-day VC (Valued Component) conditions are likely to be stable. For example, data and information on the response of a forested area to harvesting over time may help establish if the current state has reached equilibrium and/or if the response over time corresponds to the body of knowledge on recovery stages.

Some characteristics of useful baseline information for the purpose of a cumulative effects assessment under CEAA (Canadian Environmental Assessment Act) 2012 include:

- detailed data (either qualitative or quantitative) are available for each selected VC (Valued Component) within the spatial and temporal boundaries identified for the cumulative effects assessment;
- natural variability, drivers of change, and historical shifts for the VC (Valued Component) are identified, if reasonably obtainable;
- trends or spatial patterns in quality, quantity, value, or use of VCs are identified where reasonably obtainable;
- the current status of the existing environment is presented in the context of relevant benchmarks; and
- data or perspectives relevant to baseline conditions include those that are obtained through community knowledge and/or ATK (Aboriginal Traditional Knowledge), where appropriate.

Models may be used to generate baseline conditions. For more information on conceptual and numerical models, see [Appendix 3](#).

## 2. Using information on the environmental effects of physical activities

### OPS Approach

Information on the environmental effects of past or existing physical activities may be helpful:

- if the effects of past or existing physical activities on a specific VC (Valued Component) will help predict the environmental effects of a designated project;
- if information on past or existing physical activities will assist in the identification of appropriate mitigation measures for the designated project; or
- if an existing physical activity will be decommissioned in the future and this decommissioning would affect the future condition of a specific VC (Valued Component).

The focus of a cumulative effects assessment is on understanding key environmental effects on specific VCs in conjunction with other past, present and reasonably foreseeable physical activities.

Pathway diagrams are useful to identify and evaluate potential cumulative effects on VCs by exploring linkages to other physical activities (see [Appendix 1](#) for more information).

However, as a region becomes more heavily disturbed due to increasing development, it may become difficult and less relevant to determine which physical activity is contributing to specific environmental effects, and to

what degree. While attributing specific environmental effects to individual physical activities may not always be feasible, estimation of the cumulative effects on VCs should be done.

It is important to consider if past physical activities that are no longer physically present, operating, or active continue to affect an identified VC (Valued Component) (e.g., ongoing environmental effects of an abandoned gravel pit, or a contaminant plume from a brownfield site). In some cases, the source and pathways of environmental effects may no longer be readily observable; however, they may continue to affect the state of the receptor VC (Valued Component). Consideration should also be given to whether an existing physical activity will be decommissioned in the future, and whether this decommissioning might affect the future condition of a specific VC (Valued Component).

If the state of the VC (Valued Component) is likely to be stable, then the cumulative effects assessment can address how the baseline will be further affected by additional changes in the environment due to future activities. On the other hand, if the VC (Valued Component) is still changing as a result of past or existing activities, then the analysis has to address two influences: i) how past and existing activities are expected to affect the future; and ii) how future activities will affect the future.

With complex interactions, the whole does not necessarily correspond to the sum of the parts. Continuing environmental changes associated with past and existing activities may result in a worsening or improvement of VC (Valued Component) conditions. Where there is evidence that effects are not simply additive, it should be noted.

Example: The operation of a generating station releases cooling-water effluent into a lake that results in a change in the fish population due to thermal pollution. The fish population is also affected by fishing and

sewage-related pollutants from residential development along the shoreline. All of these types of environmental effects on the fish should be included in the cumulative effects assessment.

### **3. Using Aboriginal traditional knowledge and community knowledge**

#### **OPS Approach**

Community knowledge and ATK (Aboriginal Traditional Knowledge) available to the proponent should be incorporated into the cumulative environmental effects assessment, in keeping with appropriate ethical standards and without breaking obligations of confidentiality, if any.

Collection and use of ATK (Aboriginal Traditional Knowledge) is addressed in the reference guide Considering Aboriginal traditional knowledge in environmental assessments conducted under the Canadian Environmental Assessment Act, 2012.

How community knowledge and ATK (Aboriginal Traditional Knowledge) available to the proponent are used for the assessment of cumulative effects should be described and be a part of the selected methodological approach, without breaking obligations of confidentiality, if any, while also maintaining appropriate ethical standards. Legislated requirements associated with access to information must be considered.

#### **Considerations**

##### **1. Establishing the proper scale for analysis**

The assessment area for cumulative effects may be larger than required for the assessment of the project-related environmental effects to capture the greater extent of overlapping cumulative effects of other physical activities.

The type of data required may change as the scale of the assessment changes.

Where cumulative effects extend over larger areas, the assessment may have to be based on satellite imagery or existing habitat surveys completed at very broad scales.

Example: Maps or photo mosaics at scales ranging from 1:250,000 to 1:50,000 are sometimes used to depict broad-level baseline environmental data for the purposes of a cumulative effects assessment (e.g., to convey available habitat). In some cases, it may be more instructive to include photos of the area (regular or panoramic views) and surrounding areas rather than maps (e.g., to depict changes in viewscape).

In other cases, practitioners may rely on various landscape-level metrics, such as linear feature density, as a predictor of the change in VC (Valued Component) health, status, or condition, or to characterize the degree of disturbance or activity. Regardless, practitioners should select appropriate scales and tools to support meaningful evaluation.

In some cases, the scale is small and relies on field surveys.

Example: Species-at-risk studies may be relatively intensive within the proposed footprint of the project and involve on-site mapping.

## **2. Selecting the appropriate analytical method**

Different methods can be used to analyse the data and information (see Appendix 3). Selecting the method to be used will depend on the nature of the data and information available and generated for the cumulative

effects assessment, as well as the nature of the VC (Valued Component) and pathways of effects.

## **Level of Effort and Types of Data and Information**

In addition to the overall level-of-effort considerations outlined in previous sections of this document, the level of effort needed to undertake the analysis of cumulative effects will vary depending on the:

- quality/quantity of information collected about cumulative effects for each VC (Valued Component) during the scoping process;
- quality/quantity of information available about the environmental effects of other physical activities that contribute to cumulative effects;
- amount of existing knowledge on a VC (Valued Component)'s sensitivity to environmental effects (natural and anthropogenic); and
- amount of data judged useful for modelling, mapping, statistical analyses or any other methods used.

## **Outcome Documentation**

EA (environmental assessment) documentation must clearly explain and justify the methodologies and methods that have been used to assess cumulative effects, along with the following supporting information:

- types of data and information that were gathered or generated for each VC (Valued Component), and why this information was deemed necessary ;
- specific methods that were used to gather or generate this data and information, and why they were selected; and
- specific methods that were used to analyze this data and information, and why they were selected.



The outcome documentation should be commensurate with the level of effort established. For example, the amount of existing data used in the analysis versus the generation of new data will vary according to project-specific variables. Concerns of Indigenous groups regarding a specific aspect of a VC (Valued Component) may necessitate the generation of new data through field studies. In this case, detail regarding the methods used in the study and any rationale for their selection should be documented.

## 2.2 Addressing Data Limitations and Uncertainty in the Analysis

Collecting and using appropriate data and information is central to the analysis of cumulative effects. A reasonable attempt to collect data and information must be demonstrated. A lack of reliable data and information will tend to make the predictions less certain, and potentially faulty.

Few – if any – cumulative effects predictions are certain. Uncertainties associated with information and methods may occur at many points in the process of analyzing cumulative effects. For example, there may be poor information about other physical activities, or conflicting reports about the effectiveness of mitigation measures. Even where the data are reliable, data interpretation could be challenging. For example, it may not be clear to what extent an effect pathway is likely to result in a change in the environment.

Practitioners must meet the requirement to assess cumulative effects in the face of data limitations and uncertainty. The EIS (environmental impact statement) should present a complete picture of the potential types and scale of cumulative effects and the data required and used for their

assessment. While there are frequent data limitations in cumulative effects assessment that cannot be fully overcome, the uncertainties that result from these limitations should be documented.

Assumptions used in modelling and other analytical methods may limit the analysis. Where possible, it should be noted if results are sensitive to small changes in assumptions

### **OPS Approach**

Potential cumulative environmental effects should be considered, as appropriate, in the analysis, even when there is little supporting data or there is predictive uncertainty.

Reviewers of the EIS should be presented with a complete picture of the potential types and scale of cumulative environmental effects. In all cases, uncertainties and assumptions underpinning an analysis should be described and information sources clearly documented.

## **Methodologies**

Various methodologies used to address data limitations and uncertainties in a project EA (environmental assessment) are also useful in considering cumulative effects.

### **1. Documenting efforts and limitations**

A reasonable attempt to collect and/or generate information must be demonstrated. A lack of usable information for the analysis can have important implications to the predictive certainty of the cumulative effects assessment.

Where there is little supporting data, or where there is predictive uncertainty, the assessment of cumulative effects should still be conducted.

Limitations imposed by data and other types of uncertainty should be clearly described. This involves outlining how these limitations affected the choice of methodology and assumptions.

## **2. Using various sources and types of knowledge**

A variety of approaches for addressing data limitations are available and have been mentioned in other parts of this technical guidance, including:

- use of ATK (Aboriginal Traditional Knowledge) and community knowledge to fill data gaps;
- use of surrogate data from similar areas to estimate past environmental conditions;
- use of surrogate data from similar physical activities to predict cumulative effects;
- modelling to assess possible cumulative effects over the range of future conditions; and
- inferences based on an appropriate body of knowledge, using professional judgment.

## **3. Using scenario building**

Scenario building may be useful to account for a range of future conditions for a VC (Valued Component) and address uncertainty regarding the future state of a VC (Valued Component).

Scenario building consists of describing a set of possible alternatives that might reasonably take place leading to several possible past or future conditions. They are most helpful for studies of the mid- and long-range future and when several alternative scenarios – each one significantly different from the others – are to be considered.

## **4. Using adaptive management**

Adaptive management may be an appropriate strategy for helping to reduce uncertainty about the environmental effects and the effectiveness of mitigation. Adaptive management provides flexibility to identify and implement new mitigation measures or to modify existing ones during the life of a project.

However, a commitment to implementing adaptive management measures does not eliminate the need for sufficient information regarding the cumulative effects of the project, the significance of those effects, and the appropriate mitigation measures required to eliminate, reduce or control those effects.

For further information on adaptive management, see the Agency's [Operational Policy Statement: Adaptive Management Measures under the Canadian Environmental Assessment Act](#), or any future updates to that document.

## **Considerations**

Although aspects of cumulative effects cannot be known with certainty, that does not mean the [EA \(environmental assessment\)](#) is deficient. The practitioner must simply strive to provide the best information to support decisions about the project.

In determining whether data and information should be obtained or generated, practitioners should consider the ability, cost, and utility of the data to be collected, its intended use, and the limitations to its use in the assessment of cumulative effects. This also needs to be weighed against the nature and scale of the project, the receiving environment and the potential cumulative effects.

Caution should be exercised if the degree of uncertainty is unusually large (e.g., effects are expected in the future, but it is not possible to predict whether they will improve or harm a particular VC (Valued Component)). In these cases, predictions will be highly sensitive to the assumptions made. Relying on a particular assumption could result in a faulty conclusion. It would therefore be appropriate to present the results as a range, in line with the range of underlying assumptions.

In addition, as set out in the OPS, a Step 5 follow-up program can be established to monitor the VC (Valued Component). This will help determine whether the mitigation measures identified in Step 3 are appropriate in the face of actual environmental effects.

## **Level of Effort to Address Uncertainties**

The level of effort needed to address uncertainty will depend on:

- what decisions were made in Steps 1 and 2 concerning VCs, methodologies, methods, and data collection; and
- what is required to clearly state assumptions and data limitations throughout the EA (environmental assessment).

## **Outcome Documentation**

In addition to the criteria identified in previous subsections on analysis, the outcome of the discussion of data limitations and uncertainties should be a clear, well-supported documentation of:

- model assumptions and data limitations in the assessment of cumulative effects; and
- the implications of assumptions used and their limitations for the predictive certainty of the cumulative effects assessment.

The outcome documentation should be commensurate with the level of effort established. For example, the number and complexity of any model assumptions and data limitations will affect the documentation needed to explain the implications of the assumptions and data limitations.

## **Appendix 1: Source-pathway-receptor Model**

This Appendix provides information on the source-pathway-receptor model as background information. This model (see Figure 5) is used in EAs to identify:

### **The source of an environmental change (source)**

The source is the activity or event that causes environmental stresses. For example, the source might be the project (i.e., a mine) or another physical activity (i.e., agriculture).

### **What the source may affect (receptor)**

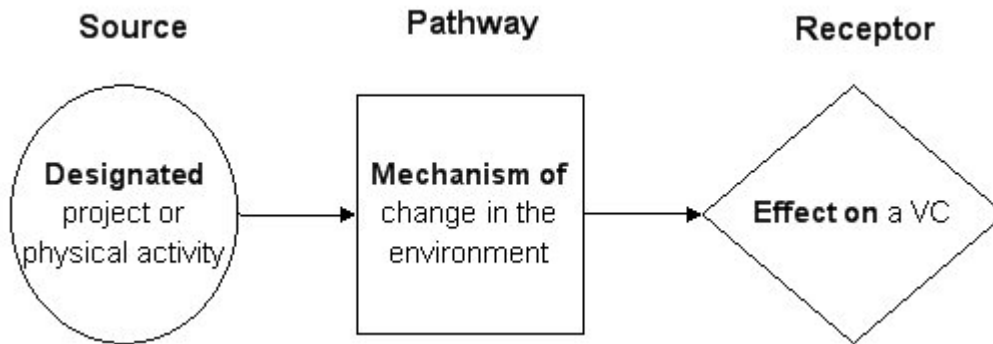
The receptor is the environmental component that is affected by the impacts of a physical activity. Since receptors differ in health and resiliency, each receptor has its own, unique sensitivity to environmental change. These receptors are the focus of the cumulative effects assessment and are typically referred to as VCs.

### **How the source may reach the receptor (pathway)**

The pathway is the route the source takes to reach a VC (Valued Component). Pathways are the mechanisms through which a change in the environment occurs. Pathways can include physical or chemical transport

through air, water, soil, animals, food supplies, etc. In order to consider cumulative effects, it is essential to understand these mechanisms and the state of the receiving environment within which a project takes place.

Figure 5. Source-Pathway-Receptor Model



## Appendix 2: Types of Cumulative Effects

This Appendix provides information on types of cumulative effects.

It is important to consider how cumulative effects may interact and manifest in practice in order to make sound and justifiable predictions about their significance. Key types of cumulative effects presented in this reference document include:

- additive;
- synergistic;
- compensatory; and
- masking.

Determining how cumulative effects occur can be a complex task, and can vary based on the VC (Valued Component) being assessed. For example, even if the cumulative effects on habitat are additive, the ultimate effect on a species may be synergistic. Although classifying cumulative effects can be helpful to conceptualize various forms of cumulative effects, the critical point is the need to assess how the cumulative effects are acting on VCs (Duinker & Grieg 2006).

## Additive Cumulative Effects

An additive cumulative effect is the sum of individual effects of two or more physical activities. Figure 6 demonstrates the loss of habitat increases with each new element of development (a new town, followed by new roads and a golf course).

Figure 6. Additive Cumulative Effects <sup>1</sup>



## Synergistic cumulative effects

A synergistic cumulative effect occurs as a result of the interaction between two or more effects, when the resultant combination is greater or different than the simple addition of the effects. Consider the example described in the following text and shown in Figure 7 (adapted from Greig, L.A. et al, 2003).

Panel A: Caribou habitat is divided in two large blocks joined by a migration corridor. Each block has contiguous winter and summer habitats, but their proportions are unequal and reversed in the two blocks.

Panel B: Harvest of timber is assumed to remove the small southern areas of winter and summer habitats with relatively little effect on carrying capacity for the migratory caribou herd.

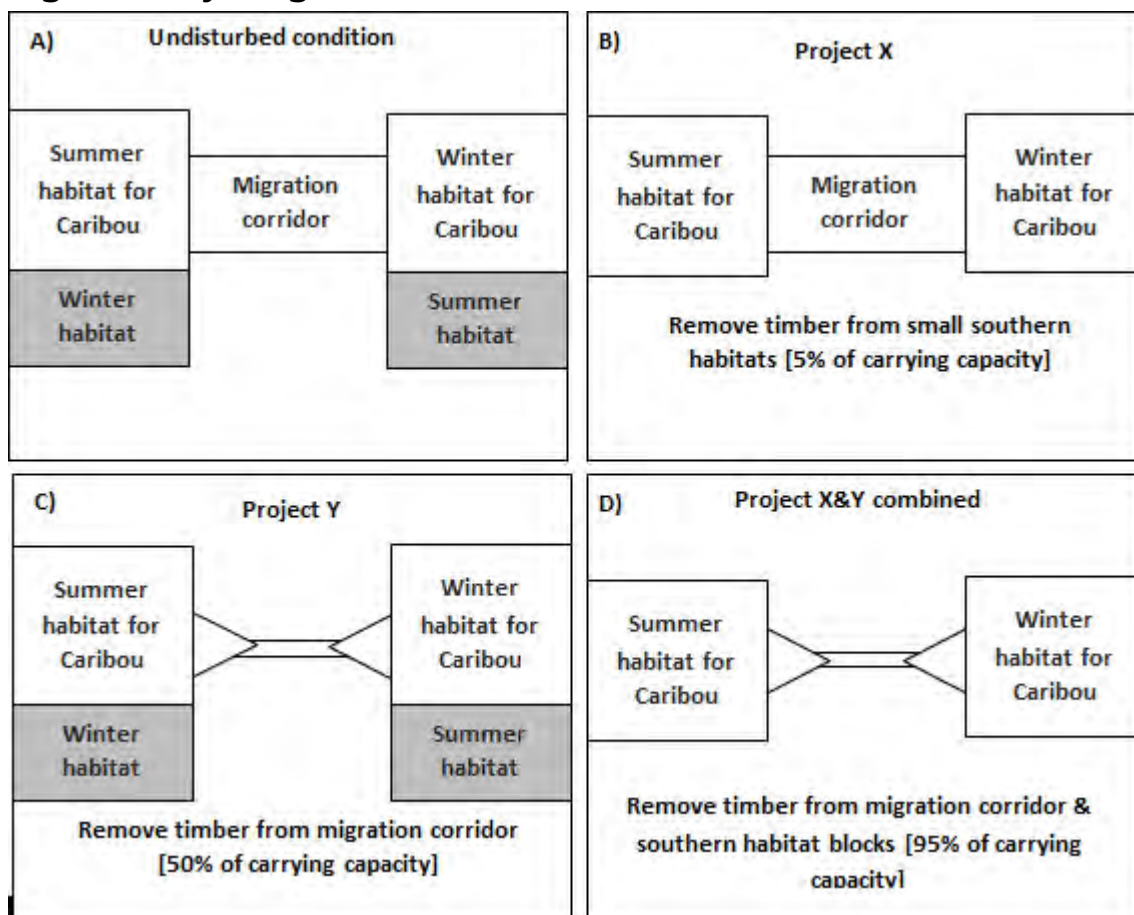
Panel C: Harvest of timber in the migration corridor is assumed to almost completely block migration. Animals stranded in one or the other large habitat block need to find life requisites for the entire year in that block by



utilizing the smaller habitat blocks, and the carrying capacity is substantially reduced.

Panel D: The synergistic cumulative effects of both projects combined is expected to reduce the caribou carrying capacity of the total area much more than the sum of the carrying capacity reductions of the two actions when taken independent of each other.

Figure 7. Synergistic Cumulative Effects <sup>2</sup>



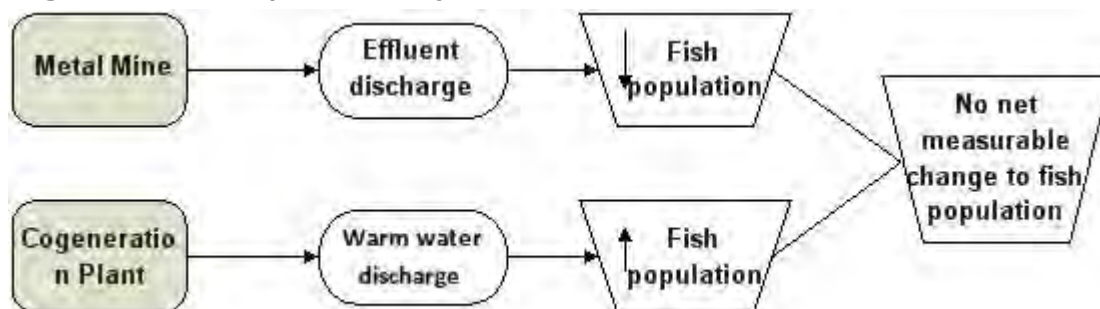
## Compensatory Cumulative Effects

Compensatory cumulative effects are effects from two or more physical activities that “offset” each other.

For example, as illustrated in Figure 8, a metal mine project might cause a decrease in a specific fish population due to effluent discharges, while a cogeneration plant might enable an increase in this same population

through its warm water discharges. These effects may offset each other and, accordingly, the cumulative effects on this fish population may not be measurable.

Figure 8. Compensatory Cumulative Effects <sup>3</sup>

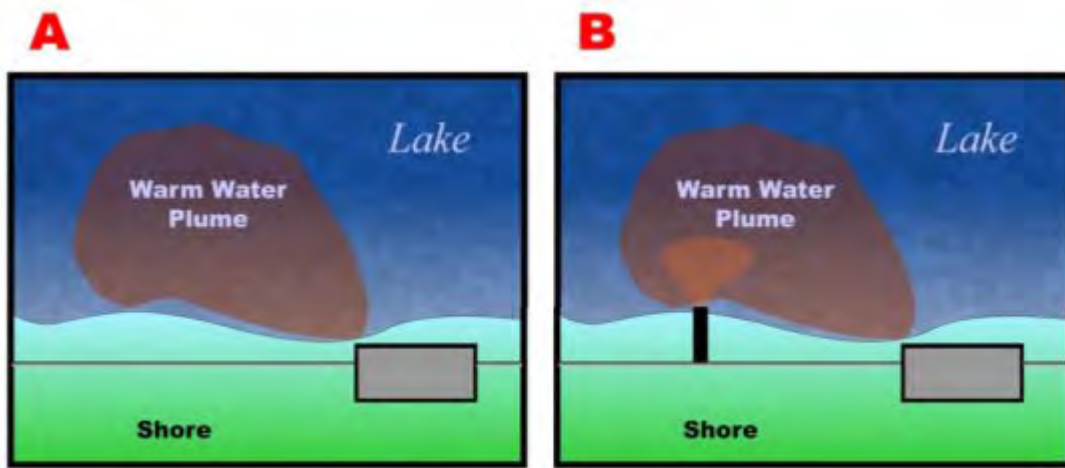


## Masking Cumulative Effects

The effects of one project might mask the effects of another in the field. For example, as illustrated in Figure 9, the warm water plume associated with a generating station (shown under “A” in Figure 9) may be of such magnitude that the effects of a small plume associated with another project (introduced as shown under “B” in Figure 9) would not be detected. If the generating station were to stop its physical activities, then the effect of the other project would become visible.

It is therefore possible that the effects of an earlier project could mask the effects of a new project. In this case, it is reasonable to conclude that the new project is not likely to result in environmental effects. This conclusion is correct as long as the effect of the earlier project continues. Once this earlier project is terminated, the effect from the new project would become evident. If masking of cumulative effects is predicted, a follow-up program may be required to ensure that mitigation measures remain effective in managing cumulative effects when the earlier project is terminated.

Figure 9. Masking Cumulative Effects <sup>4</sup>



## References

Gartner Lee Ltd. 2006. Cumulative Effects Assessment "Tips" Document. Prepared for the Canadian Environmental Assessment Agency.

Greig, L. A., P. N. Duinker, R. R. Everitt, and K. Pawley. (2003). Scoping for cumulative effects assessment. Prepared for Indian and Northern Affairs Canada Environment Directorate, Whitehorse, Yukon Territory. ESSA Technologies Ltd., Richmond Hill, Ontario.

Duinker, P. N., & Greig, L. A. (2006). The impotence of cumulative effects assessment in Canada: ailments and ideas for redeployment. *Environmental Management*, 37(2), 153-161.

## Appendix 3: Methods for Cumulative Effects Assessment

This Appendix provides a brief introduction to some of the methods that may be used in the cumulative effects assessment for Step 1 (scoping) or Step 2 (analysis).

Numerous methods are available for conducting a cumulative effects assessment, and often these are simply typical EA (environmental assessment) tools modified to better consider cumulative effects. The

methods discussed in this Appendix include:

- Questionnaires and Interviews;
- Checklists and Matrices;
- Network and Systems Analysis/Diagrams;
- Indicators and Indices;
- Conceptual and Numerical Models;
- Trend Analysis; and
- Spatial Analysis.

## **Questionnaires and Interviews**

### **Description**

Questionnaires and interviews are a means of gathering a broad range of information from knowledgeable or interested individuals or groups.

These methods can be used to collect information about past, present, or planned development projects, baseline data, changes in the socio-economic environment over a period of time, and opinions about where, why, and how cumulative effects may occur.

### **Applicability to Cumulative Effects Assessment**

Interviews and questionnaires can be used to assist in the collection of baseline data and increase understanding of the environmental effects of other physical activities, the VCs affected, and possible mitigation measures. Interviews and questionnaires are most applicable to the scoping of the cumulative effects assessment.

It can be useful to interview experts during scoping and/or analysis to provide a range of expert knowledge during a cumulative effects assessment.

## Checklists and Matrices

### Description

A checklist is a simple method that can be used to record VCs and potential cumulative effects, but is not typically useful for analysis.

Matrices can be used to summarize and present complex information in a concise manner. Matrices are two-dimensional grids, with information arranged in rows and columns. Practitioners can enter data in the form of descriptive words, symbols, or numbers into the grid to record and organize information. Matrices range from simple interaction matrices, with project physical activities along one axis and VCs along the other, to more complex matrices that describe potential cumulative effects. Matrices can also describe mitigation and follow-up relative to specific cumulative effects.

### Applicability to Cumulative Effects Assessment

Checklists are most applicable to the scoping of the cumulative effects assessment to, for example, help highlight common or likely cumulative effects among physical activities and the project under consideration.

Matrices can be used to present and organize information on the cumulative effects of a project and other physical activities on VCs. They are often used to identify the likelihood of cumulative effects on one or more VCs. They can also be used to score or rank cumulative effects. Matrices are often used in EA (environmental assessment) reports to add information such as mitigation and follow-up recommendations, and even the significance of the cumulative effects and the contribution of the project.

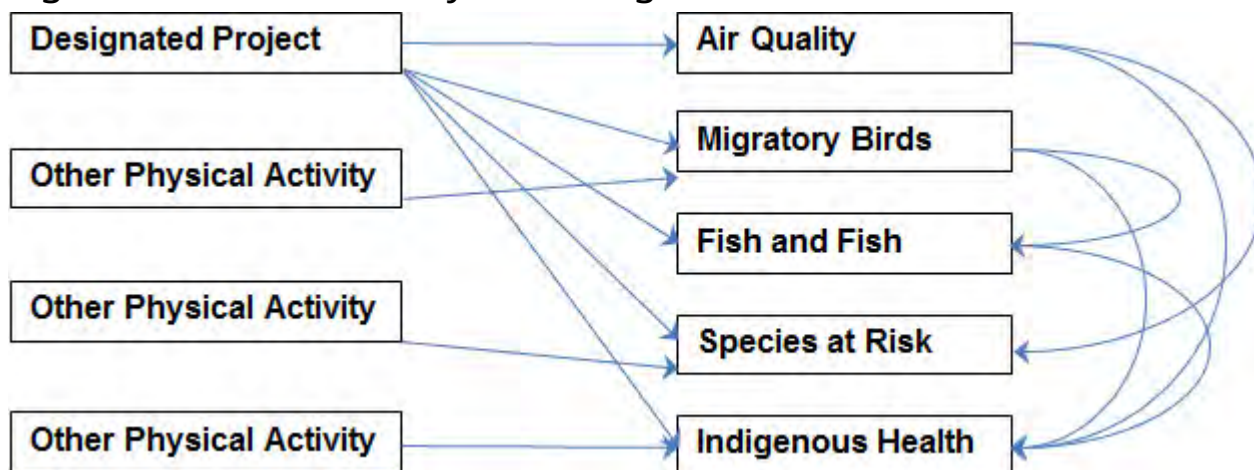
## Network and Systems Analysis/Diagrams

### Description

Network and systems analysis identifies the pathway of cumulative effects using a series of chains or webs between a proposed action and a VC (Valued Component). This method is based on the concept that there are links and interactions between individual VCs. A VC (Valued Component) is affected not only directly by the source activity, but also indirectly through another VC (Valued Component). This method uses a network or system diagram, which is essentially a flow chart with connector lines between a project and/or physical activities and VCs.

An example of a network or system diagram for cumulative effects assessment is provided in Figure 10.

Figure 10. Network or System Diagram of Cumulative Effects



## Applicability to Cumulative Effects Assessment

By mapping cause-and-effect relationships among projects, other physical activities, and VCs, possible cumulative effects can be identified. Network and systems analyses are most applicable to the scoping of the cumulative effects assessment, and can be helpful to identify the pathways among a project, multiple other physical activities, and multiple VCs.

## Indicators and Indices

### Description

In EA (environmental assessment), an indicator is a measurable variable and an index is an aggregation of variables. Both can represent the state (health, status, or condition) of a VC (Valued Component). For example, if caribou are selected as a VC (Valued Component), then indicators might include the total size of the herd, the density of animals in a habitat, and rates of mortality and reproduction.

An indicator or index can represent environmental effects on more than one VC (Valued Component). For example, habitat fragmentation can be an indicator of habitat quality for wildlife or vegetation or the current use of lands and resources for traditional purposes by Aboriginal peoples.

#### **a) Stress Indicators**

Stress indicators are measurements that provide information about the attributes of human-caused disturbances or the surrounding environment, such as the magnitude, intensity, and frequency of physical activities, or natural phenomena that may bring about changes in environmental components. Some examples of stress indicators for which models have been developed and have been correlated to specific VC (Valued Component) conditions include kilometres of roads per square kilometre; total cleared area; percent of area disturbed by class of activity; total area burned; and stream crossing density.

#### **b) Ecological Indices**

An ecological index is a numerical or descriptive categorization of a large quantity of ecological data or information involving multiple metrics. It is used to summarize and simplify information, to make it useful to decision-makers and stakeholders. Some examples of ecological indices are core habitat area, habitat patch size, index of biological integrity, and Hilsenhoff biotic index.

## c) Social Indicators

Social indicators provide information on social VCs and facilitate comparisons over time that are well-suited for examining long-term trends in a community. Some examples of social indicators are population size and growth, equity (distribution of benefits), quality of life (self-assessed), locus of control (psychological), and cultural well-being.

### **Applicability to Cumulative Effects Assessment**

Indicators and indices can be used during the scoping, analysis, significance, and follow-up steps of the cumulative effects assessment. For the determination of significance, indicators and indices can form the basis for establishing benchmarks. In cumulative effects assessment, indicators and indices can be useful for:

- summarizing and communicating information on the health, status, or condition of a VC (Valued Component), either in the present or historically;
- increasing the understanding of a VC (Valued Component)'s response to environmental effects;
- acting as a tool for evaluating VC (Valued Component) sustainability over time;
- evaluating the effectiveness of mitigation measures and cumulative effects management strategies; and
- planning follow-up, monitoring, and adaptive management programs.

## **Conceptual and Numerical Models**

### **Description**



Conceptual and numerical models are methods that represent or simulate the environmental interactions among projects, VCs, and other physical activities. Models used in cumulative effects assessment can be qualitative (conceptual models) or quantitative (numerical models).

### **a) Conceptual Models**

Conceptual models are generalizations of reality that provide an understanding of a more complex process or system. They represent the relationships among receptors (e.g., VCs), stressors (e.g., environmental effects), and sources of stressors (e.g., projects or other physical activities). The outputs from conceptual models are typically qualitative or descriptive narratives, or graphic representations, such as a matrix or a box-and-arrow diagram.

Conceptual models may enhance understanding of the response of VCs to environmental effects resulting from past and existing physical activities. They may also serve as a useful tool to represent the structure, functions, and hierarchical relationships of the terrestrial, aquatic, and atmospheric systems affected by physical activities.

### **b) Numerical Models**

Numerical models are a set of mathematical equations developed to simulate the behaviour of a system over time. They enable the quantification of cause-and-effect relationships by representing environmental conditions. A model could focus on a particular VC (Valued Component) (e.g., water quality), or could represent a complex natural system. Some examples of commonly used numerical models are hydrological and hydrogeological models, air and water dispersion models, and species habitat models. In order to assess changes in the environment,

such as air and water quality, water volume flows, and airborne deposition on soils and vegetation, numerical models usually require computers to provide solutions using complex and iterative numerical methods.

Modelling can be a powerful technique for quantifying the cause-and-effect relationships leading to cumulative effects. Once the linkages have been quantified, numerical models can be used to make predictions into the future.

## **Applicability to Cumulative Effects Assessment**

In a cumulative effects assessment, models can be used to identify and provide:

- the characteristics and interactions between VCs, the project, and other physical activities;
- the anticipated cumulative effects of multiple physical activities or events within identified study spatial and temporal boundaries;
- linkages of processes and environmental effects across disciplinary boundaries; and
- a scientific basis for the identification of VCs and their associated indicators, the establishment of spatial and temporal boundaries, the identification of other physical activities, and the prediction of cumulative effects.

For example, the Impact Model approach involves testing the validity of a statement, similar to that made in a scientific hypothesis. Such hypotheses provide a clear basis for prediction of cumulative effects by setting out how cumulative effects are likely to arise, and the accompanying rationale for a prediction.

## **Trends Analysis**

## Description

Trends analysis assesses the health, condition, or status of VCs over time, and is commonly used to develop projections of past or future conditions. The trend is often described relative to an environmental benchmark. The objective of trends analysis is to identify a pattern – in the form of a mathematical equation – which represents the behaviour of a VC (Valued Component). To support trends analysis, the data can be depicted in various ways, including:

- a simple quantitative indicator of a trend, such as numbers of animals from annual surveys, to reflect changes in population levels over time;
- a series of figures illustrating changes in habitat pattern;
- video simulations from a modelling exercise, showing complex changes in geographic or aesthetic resources (i.e. visual landscape); and
- aerial imagery showing time-series information.

## Applicability to Cumulative Effects Assessment

Trends can help practitioners identify cumulative effects issues, establish appropriate environmental baselines, or project future cumulative effects.

## Spatial Analysis Using Geographic Information Systems

### Description

Spatial analysis is a method for identifying the spatial distribution of effects or analyzing geographic information. Spatial analysis can be applied to a range of physical activities and environmental conditions, and is used for identifying physical effects in terms of geographical location. Geographic information systems (GIS) are the most commonly used tool in spatial analysis.

## **a) Geographic Information Systems**

GIS typically involves the preparation of maps or layers of geographic information that are then superimposed on one another. The layered map can be used to provide a composite picture of the baseline environment .

With GIS it is possible to correlate measures of disturbance to physical activities and relate those disturbances to the occurrence of VCs. This is a tool for creating a model of cause-effect relationships.

## **b) Overlay Mapping**

Overlays provide a technique for illustrating the geographical extent of different environmental effects. Each overlay can be a layer of information, such as a map of a single effect. When superimposed on one another, the overlaps illustrate areas where there are potential cumulative effects.

With GIS software, overlay mapping is particularly suitable for pinpointing sensitive zones where development should not occur. This can then serve as the basis for land management proposals and other mitigation measures.

## **Applicability to Cumulative Effects Assessment**

Spatial analysis is useful for identifying where cumulative effects may occur as a result of the geographic location of the project in relation to other physical activities.

GIS is also a useful tool in cumulative effects assessment owing to its ability to store, manipulate, and display large sets of complex, geographically referenced data. It is well suited to complex spatial applications, and can be used to display the consequences of multiple actions and to support mitigation proposals for undertaking cumulative effects assessments.

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# Footnotes

- 1 Source: Gartner Lee Ltd. 2006. Cumulative Effects Assessment “Tips” Document
  - 2 Source: Greig, L.A. et al, 2003
  - 3 Source: Adapted from Gartner Lee Ltd. 2006. Cumulative Effects Assessment “Tips” Document
  - 4 Source: Gartner Lee Ltd. 2006. Cumulative Effects Assessment “Tips” Document
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**Date modified:**

2018-03-05

# TAB U



File OF-Fac-Oil-T260-2013-03 02  
23 April 2014

To: Distribution List

**Trans Mountain Pipeline ULC (Trans Mountain)  
Application for the Trans Mountain Expansion Project (Project)  
Potential effects on species listed under the *Species at Risk Act* (SARA)**

Pursuant to the SARA, the National Energy Board (Board) hereby advises the Ministers of the Environment and Fisheries and Oceans that the above-noted Project, if approved and constructed, may affect species listed on Schedule 1 of the SARA and/or their habitat, as referenced in the following:

**Terrestrial wildlife**

- [A3S2R4](#), Application Volume 5C – Environmental and Socio-Economic Assessment (ESA) – Biophysical Technical Reports, TR 5C-10 – Wildlife Technical Report, Appendix B – Potential Wildlife Species with Special Conservation Status, PDF pages 1 to 35 of 97

**Vegetation**

- [A3S1L9](#), Application Volume 5A – ESA – Biophysical, Section 5.9.3 – Plant and Lichen Species of Concern, PDF pages 10 to 15 of 21
- [A3S2I7](#), Application Volume 5C – ESA – Biophysical Technical Reports, TR 5C-9 – Vegetation Technical Report, Sections 4.3 and 5.3 Plant and Lichen Species of Concern, PDF pages 54 to 76 and 110 to 124 of 184

**Marine birds**

- [A3S2R8](#), Application Volume 5C – ESA – Biophysical Technical Reports, TR 5C-14 – Marine Birds – Westridge Marine Terminal Technical Report, Section 4.4 – Marine Bird Species at Risk, PDF pages 35 and 36 of 69
- [A3S4J6](#), Application Volume 8B – Marine Environmental and Socio-Economic Technical Reports, TR 8B-2 – Marine Birds – Marine Transportation Technical Report, Section 4.3.7 – Marine Bird Species at Risk, PDF pages 57 to 59 of 90

.../2

**Marine aquatic species**

- [A3S4Y0](#), Application Volume 8A – Marine Transportation, Section 4.2.9 – Marine Species at Risk, PDF pages 13 to 16 of 34
- [A3S1Q8](#), Application Volume 5A – ESA – Biophysical, Section 6.2 – Westridge Marine Terminal, PDF page 32 of 48

**Freshwater aquatic species**

- [A3S2C1](#), Application Volume 5C – ESA – Biophysical Technical Reports, TR 5C-7 – Fisheries (British Columbia) Technical Report, Section 4.1.3 – Fish Species of Concern, PDF page 52 of 106

Trans Mountain did not identify any SARA-listed species in its Fish and Fish Habitat Regional Study Area in Alberta ([A3S1W7](#), Application Volume 5C – ESA – Biophysical Technical Reports, TR 5C-6 – Fisheries (Alberta) Technical Report, Section 4.1.2 – Species of Management Concern, PDF page 2 of 116).

As you are likely aware, the Project is subject to an environmental assessment under the *Canadian Environmental Assessment Act, 2012*. Additional information about the environmental assessment is available through the Canadian Environmental Assessment Registry Internet Site using Reference No. 80061.

Yours truly,

*Original signed by*

Sheri Young  
Secretary of the Board

Attachment (Distribution List)



## Distribution List

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Dossier OF-Fac-Oil-T260-2013-03 02  
Le 23 avril 2014

Destinataires : Liste de distribution

**Trans Mountain Pipeline ULC (Trans Mountain)  
Demande visant le projet d'agrandissement du réseau de Trans Mountain (le projet)  
Effets possibles sur des espèces figurant sur la liste de la *Loi sur les espèces en péril***

Madame, Monsieur,

L'Office national de l'énergie, aux termes de la *Loi sur les espèces en péril*, informe par les présentes le ministre de l'Environnement et le ministre des Pêches et des Océans que le projet susmentionné, s'il est approuvé et construit, pourrait avoir des répercussions sur des espèces mentionnées à l'annexe 1 de cette loi, ou sur leur habitat, tel qu'il est indiqué dans les dépôts suivants qui font partie de la demande (en anglais seulement).

**Faune terrestre**

- [A3S2R4](#), Demande, volume 5C – Environmental and Socio-Economic Assessment (ESA) – Biophysical Technical Reports, TR 5C-10 – Wildlife Technical Report, annexe B – Potential Wildlife Species with Special Conservation Status, pages 1 à 35 sur 97 du PDF

**Végétation**

- [A3S1L9](#), Demande, volume 5A – ESA – Biophysical, section 5.9.3 – Plant and Lichen Species of Concern, pages 10 à 15 sur 21 du PDF
- [A3S2I7](#), Demande, volume 5C – Environmental and Socio-Economic Assessment – Biophysical Technical Reports, TR 5C-9 – Vegetation Technical Report, sections 4.3 et 5.3 Plant and Lichen Species of Concern, pages 54 à 76 et 110 à 124 sur 184 du PDF

**Oiseaux de mer**

- [A3S2R8](#), Demande, volume 5C – Environmental and Socio-Economic Assessment – Biophysical Technical Reports, TR 5C-14 – Marine Birds – Westridge Marine Terminal Technical Report, section 4.4 – Marine Bird Species at Risk, pages 35 et 36 sur 69 du PDF
- [A3S4J6](#), Demande, volume 8B – Marine Environmental and Socio-Economic Technical Reports, TR 8B-2 – Marine Birds – Marine Transportation Technical Report, section 4.3.7 – Marine Bird Species at Risk, pages 57 à 59 sur 90 du PDF

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### Espèces marines

- [A3S4Y0](#), Demande, volume 8A – Marine Transportation, section 4.2.9 – Marine Species at Risk, pages 13 à 16 sur 34 du PDF
- [A3S1Q8](#), Demande, volume 5A – ESA – Biophysical, section 6.2 – Westridge Marine Terminal, page 32 sur 48 du PDF

### Espèces dulcicoles

- [A3S2C1](#), Demande, volume 5C – ESA – Biophysical Technical Reports, TR 5C-7 – Fisheries (British Columbia) Technical Report, section 4.1.3 – Fish Species of Concern, page 52 sur 106 du PDF

Trans Mountain n'a recensé aucune espèce inscrite à la liste de la *Loi sur les espèces en péril* dans sa zone d'étude régionale du poisson et de l'habitat du poisson en Alberta ([A3S1W7](#), Demande, volume 5C – ESA – Biophysical Technical Reports, TR 5C-6 – Fisheries (Alberta) Technical Report, section 4.1.2 – Species of Management Concern, page 2 sur 116 du PDF).

Vous savez sans doute que le projet est assujéti à l'exigence d'une évaluation environnementale aux termes de la *Loi canadienne sur l'évaluation environnementale (2012)*. Pour un complément d'information au sujet de l'évaluation visée aux présentes, veuillez consulter le site Internet du Registre canadien d'évaluation environnementale, numéro de référence 80061.

Veuillez agréer, Madame, Monsieur, mes sincères salutations.

La secrétaire de l'Office,

*Original signé par*

Sheri Young

Pièce jointe (liste de distribution)

## Liste de distribution

Triage & Planning Unit  
Fisheries Protection Program  
Ecosystem Management Branch  
Fisheries and Oceans Canada  
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be shot or snared, or hunted by net and spear. Common kinds of birds and eggs harvested in the Marine RSA include goldeneye, canvasback, ruddy duck, wood duck, American wigeon, northern pintail, mallard, northern shoveler, green-winged teal, grebe and murre (First Nations Health Council 2011a, Jacques Whitford Ltd. 2006, Simonsen *et al.* 1995). Extensive studies completed by Fediuk and Thom (2003) with the Elders from various Salish communities have identified 31 bird species as culturally relevant that have been traditionally harvested (*e.g.*, black scoter, white scoter, murre, bald eagle, golden eagle, ruffed grouse, blue grouse, mallard, trumpeter swan, western grebe).

#### 4.2.8.8 *US Waters*

The WDFW has set aside certain areas of Puget Sound marine waters for the protection and preservation of marine species and/or habitats. These are generally known as MPAs and include 9 Conservation areas, 16 Marine Preserves and 2 Sea Cucumber and Sea Urchin Commercial Harvest Exclusion Zones. The greater San Juan Island archipelago holds the most MPAs. Many of these sites provide habitat for breeding colonies of several species of marine birds. The north coast of the state has the largest MPA, the Olympic Coast National Marine Sanctuary. Several state parks, IBAs, federal historical parks and federal marine sanctuaries are also present in Puget Sound (Van Cleve *et al.* 2009, WDFW 2013a) as well as MPAs administered by other agencies, such as the Department of Natural Resources, as mentioned above.

#### 4.2.9 **Marine Species at Risk**

This subsection identifies the federally and provincially listed marine species at risk (fish, mammals and birds) that may occur within the Marine RSA (Table 4.2.9.1), including those whose potential occurrence would be considered rare or unlikely. More detailed technical information pertaining to marine species at risk and their potential occurrence in the Marine RSA is presented in the marine fish and fish habitat, marine mammals and marine birds sections (Section 4.2.6, 4.2.7 and 4.2.8 respectively).

A discussion of the potential effects of the increased Project-related marine vessel traffic for marine species at risk can be found in Section 4.3.9.

This list was developed through a review of the federal Species at Risk Public Registry, COSEWIC assessments and status reports, and the BC CDC Red and Blue lists.

A total of 53 marine species at risk have been identified as potentially occurring within the Marine RSA, including 19 marine fish and invertebrate species (or populations), 15 marine mammal species (or ecotypes) and 19 marine bird species (BC CDC 2013, Government of Canada 2013a,b).

**TABLE 4.2.9.1**

**MARINE SPECIES AT RISK IN THE MARINE RSA**

<b>Species Name (population[s])</b>	<b>Taxon</b>	<b>SARA Status<sup>1</sup></b>	<b>COSEWIC Status<sup>1</sup></b>	<b>BC List Status<sup>1</sup></b>
Ancient murrelet <i>Synthliboramphus antiquus</i>	Marine bird	Special Concern Schedule 1	Special Concern	Blue
Basking shark <i>Cetorhinus maximus</i>	Fish	Endangered Schedule 1	Endangered	No Status
Black-footed albatross <i>Phoebastria nigripes</i>	Marine bird	Special Concern Schedule 1	Special Concern	Blue
Blue whale <i>Balaenoptera musculus</i>	Marine mammal	Endangered Schedule 1	Endangered	Red
Bluntnose sixgill <i>Shark Hexanchus griseus</i>	Fish	Special Concern Schedule 1	Special Concern	No Status
Bocaccio <i>Sebastes paucispinis</i>	Fish	No Status	Threatened	No Status
Brandt's cormorant <i>Phalacrocorax penicillatus</i>	Marine bird	No Status	No Status	Red
Brant <i>Branta bernicla</i>	Marine bird	No Status	No Status	Blue
Canary rockfish <i>Sebastes pinniger</i>	Fish	No Status	Threatened	No Status
Caspian tern <i>Hydroprogne caspia</i>	Marine bird	No Status	Not at Risk	Blue
Cassin's auklet <i>Ptychoramphus aleuticus</i>	Marine bird	No Status	Candidate	Blue
Chinook salmon <i>Oncorhynchus tshawytscha</i> (Okanagan population)	Fish	No Status	Threatened	Yellow
Common murre <i>Uria aalge</i>	Marine bird	No Status	No Status	Red
Coho salmon <i>Oncorhynchus kisutch</i> (Interior Fraser population)	Fish	No Status	Endangered	No Status
Darkblotched rockfish <i>Sebastes crameri</i>	Fish	No Status	Special Concern	No Status
Double-crested cormorant <i>Phalacrocorax auritus</i>	Marine bird	No Status	Not at Risk	Blue
Eulachon <i>Thaleichthys pacificus</i> (Fraser River population)	Fish	No Status	Endangered	Blue
Fin whale <i>Balaenoptera physalus</i>	Marine mammal	Threatened Schedule 1	Threatened	Red
Great blue heron <i>Ardea herodias fannini</i>	Marine bird	Special Concern Schedule 1	Special Concern	Blue

**TABLE 4.2.9.1**

**MARINE SPECIES AT RISK IN THE MARINE REGIONAL STUDY AREA (continued)**

Species Name (population[s])	Taxon	SARA Status <sup>1</sup>	COSEWIC Status <sup>1</sup>	BC List Status <sup>1</sup>
Grey whale <i>Eschrichtius robustus</i>	Marine mammal	Special Concern Schedule 1	Special Concern	Blue
Harbour porpoise <i>Phocoena phocoena</i>	Marine mammal	Special Concern Schedule 1	Special Concern	Blue
Horned puffin <i>Fratercula corniculata</i>	Marine bird	No Status	No Status	Red
Humpback whale <i>Megaptera novaeangliae</i>	Marine mammal	Threatened Schedule 1	Special Concern	Blue
Killer whale <i>Orcinus orca</i> (Northeast Pacific southern resident population)	Marine mammal	Endangered Schedule 1	Endangered	Red
Killer whale <i>Orcinus orca</i> (Northeast Pacific northern resident population)	Marine mammal	Threatened Schedule 1	Threatened	Red
Killer whale <i>Orcinus orca</i> (Northeast Pacific transient [or Bigg's] population)	Marine mammal	Threatened Schedule 1	Threatened	Red
Killer whale <i>Orcinus orca</i> (offshore population)	Marine mammal	Threatened Schedule 1	Threatened	Red
Long-billed curlew <i>Numenius americanus</i>	Marine bird	Special Concern Schedule 1	Special Concern	Blue
Longspine thornyhead <i>Sebastolobus altivelis</i>	Fish	Special Concern Schedule 1	Special Concern	No Status
Marbled murrelet <i>Brachyramphus marmoratus</i>	Marine bird	Threatened Schedule 1	Threatened	Blue
North Pacific right whale <i>Eubalaena japonica</i>	Marine mammal	Endangered Schedule 1	Endangered	Red
North Pacific spiny dogfish <i>Squalus suckleyi</i>	Fish	No Status	Special Concern	No Status
Northern abalone <i>Haliotis kamtschatkana</i>	Mollusc	Endangered Schedule 1	Endangered	Red
Northern fulmar <i>Fulmarus glacialis</i>	Marine bird	No Status	No Status	Red
Northern fur seal <i>Callorhinus ursinus</i>	Marine mammal	No Status	Threatened	Blue
Olympia oyster <i>Ostrea lurida</i>	Mollusc	Special Concern Schedule 1	Special Concern	Blue

**TABLE 4.2.9.1**

**MARINE SPECIES AT RISK IN THE MARINE REGIONAL STUDY AREA (continued)**

Species Name (population[s])	Taxon	SARA Status <sup>1</sup>	COSEWIC Status <sup>1</sup>	BC List Status <sup>1</sup>
Pacific sardine <i>Sardinops sagax</i>	Fish	Special Concern Schedule 3	Not at Risk	No Status
Pelagic cormorant <i>Phalacrocorax pelagicus pelagicus</i>	Marine bird	No Status	No Status	Red
Pink-footed shearwater <i>Puffinus creatopus</i>	Marine bird	Threatened Schedule 1	Threatened	Blue
Quillback rockfish <i>Sebastes maliger</i>	Fish	No Status	Threatened	No Status
Red knot <i>Calidris canutus roselaari</i>	Marine bird	Threatened Schedule 1	Threatened	Red
Rougheye rockfish type I <i>Sebastes</i> sp. type I & II	Fish	Special Concern Schedule 1	Special Concern	No Status
Sea otter <i>Enhydra lutris</i>	Marine mammal	Special Concern Schedule 1	Special Concern	Blue
Sei whale <i>Balaenoptera borealis</i>	Marine mammal	Endangered Schedule 1	Endangered	Red
Short-tailed albatross <i>Phoebastria albatrus</i>	Marine bird	Threatened Schedule 1	Threatened	Red
Sockeye salmon <i>Oncorhynchus nerka</i> (Cultus population, Sakinaw population)	Fish	No Status	Endangered	No Status
Sperm whale <i>Physeter macrocephalus</i>	Marine mammal	No Status	Not at Risk	Blue
Steller sea lion <i>Eumetopias jubatus</i>	Marine mammal	Special Concern Schedule 1	Special Concern	Blue
Thick-billed murre <i>Uria lomvia</i>	Marine bird	No Status	No Status	Red
Tope <i>Galeorhinus galeus</i>	Fish	Special Concern Schedule 1	Special Concern	No Status
Tufted puffin <i>Fratercula cirrhata</i>	Marine bird	No Status	No Status	Blue
Yelloweye rockfish <i>Sebastes ruberrimus</i> (Pacific Ocean outside waters population, inside waters population)	Fish	Special Concern Schedule 1	Special Concern	No Status
Yellowmouth rockfish <i>Sebastes reedi</i>	Fish	No Status	Threatened	No Status

**Sources:** BC CDC 2013, Government of Canada 2013a,b. List was last updated on November 25, 2013.

**Note:** 1 See Section 4.2.1.3 for definitions of COSEWIC, SARA and BC List status

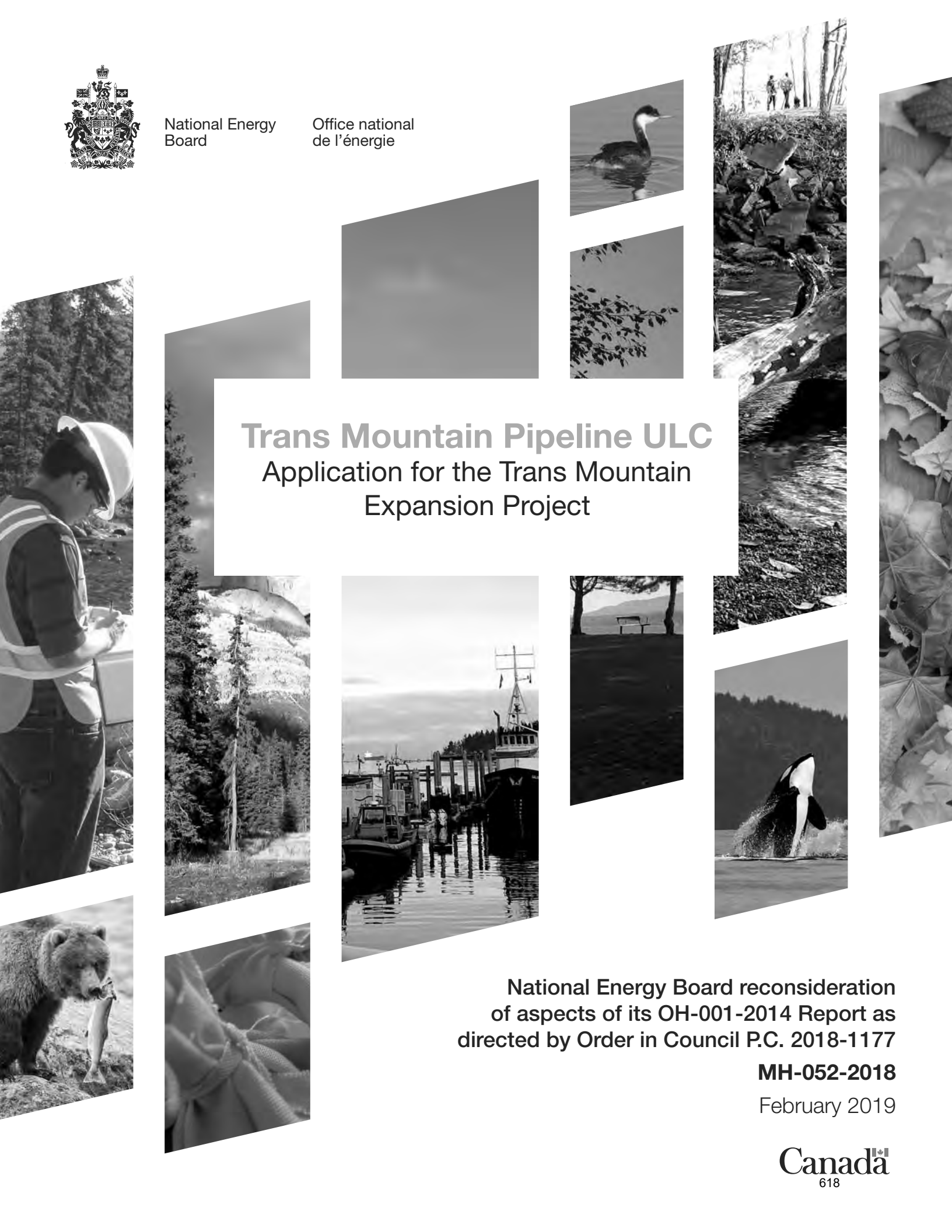


# TAB V



National Energy Board

Office national de l'énergie



# Trans Mountain Pipeline ULC Application for the Trans Mountain Expansion Project

National Energy Board reconsideration  
of aspects of its OH-001-2014 Report as  
directed by Order in Council P.C. 2018-1177

**MH-052-2018**

February 2019

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# National Energy Board Report

## **Application for the Trans Mountain Expansion Project**

National Energy Board  
reconsideration of aspects of its  
OH-001-2014 Report as directed by  
Order in Council P.C. 2018-1177

MH-052-2018

February 2019

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This report does not provide any indications of whether or not any application will be approved. The NEB will decide on specific applications based on the material in evidence before it at that time.

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National Energy Board - Reconsideration Report -  
Trans Mountain Pipeline ULC - MH-052-2018

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Le présent rapport ne fournit aucune indication relativement à l'approbation ou au rejet d'une demande quelconque. L'Office étudie chaque demande en se fondant sur les documents qui lui sont soumis en preuve à ce moment.

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Office national de l'énergie - Rapport de réexamen -  
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Ce rapport est publié séparément dans les deux langues officielles. On peut obtenir cette publication sur supports multiples, sur demande.

Burden associated with:	Brief description	Type of impact	Report chapter(s)
Marine greenhouse gas emissions	The Board finds that greenhouse gas emissions from Project-related marine vessels would result in measureable increases and, taking a precautionary approach, are likely to be significant.	Regional National	14
Municipal development plans	The Board finds that the Project may pose a modest burden on municipalities with respect to potentially constraining future plans for municipal development. There is the potential for reduced flexibility and/ or additional municipal time constraints with respect to planned or possible future municipal projects that may be impacted by the Project.	Local	11
Indigenous groups' ability to use the land and water during construction and operation	The Board finds that there would be modest burdens sustained by Indigenous groups as their ability to use the lands, waters and resources for traditional purposes would be temporarily impacted by construction and routine maintenance activities, and that some opportunities for certain activities such as harvesting or accessing sites or areas of traditional use would be temporarily interrupted. For activities directly affected by the Westridge Marine Terminal, the Board finds that these effects would persist for the operational life of the Project, as traditional activities would not occur within the expanded water lease boundaries. The Board finds that while the effects would be long term in duration, they would be reversible in the long term and would be confined to the water lease boundary for the WMT.	Local	11
Landowners' and land users' ability to use the land and water during construction and operation	The Board finds that there would be modest burdens sustained by Landowners and land users as their ability to use the land and water would be affected by construction and routine maintenance activities during operations. Construction and routine maintenance activities will cause temporary, limited effects on recreational and commercial hunting, fishing, agricultural practices and access to property, and will cause nuisance disturbance such as noise.	Local	11
Project spill (i.e., from pipeline, tank terminals, pump stations, or Westridge Marine Terminal)	The Board finds that there is a very low probability of a Project spill (i.e., from pipeline, tank terminals, pump stations, or Westridge Marine Terminal) that may result in a significant effect (high consequence). The Board finds this level of risk to be acceptable.	Local Regional	2 9 10 11
Spill from a Project-related tanker	The Board finds that there is a very low probability of a large marine spill from a Project-related tanker (a spill along the marine shipping lanes out to the 12-nautical-mile boundary) that may result in a significant effect (high consequence). The Board finds this level of risk to be acceptable.	Local Regional	2 14

## 2.3 Recommendation and decisions of the Reconsideration Panel

### 2.3.1 Recommendation under the CEAA 2012

In the OH-001-2014 Report, the Board recommended that the GIC find that the Project is not likely to cause significant adverse environmental effects under the CEAA 2012. This resulted from the fact that Project-related marine shipping was not included within the scope of the Board's environmental assessment under the CEAA 2012 in the OH-001-2014 hearing. The Board also made a recommendation with respect to the follow-up program to be implemented in respect of the Project under the CEAA 2012.

In the MH-052-2018 hearing, the Board carried out an environmental assessment of Project-related marine shipping under the CEAA 2012 (see Chapter 14). Pursuant to the CEAA 2012, the Board is of the view that Project-related marine shipping is likely to cause significant adverse environmental effects on the Southern resident killer whale, and on Indigenous cultural use associated with the Southern resident killer whale. The Board also finds that greenhouse gas emissions from Project-related marine vessels would result in measureable increases and, taking a precautionary approach, are likely to be significant. The Board finds that, although a credible worst-case spill from a tanker associated with the Project would result in significant adverse environmental effects, such an event is not likely. Therefore, under subsection 30(4) of the CEAA-2012, the Board is setting out a different recommendation and modifying the mitigation measures set out in this MH-052-2018 Report with respect to the environmental assessment. Taking into account the implementation of any mitigation measures specified in the MH-052-2018 Report, the Board concludes, that the Designated Project is likely to cause significant adverse environmental effects. Having so concluded, the Board must consider whether these effects can be justified in the circumstances.

## Greenhouse gas emissions

The Board has focused its assessment on the direct greenhouse gas emissions generated from the Project-related vessels, as opposed to assessing the global climate effects of the greenhouse gas emissions. As described in Chapter 10, Section 10.2.2 in the Board's view, attempting to determine and assess the eventual global climate effects of greenhouse gas emissions generated by the Project-related vessels is not practical in terms of meaningfully informing an environmental assessment recommendation on this Project. The Board has not provided a table for describing the significance of GHG emissions unlike for other valued components. The Board relied on the magnitude of GHG emissions (i.e., increase in GHG emissions from Project-related marine shipping) given that the GHG emissions accumulate in the global atmosphere and are permanent in nature.

The evidence indicates that the Project-related marine vessels are expected to result in an increase of approximately 6.9 per cent in marine greenhouse gas emissions in the RSA, 2.1 per cent in marine greenhouse gas emissions in B.C., and 1.2 per cent in marine greenhouse gas emissions in Canada.

The Board notes that in the MH-052-2018 hearing, ECCC estimated a total of 76,200 tonnes of CO<sub>2</sub> emissions per year of combustion greenhouse gas emissions from Project-related tankers as opposed to Trans Mountain's estimate of 68,100 carbon dioxide equivalent tonnes per year. The Board accepts Trans Mountain's methodology for estimating total GHG emissions from Project-related tankers and finds that ECCC's estimate included emissions from the current tanker traffic as opposed to estimating emissions from Project-related marine shipping only. The Board also notes other differences in the assumptions which in Board's view would could increase the total estimate. The Board notes that the difference in Trans Mountain's and ECCC's estimates of increases from Project-related marine greenhouse gas emissions are very small and insignificant, ranging from 5.9 per cent to 6.9 per cent relative to B.C. marine greenhouse gas emissions, and 1.2 per cent to 1.5 per cent when compared to Canada-wide marine greenhouse gas emissions.

In regards to Trans Mountain's cumulative effects assessment, the Board finds the approach reasonable. Trans Mountain provided per cent increases due to Project-related tanker traffic to marine greenhouse gas emissions in Marine RSA, in B.C., and in Canada. The Board agrees with Trans Mountain's reasoning that conducting a cumulative effect assessment of greenhouse gas emissions would need to include all international foreseeable future development, which in the Board's view is not practical. In addition, the Board notes that the Canadian Environmental Assessment Agency's guidance document "Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners" does not prescribe a certain methodology for conducting cumulative effects assessment of greenhouse gas emissions.

The Board notes that in the OH-001-2014 hearing, no mitigation measures were considered in Trans Mountain's marine greenhouse gas emissions assessment and there are currently no regulatory reporting thresholds in Canada for marine greenhouse gas emissions. The Board notes that Project-related marine vessels are required to adhere to all federal and international emission requirements, including standards for bunker fuel. The Board recognizes that new energy efficiency standards were adopted by the International Maritime Organization in July 2011, and that these standards may reduce greenhouse gas emissions from new vessels in the future.

In the MH-052-2018 hearing, the Board heard that in 2017, the IMO Member States agreed on an initial strategy for reducing greenhouse gas emissions from ships, which targets at least a 50 per cent reduction from 2008 levels by year 2050. The Board also received various submissions that discussed plausible mitigation measures to reduce greenhouse gas emissions from marine vessels. These include speed reduction, vessel design, retrofit, and maintenance measures, use of alternate fuels, carbon taxation, and carbon pricing. The Board also heard that there are no fiscal incentives available at international or state level for the maritime industry to invest in more energy efficient vessels.

The Board also received evidence around use of LNG as a fuel source for Project vessels. The Board acknowledges the argument from Chamber of Shipping that notes that the efficiency of the supply chain may be an area worthy of an increased focus for achieving potential benefits from reduced greenhouse gas emissions. The Board supports Chamber of Shipping's view and encourages the supply chain visibility efforts undertaken by VFPA and Transport Canada.

The Board notes that with the federal clean fuel standard, the carbon intensity of the fuels will be lowered, thereby reducing the GHG emissions. The Board further notes that data collection system on fuel oil consumption of ships over 5,000 gross tons, which begins on 1 January 2019, will feed into a process towards adoption of a revised IMO strategy in 2023. This monitoring will provide a better understanding of actual GHG emissions for marine vessels, and to better track the intended reduction of GHG emissions.

The Board received comments from Shackan Indian Band that the Board ought to recommend additional conditions be placed on Trans Mountain to offset the GHG emissions of Project-related marine vessels. The Board notes that

Project-related marine vessels are required to adhere to all federal and international emission requirements, including standards for bunker fuel. In addition, Trans Mountain has set the age limits for tankers that would be acceptable to call at the WMT which will improve the efficiency of the vessels resulting in reduction of GHG emissions. The Board notes that this requirement related to vessel age limits is stated in Trans Mountain's VAS. The Board has imposed Condition 134 which requires Trans Mountain to file an updated VAS with the Board, at least 3 months prior to loading the first tanker at the Westridge Marine Terminal with oil transported by the Project, and thereafter on or before 31 January of each of the first five years after commencing operations. In regard to requiring offsets, the Board notes that Trans Mountain does not own or operate the vessels. The Board also notes ECCC's statement in regard to offsetting greenhouse gas emissions that Canada continues to work with the IMO on the next steps outlined in the Initial Greenhouse Gas Emissions Strategy and if a relevant measure such as an offset system for the sector was agreed to, Canada would need to develop and introduce regulations under an appropriate domestic legislation in line with the IMO regulation. Therefore, the Board is not persuaded to impose any additional conditions on Trans Mountain to offset the GHG emissions of Project-related marine vessels.

The Board finds that greenhouse gas emissions are a concern because of their long term accumulation in the atmosphere. The Board also finds that any incremental contribution from Project-related marine vessels would increase the burden at a global scale, regardless of how large or small the contribution.

Given that there are no regulatory reporting thresholds for marine greenhouse gas emissions in Canada and that the contribution from Project-related marine vessels to total Canadian greenhouse gas emissions would be 0.01 per cent, and taking a precautionary approach, the Board finds that greenhouse gas emissions from Project-related marine vessels are likely to be significant. The Board recommends to the GIC that it should support the development and implementation of greenhouse gas reduction measures related to marine shipping that would align with the final International Maritime Organization Strategy in year 2023 for reducing greenhouse gas emissions (Recommendation 10). These measures could include, but not be limited to facilitating the use of low-carbon alternate fuels, use of energy efficient technologies, and market-based measures, such as providing economic incentives for industry investment in the development and use of energy efficient technologies and offsetting any increases in ship emissions. The Board notes that Recommendation 2 would also be relevant in that it includes a description of the progress on each of the recommendations.

In the Board's view, if GIC implements the Board's recommendation around development and implementation of GHG reduction measures related to marine shipping that aligns with the final IMO strategy by 2023, the GHG emissions from Project-related shipping would be reduced. In addition, the Board is of the view that with the new energy efficiency standards adopted by the International Maritime Organization, and with the proposed regulations for federal clean fuel standard planned for spring/summer 2019, the GHG emissions will be further diminished.

#### 14.7.2 Marine mammals

Trans Mountain described the marine waters of B.C. as home to a broad range of marine mammal species, including cetaceans (whales, dolphins, and porpoises), pinnipeds (seals and sea lions), and sea otters. It said that the productive straits and sounds of the RSA provide important habitat for foraging, breeding, socializing, and migration. Trans Mountain said that many species of marine mammal can be observed in the RSA year-round, and thus depend on this environment for all aspects of their life history, while other species are predominantly seasonal in their presence, coming to feed for a season or simply passing through during migration. Trans Mountain identified 10 species of marine mammals, and 4 killer whale ecotypes, that are SARA-listed and have potential to occur in the RSA (Table 25). Trans Mountain said that critical habitat for the Southern resident killer whale and the North Pacific Humpback whale has been identified in the RSA (Figure 26).

Trans Mountain said that marine mammals in the RSA face a variety of anthropogenic threats and stressors. It said that stressors vary in intensity and relative importance for individual species but, broadly speaking, include: chemical contamination from both legacy contaminants and current inputs; reductions in prey abundance or quality; physical disturbance; acoustic disturbance or injury from both acute and chronic sources; risk of collisions; risk of entanglements; and, climate change.

# TAB W



# Action Plan for the Northern and Southern Resident Killer Whale (*Orcinus orca*) in Canada

## Resident Killer Whale



2017

**Recommended citation:**

Fisheries and Oceans Canada. 2017. Action Plan for the Northern and Southern Resident Killer Whale (*Orcinus orca*) in Canada. *Species at Risk Act* Action Plan Series. Fisheries and Oceans Canada, Ottawa. v + 33 pp.

For copies of the Action Plan, or for additional information on species at risk, including Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, recovery strategies, and other related recovery documents, please visit the [SAR Public Registry](#).

**Cover illustration:** Graeme Ellis

Également disponible en français sous le titre  
« Plan d'action pour les épaulards (*Orcinus orca*) résidents du nord et du sud au Canada »

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## Preface

The federal, provincial, and territorial government signatories under the [Accord for the Protection of Species at Risk \(1996\)](#) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of action plans for species listed as extirpated, endangered, or threatened for which recovery has been deemed feasible. They are also required to report on progress five years after the publication of the final document on the Species at Risk Public Registry.

The Minister of Fisheries and Oceans and the Minister responsible for Parks Canada Agency are the competent ministers under SARA for the Northern and Southern Resident Killer Whale and have prepared this Action Plan to implement the Recovery Strategy, as per Section 47 of SARA. In preparing this Action Plan, the competent ministers have considered, as per Section 38 of SARA, the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty. To the extent possible, this Action Plan has been prepared in cooperation with Environment and Climate Change Canada, Transport Canada, the Department of National Defence, the Canadian Coast Guard, Natural Resources Canada, the Province of British Columbia, and the U.S. National Oceanographic and Atmospheric Administration (NOAA) as per section 48(1) of SARA.

As stated in the preamble to SARA, success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions and actions set out in this Action Plan and will not be achieved by Fisheries and Oceans Canada and Environment and Climate Change Canada or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing this Action Plan for the benefit of the Northern and Southern Resident Killer Whale and Canadian society as a whole.

Under SARA, an action plan provides the detailed recovery planning that supports the strategic direction set out in the recovery strategy for the species. The plan outlines recovery measures to be taken by Fisheries and Oceans Canada and Environment and Climate Change Canada and other jurisdictions and/or organizations to help achieve the population and distribution objectives identified in the recovery strategy. Implementation of this action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

## Acknowledgments

This Action Plan was prepared by Sheila J. Thornton (Fisheries and Oceans Canada, Pacific Region). The development of the Action Plan was the result of collaborative efforts and contributions from many individuals and organizations. The Northern and Southern Resident Killer Whale Action Plan Team (Appendix C) compiled the contributions from DFO Science, the Northern and Southern Killer Whale Prey and Disturbance workshop (March 8-10, 2011), preliminary public consultations (January 19 to February 16, 2012), the NOAA/DFO bilateral workshop series on The Effects of Salmon Fisheries on Southern Resident Killer Whales (September 21-23, 2011, March 13-15, 2012 and September 18-20, 2012), and feedback obtained during public consultation on the draft (March 3 to April 16, 2014) and proposed (June 14 to August 15, 2016) versions of the document.

## Executive Summary

The Northern and Southern Resident Killer Whale (*Orcinus orca*) were listed as Threatened and Endangered, respectively, under the *Species at Risk Act* (SARA) in 2003. This Action Plan is considered one in a series of documents that are linked and should be taken into consideration together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report, a recovery potential assessment, and the Recovery Strategy.

Three distinct ecotypes of Killer Whale inhabit the waters off British Columbia, each exhibiting different prey preferences, dialects and social organization. The Resident, Offshore, and Transient (Bigg's) Killer Whale ecotypes are believed to be socially and genetically isolated, despite sharing the same waters. Resident Killer Whales feed exclusively on fish (primarily salmon) and cephalopods, while Transient (Bigg's) Killer Whales feed primarily on marine mammals. Offshore Killer Whales are the least understood of the three ecotypes, but are believed to primarily consume fish, with shark species comprising a significant portion of their diet.

Two distinct populations of Resident Killer Whales occupy the waters off the west coast of British Columbia. The populations are referred to as the Northern Residents and Southern Residents, and although the ranges of these two populations overlap, they are acoustically, genetically and culturally distinct from each other. Killer Whale populations in British Columbia are presently considered to be at risk because of their small population size, low reproductive rate, and the existence of a variety of anthropogenic threats that have the potential to prevent recovery or to cause further declines. Even under the most optimistic scenario (human activities do not increase mortality or decrease reproduction), the species' low intrinsic growth rate means that the time frame for recovery will be more than one generation (25 years).

Principal among the anthropogenic threats to recovery are reductions in the availability or quality of prey, environmental contamination, and both physical and acoustic disturbance. As these threats are common to all three ecotypes, the measures identified in the Resident Killer Whale Action Plan are highly likely to benefit Transient (Bigg's) and Offshore Killer Whale populations that frequent Canadian Pacific waters.

This Action Plan outlines measures that provide the best chance of achieving the population and distribution objectives for the species, including the measures to be taken to address the threats and monitor the recovery of the species. The recovery strategy defined the population and distribution objective for the Northern and Southern Resident Killer Whale as:

*Ensure the long-term viability of Resident Killer Whale populations by achieving and maintaining demographic conditions that preserve their reproductive potential, genetic variation, and cultural continuity<sup>1</sup>.*

Section 1.2 outlines the measures to be taken under the following broad strategies:

- *Monitor and refine knowledge of Resident Killer Whale population and distribution in Canadian Pacific waters*

---

<sup>1</sup> Culture refers to a body of information and behavioural traits that are transmitted within and between generations by social learning

- *Ensure that Resident Killer Whales have an adequate and accessible food supply to allow recovery*
- *Ensure that disturbance from human activities does not prevent the recovery of Resident Killer Whales*
- *Ensure that chemical and biological pollutants do not prevent the recovery of Resident Killer Whale populations*
- *Protect critical habitat for Resident Killer Whales and identify additional areas for critical habitat designation and protection*

For the Northern and Southern Resident Killer Whale, critical habitat was identified to the extent possible, using the best available information, in Section 8 of the Recovery Strategy. The species' critical habitat is protected from destruction by a SARA Critical Habitat Order made under subsections 58(4) and (5), which invokes the prohibition in subsection 58(1) against the destruction of the identified critical habitat (Section 2.3).

An evaluation of the socio-economic costs of the Action Plan and the benefits to be derived from its implementation is provided in Section 3.

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# 1. Recovery Actions

## 1.1 Context and Scope of the Action Plan

The Northern and Southern Resident Killer Whale (*Orcinus orca*) were listed as Threatened and Endangered respectively under the *Species at Risk Act* (SARA) in 2003. This Action Plan is part of a series of documents regarding the Northern and Southern Resident Killer Whale, including the [COSEWIC Status Report](#) (COSEWIC 2009), and the [Recovery Strategy](#) that should be taken into consideration together. Under SARA, an action plan provides the detailed recovery planning that supports the strategic direction set out in a recovery strategy for the species. A recovery strategy also provides background information on the species and its threats and critical habitat information.

Two distinct populations of fish-feeding ‘resident’ Killer Whales (*Orcinus orca*), known as the Northern and Southern Residents, occupy the waters off the west coast of British Columbia. Although the ranges of these two populations overlap, they are acoustically, genetically and culturally distinct from each other. Resident Killer Whale populations in British Columbia are presently considered to be at risk because of their small population size, low reproductive rate, and the existence of a variety of anthropogenic threats that have the potential to prevent recovery or to cause further declines. Principal among these anthropogenic threats are reductions in the availability or quality of prey, environmental contamination, and both physical and acoustic disturbance. Even under the most optimistic scenario (human activities do not increase mortality or decrease reproduction), the species’ low intrinsic growth rate means that the time frame for recovery will be more than one generation (25 years).

The Southern Resident Killer Whale population experienced declines of 3% per year between 1995 and 2001, and since then has shown little recovery, having 80 members in 2016. During the summer and fall, Southern Residents are primarily found in the transboundary waters of Haro Strait, Boundary Pass, the eastern portion of the Juan de Fuca Strait, and southern portions of the Strait of Georgia. This area is designated as ‘critical habitat’ based on consistent and prolonged seasonal occupancy. Some members of the population typically remain in the same general area in winter and spring, but others appear to range over much greater distances, and have been reported as far south as Monterey Bay, California, and as far north as Southeast Alaska. Winter and spring critical habitat has not been identified for the latter group. During the summer and fall, the principal prey of Southern Residents appears to be Chinook and Chum Salmon (*Oncorhynchus tshawytscha* and *O. keta*); little is known of their diet in the winter and spring. The lack of information about winter diet and distribution of the Southern Residents is a major knowledge gap that impedes our understanding of the principal threats facing the population.

The Northern Resident Killer Whale population experienced a decline of 7% between 1997 and 2001. The population has since increased from 219 members in 2004, to 290 members in 2014 (Towers *et al*, 2015). Northern Residents appear to spend the majority of their time from central Vancouver Island (both west and east coasts) and northwest to Dixon Entrance, but have been sighted as far south as Grays Harbor, Washington, and as far north as Glacier Bay, Alaska. A portion of the population is regularly found in Johnstone Strait and southeastern portions of Queen Charlotte Strait (and adjoining channels) during the summer and fall, and this area is identified as critical habitat based on this consistent seasonal occupancy. Other areas are likely very important to Northern Residents during this time but they have yet to be clearly identified. Similarly, areas that may constitute critical habitat during the winter and spring are not yet



known. Northern Residents also appear to feed primarily on Chinook and Chum Salmon during the summer and fall. However, like Southern Residents, very little is known of their winter distribution and diet, and this knowledge gap must be addressed to fully understand the principal threats affecting the population.

The recovery strategy defined the population and distribution objective for the Northern and Southern Resident Killer Whale as:

*Ensure the long-term viability of Resident Killer Whale populations by achieving and maintaining demographic conditions that preserve their reproductive potential, genetic variation, and cultural continuity<sup>2</sup>.*

Under Section 47 of SARA, the competent minister must prepare one or more action plans based on the recovery strategy. Therefore, action planning for species at risk recovery is an iterative process. The Implementation Schedule in this Action Plan may be modified in the future depending on the progression towards recovery.

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<sup>2</sup> Culture refers to a body of information and behavioural traits that are transmitted within and between generations by social learning

## 1.2 Measures to be Taken and Implementation Schedule

Success in the recovery of this species is dependent on the actions of many different jurisdictions; it requires the commitment and cooperation of the constituencies that will be involved in implementing the directions and measures set out in this Action Plan.

This Action Plan provides a description of the measures that provide the best chance of achieving the population and distribution objectives for the Northern and Southern Resident Killer Whale, including measures to be taken to address threats to the species and monitor its recovery, to guide not only activities to be undertaken by Fisheries and Oceans Canada and Environment and Climate Change Canada, but those for which other jurisdictions, organizations and individuals have a role to play. As new information becomes available, these measures and the priority of these measures may change. Fisheries and Oceans Canada strongly encourages all Canadians to participate in the conservation of the Northern and Southern Resident Killer Whale through undertaking measures outlined in this action plan.

Principal among the anthropogenic threats to recovery are reductions in the availability or quality of prey, environmental contamination, and both physical and acoustic disturbance. As these threats are common to all three ecotypes, of the 98 measures identified to recover Resident Killer Whales, 63 (64%) are likely to benefit Transient (Bigg's) and Offshore Killer Whale populations that frequent Canadian Pacific waters.

Table 1 identifies the measures to be undertaken by Fisheries and Oceans Canada to support the recovery of the Northern and Southern Resident Killer Whale.

Table 2 identifies the measures to be undertaken collaboratively between Fisheries and Oceans Canada and its partners, other agencies, organizations or individuals. Implementation of these measures will be dependent on a collaborative approach, in which Fisheries and Oceans Canada is a partner in recovery efforts, but cannot implement the measures alone.

Table 3 identifies the remaining measures that represent opportunities for other jurisdictions, organizations or individuals to lead for the recovery of the species, as all Canadians are invited to join in supporting and implementing this Action Plan. If your organization is interested in participating in one of these measures, please contact the Species at Risk Pacific Region office at [sara@pac.dfo-mpo.gc.ca](mailto:sara@pac.dfo-mpo.gc.ca).

Implementation of this action plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

**Table 1: Measures to be undertaken by Fisheries and Oceans Canada.**

Measures noted by an asterisk (\*) have been identified as also likely to provide benefits to Transient (Bigg's) and Offshore Killer Whales (6 of 17, or 35% of measures).

#	Recovery Measures	Priority <sup>3</sup>	Threats or Concerns Addressed	Timeline <sup>4</sup>
<b>Broad Strategy 1: Monitor the population abundance and demographics of Resident Killer Whales and refine knowledge of their seasonal distribution and foraging ecology in Canadian Pacific waters.</b>				
1	Undertake an annual census to monitor and assess Resident Killer Whale population dynamics (multi-species ship surveys and dedicated vessel surveys).	High	Prey availability Disturbance Contaminants	Annual; ongoing
2	Estimate the carrying capacity of Resident Killer Whale habitat (population modeling).	High	Prey availability	5 years
<b>Broad Strategy 2: Ensure that Resident Killer Whales have an adequate and accessible food supply to allow recovery.</b>				
<b>Approach 1: Determine the seasonal diet, feeding areas and energetic requirements of Northern and Southern Resident Killer Whales.</b>				
3	Examine indicators of prey aggregation to identify potential Resident Killer Whale foraging areas (e.g. salmon fishing effort, catch success).	High	Prey availability	Annual; ongoing

<sup>3</sup> "Priority" reflects the degree to which the action contributes directly to the recovery of the species or is an essential precursor to an action that contributes to the recovery of the species.

- "High" priority measures are considered likely to have an immediate and/or direct influence on the recovery of the species.
- "Medium" priority measures are important but considered to have an indirect or less immediate influence on the recovery of the species.
- "Low" priority measures are considered important contributions to the knowledge base about the species and mitigation of threats.

<sup>4</sup> "Timeline" is the timeframe from posting of the final document in which the measure will be accomplished. A timeline listed as "ongoing" indicates the importance that that measure be conducted regularly through the foreseeable future; "unknown" means that the current paucity or complete lack of data for a given species does not allow us to state a certain timeline at this point; "uncertain" indicates that the measure is led by a 3rd party and timelines have not yet been determined.

#	Recovery Measures	Priority <sup>3</sup>	Threats or Concerns Addressed	Timeline <sup>4</sup>
<b>Approach 3: Establish long term monitoring programs capable of detecting changes in abundance, distribution and quality of Resident Killer Whale prey.</b>				
4	Identify features that define “quality” prey for Resident Killer Whales and determine a means of assessment (e.g. length, age, caloric value, lipid content, contaminant load).	Medium	Prey availability	5 years
5	Assess the quality of identified prey species on an annual basis.	Medium	Prey availability	Annual; ongoing
<b>Approach 4. Develop prospective actions to be taken during poor Chinook return years to ensure sufficient prey availability for Resident Killer Whales.</b>				
6	Take into account both the seasonal (acute) as well as the cumulative (chronic) effects of poor returns for Chinook and other important prey species on Resident Killer Whales when managing fisheries.	High	Prey availability	5 years
7	Investigate the benefits of strategic salmon fishery planning approaches and management actions to reduce Resident Killer Whale prey competition in specific feeding areas (e.g. modeling, retention limits, fishery area boundary adjustments or closures), and implement where appropriate.	High	Prey availability	5 years
8	Evaluate the potential impacts of disturbance and prey competition from fisheries on foraging success in key Resident Killer Whale foraging areas.	High	Prey availability	5 years
9	Develop and implement reporting systems for the fishing sectors that improve salmonid catch, release, and retention data to more accurately portray potential fishery impacts	High	Prey availability	5 years

#	Recovery Measures	Priority <sup>3</sup>	Threats or Concerns Addressed	Timeline <sup>4</sup>
<b>Broad Strategy 3: Ensure that disturbance from human activities does not prevent the recovery of Resident Killer Whales.</b>				
<b>Approach 3: Develop and implement regulations, guidelines, sanctuaries and other measures to reduce or eliminate physical and acoustic disturbance of Resident Killer Whales.</b>				
10	Investigate the benefits of management actions (e.g. protected areas, fishery area boundary adjustments or closures) to protect important foraging and beach rubbing locations such as Robson Bight and other identified areas, and implement where appropriate.	High	Disturbance Noise pollution Prey availability	5 years
11*	Assess cumulative effects of potential anthropogenic impacts on Resident Killer Whales using an appropriate impact assessment framework for aquatic species.	High	Disturbance Noise pollution	2 years
12*	Develop and recommend implementation of best practices, guidelines, regulations, or other measures to minimize or eliminate physical and acoustic disturbance to Resident Killer Whales.	High	Disturbance Noise pollution	Ongoing
13*	Prioritize on-water enforcement efforts for compliance with legal protections for Resident Killer Whales and their habitat.	High	Disturbance Noise pollution Prey availability	Ongoing
14*	Support Resident Killer Whale recovery during the planning, development, and implementation of marine protected areas by contributing to prey availability and threat abatement.	Medium	Disturbance Noise pollution Prey availability	Ongoing
15*	Institute a communications plan around the Marine Mammal Regulations and ensure the message is transboundary.	Medium	Disturbance Noise pollution	2 years

#	Recovery Measures	Priority <sup>3</sup>	Threats or Concerns Addressed	Timeline <sup>4</sup>
<b>Broad Strategy 5: Protect critical habitat for Resident Killer Whales and identify additional areas for critical habitat designation and protection.</b>				
<b>Approach 1: Identify key feeding areas and other critical habitat of Resident Killer Whales intra and inter-annually.</b>				
16	Analyse new acoustic and sightings data to identify additional areas of habitat necessary for the survival and recovery of Resident Killer Whales.	High	Prey availability	1 year
<b>Approach 2: Protect the access of Resident Killer Whales to their critical habitat.</b>				
17*	Review and assess project impacts on Resident Killer Whales and their habitat, and provide advice on avoidance and mitigation measures as required.	High	Disturbance Noise pollution	Ongoing

**Table 2: Measures to be undertaken collaboratively between Fisheries and Oceans Canada and its partners.**

Measures noted by an asterisk (\*) have been identified as also likely to provide benefits to Transient (Bigg's) and Offshore Killer Whales (48 of 70, or 69% of measures).

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
<b>Broad Strategy 2: Ensure that Resident Killer Whales have an adequate and accessible food supply to allow recovery.</b>					
<b>Approach 1: Determine the seasonal diet, feeding areas and energetic requirements of Northern and Southern Resident Killer Whales.</b>					
18	Identify year round Resident Killer Whale distribution and diet using acoustic monitoring and dedicated vessel surveys.	High	Prey availability	Annual; ongoing	NOAA Other agencies ENGOs <sup>5</sup>
19	Further identify Resident Killer Whales' prey preferences (species/size/sex/stock).	High	Prey availability	Annual; ongoing	NOAA Other agencies
20*	Incorporate aboriginal traditional knowledge (ATK) on the behavior and distribution of Resident Killer Whales and their prey into measures for the recovery of the species.	Medium	Prey availability Disturbance Noise pollution	Annual; ongoing	First Nations
<b>Approach 2: Determine Resident Killer Whale foraging success rates.</b>					
21	Undertake a catch per unit effort assessment of Resident Killer Whale foraging effort and success rate to provide information on foraging areas and inform management decisions.	High	Prey availability	Ongoing	Other agencies

<sup>5</sup> Environmental Non-Governmental Organizations

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
22	Continue to investigate the role of abundance of Chinook and other important salmonid prey species in the population dynamics of the Northern and Southern Resident Killer Whale populations.	High	Prey availability	Ongoing	NOAA Other agencies
23	Assess seasonal and inter-annual changes in body condition and growth of Resident Killer Whales and refine the relationship between prey abundance to inform management actions in support of prey availability.	High	Prey availability	Annual; ongoing	NOAA Other agencies ENGOS
24	Assess the potential impact of prey competition between Southern Resident Killer Whales, Northern Resident Killer Whales and other salmonid predators.	High	Prey availability	2 years	NOAA Other agencies
<b>Approach 3: Establish long term monitoring programs capable of detecting changes in abundance, distribution and quality of Resident Killer Whale prey.</b>					
25	Continue to monitor abundance, distribution and age specific composition of Chinook and other important salmonid prey species.	High	Prey availability	Annual; ongoing	NOAA Other agencies
26	Identify and monitor natural and anthropogenic factors affecting Resident Killer Whale prey over the long term (e.g. climate change, Pacific Decadal Oscillation, El Niño).	High	Prey availability	Annual; ongoing	NOAA Other agencies Academia
<b>Approach 4: Develop prospective actions to be taken during poor Chinook return years to ensure sufficient prey availability for Resident Killer Whales.</b>					



#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
27	Form a transboundary working group of representatives from DFO, NOAA, as well as other technical experts to ensure that Resident Killer Whale needs are considered in the management of fisheries (e.g. Canada's Policy for Conservation of Wild Salmon, Pacific Salmon Treaty).	High	Prey availability	Ongoing	NOAA Other agencies Academia
<b>Approach 5: Ensure that the populations and habitat of Resident Killer Whale prey species are adequately protected from anthropogenic factors such as exploitation and degradation, including contamination.</b>					
28	Protect and preserve the freshwater habitat of important Resident Killer Whale prey stocks.	High	Prey availability	Ongoing	NOAA Other agencies ENGOS
29	Continue to implement and support salmon recovery plans (e.g. Canada's Policy for Conservation of Wild Pacific Salmon, Puget Sound Chinook Recovery Plan).	High	Prey availability	Ongoing	NOAA Other agencies ENGOS
30	Continue to assess the potential impact of salmon enhancement and aquaculture operations on Resident Killer Whales, both directly and through effects on wild salmon populations, and develop actions to mitigate such effects, should impacts be detected.	Medium	Prey availability	5 years	NOAA Academia ENGOS
<b>Broad Strategy 3: Ensure that disturbance from human activities does not prevent the recovery of Resident Killer Whales.</b>					
<b>Approach 1: Determine baseline natural and anthropogenic noise profiles and monitor sources and changes in the exposure of Resident Killer Whales to underwater noise.</b>					

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
31*	Expand transboundary coverage of calibrated hydrophones to quantify ocean noise budget throughout Resident Killer Whale range, giving priority to improving and utilizing existing hydrophone networks.	High	Disturbance Noise pollution	10 years	NOAA ENGOS Stakeholders Other agencies
32*	Standardize protocols and methodologies for data analysis, data presentation, and archiving of acoustic information obtained from hydrophones in the Resident Killer Whale range.	High	Disturbance Noise pollution	2 years	NOAA ENGOS Stakeholders Other agencies
33*	Investigate Resident Killer Whale use of marine Navy ranges, geographically and temporally in order to help inform decisions around Naval exercise planning.	High	Disturbance Noise pollution	5 years; ongoing	Other agencies
34*	Link hydrophone-detected noise events with vessel presence using the Automatic Identification System (AIS) for real time detection of acoustic disturbance in Resident Killer Whale critical habitat, and implement a response mechanism to mitigate potential impacts.	High	Disturbance Noise pollution	5 years	Stakeholders ENGOS
35*	Undertake systematic monitoring of ambient noise records for non-vessel related acute acoustic events that may cause harm to Resident Killer Whales.	High	Disturbance Noise pollution	5 years; ongoing	Stakeholders ENGOS
36*	Compile metadata on acoustic recordings from existing archives and current available sources (e.g. Navy, government agencies, individuals, consultants); identify format, calibration, temporal and spatial distribution, data gaps, and data collection protocols.	Medium	Disturbance Noise pollution	2 years	Stakeholders ENGOS
<b>Approach 2: Determine the short and long-term effects of chronic and immediate forms of disturbance, including vessels and noise, on the physiology, foraging and social behaviour of Resident Killer Whales.</b>					

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
37	Undertake behavioural studies of Resident Killer Whales in the winter months.	High	Disturbance Noise pollution Prey availability	Ongoing, long term	NOAA ENGOS Other agencies Academia
38	Utilize D-tag data to create a 3D model of the Resident Killer Whale's immediate (received) acoustic environment.	High	Disturbance Noise pollution	5 years; ongoing	NOAA Academia
39*	Develop an acoustic model that incorporates effects of increasing ambient noise levels on communication signals of Resident Killer Whales.	High	Disturbance Noise pollution	5 years; ongoing	Stakeholders Academia
40*	Continue and expand existing behavioural monitoring programs involving vessel/whale interactions and increase support for data analysis and publication.	High	Disturbance Noise pollution	5 years; ongoing	Stakeholders ENGOS
41*	Maintain and improve the existing 24 hour hotline (BCMMRN/ORR) for acoustic incidents as a mechanism for timely response.	Medium	Disturbance Noise pollution	Ongoing	ENGOS
42*	Increase transboundary communication of research methods and objectives to address disturbance issues with counterpart agencies in the US.	Medium	Disturbance Noise pollution	Ongoing	NOAA
<b>Approach 3: Develop and implement regulations, guidelines, sanctuaries and other measures to reduce or eliminate physical and acoustic disturbance of Resident Killer Whales.</b>					

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
43	Improve interagency communication and coordination to ensure that new activities, projects and developments that may impact Resident Killer Whales are identified, and appropriate mitigation measures are developed and implemented (e.g. Canadian Environmental Assessment Agency, Fisheries Protection Program).	High	Disturbance Noise pollution	Ongoing	Other agencies
44	Review operational impacts of existing activities, projects and developments that may have acute or cumulative impact on Resident Killer Whales and work with stakeholders to develop and apply appropriate mitigation measures.	High	Disturbance Noise pollution	Ongoing	Other agencies
45*	Encourage the development and use of methodologies that mitigate acoustic impacts (e.g. bubble curtains, ship quieting technologies).	High	Disturbance Noise pollution	Ongoing	Stakeholders
46*	Review and improve 1) thresholds for disturbance and injury, and 2) measures to mitigate marine mammal impacts from acute noise (e.g. seismic surveys, sonar use, pile driving and at-sea detonation); and implement through inclusion in Standards and Statements of Practice (e.g. Naval Orders, Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment).	High	Disturbance Noise pollution	5 years; ongoing	NOAA Stakeholders Other agencies
47*	Develop a means to assess individual ship noise and determine response strategies as necessary.	High	Disturbance Noise pollution	5 years	Stakeholders
48*	Develop a communication strategy to inform foreign vessel operators of the Canadian legislation protecting marine mammals and Canadian acoustic mitigation protocols.	High	Disturbance Noise pollution	Ongoing	Other agencies

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
49	Investigate area-specific shipping and boating guidelines and/or regulations (e.g. speed restrictions, vessel traffic routes and scheduling) that reduce acoustic impact as well as risk of collision in Resident Killer Whale habitat.	Medium	Disturbance Noise pollution Prey availability	5 years	NOAA Stakeholders Other agencies
50*	Improve boater education and tourism programs using the latest marine mammal regulations and guidelines (e.g. boater courses, marine safety courses, fishing licenses, vessel registration and licensing courses).	Medium	Disturbance Noise pollution	2 years	NOAA Stakeholders Other agencies
51*	Promote awareness of, and compliance with, guidelines and regulations to reduce acoustic impacts and vessel interactions (e.g. Be Whale Wise guidelines, stewardship programs, on-the-water education).	Medium	Disturbance Noise pollution	2 years; ongoing	NOAA Stakeholders ENGOS
52*	Investigate new methodologies and technologies to aid in compliance and enforcement of Marine Mammal Regulations and SARA.	Medium	Disturbance Noise pollution	5 years; ongoing	NOAA Other agencies
53*	Ensure that the development and delivery of SARA enforcement training for DFO fishery officers includes content from whale experts.	Medium	Disturbance Noise pollution	Ongoing	Academia ENGOS
54*	Evaluate and revise whale watching guidelines and/or regulations to reflect most recent understanding of effects of chronic physical disturbance.	Medium	Disturbance Noise pollution	Ongoing	NOAA Academia Other agencies
55*	Evaluate the efficacy of a license program and conditions for commercial whale watching as a means of mitigating potential disturbance (e.g. training standards for boat operators and naturalists, number and/or type of vessels, standard of practice).	Medium	Disturbance Noise pollution	2 years	Stakeholders

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
56*	Promote responsible advertising and documentaries that reflect the Be Whale Wise guidelines and demonstrate appropriate viewing practices.	Medium	Disturbance Noise pollution	2 years	Stakeholders
<b>Broad Strategy 4: Ensure that chemical and biological pollutants do not prevent the recovery of Resident Killer Whale populations.</b>					
<b>Approach 1: Investigate the health and reproductive capacity of Resident Killer Whales using scientific studies on free-ranging and stranded individuals, as related to chemical and biological pollution.</b>					
57*	Investigate diseases in stranded Resident Killer Whales and identify those caused by biological pollution (e.g. viruses, bacteria, fungi, parasites).	High	Environmental contaminants	Opportunistic; ongoing	NOAA Other agencies ENGOS
58*	Collate and summarize information on marine mammal necropsy and disease reports.	High	Environmental contaminants	Annual; ongoing	NOAA ENGOS
59*	Evaluate the type and level of risk of biological pollutants from agricultural runoff, sewage effluent, wildlife rehabilitation facilities and other sources.	High	Environmental contaminants	5 year	Other agencies
60*	Investigate and monitor priority pathogens of concern in marine mammals as a means to identify risk to Resident Killer Whales (e.g. <i>Morbillivirus</i> spp.).	Medium	Environmental contaminants	Annual; ongoing	NOAA Other agencies
61*	Conduct research in support of evaluating risks associated with disposal at sea operations in coastal waters (e.g. with a focus on emerging concerns such as PBDEs).	Medium	Environmental contaminants	2 years	Other agencies

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
<b>Approach 2: Monitor the chemical and biological pollutant levels in Resident Killer Whales, their prey, and their habitat.</b>					
62*	Quantify the background levels of natural and anthropogenic hydrocarbons to provide a baseline for assessing spill impacts in Resident Killer Whale habitat.	High	Environmental contaminants	5 years	NOAA Other agencies
63*	Identify and monitor contaminants of concern (e.g. flame retardants, pharmaceuticals and personal care products, PBTs, hydrocarbons), and conduct a risk-based assessment of different chemicals of concern in Resident Killer Whales, their prey, and their habitat.	High	Environmental contaminants	3 years; ongoing	NOAA Other agencies
64*	Evaluate contaminant concentration trends in Resident Killer Whales, based on both published and new measurements of different contaminants.	High	Environmental contaminants	5 years	NOAA Other agencies
65*	Develop a monitoring program for pathogens and biological pollutants to evaluate long-term trends in Resident Killer Whales and their prey.	High	Environmental contaminants	5 years	NOAA Other agencies
<b>Approach 3: Identify and prioritize the sources of key chemical and biological pollutants affecting Resident Killer Whales and their habitat.</b>					
66*	Undertake a workshop to identify source of persistent bioaccumulative contaminants presenting a risk to Resident Killer Whales.	High	Environmental contaminants	5 years	ENGOS
67*	Undertake a workshop to identify source of biological pollutants presenting a risk to Resident Killer Whales.	High	Environmental contaminants	5 years	ENGOS

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
68*	Collate information on remediation efforts for land-based PCBs.	High	Environmental contaminants	5 years	Other agencies
69*	Work with the Federal Contaminated Sites Action Plan (FCSAP) to evaluate the potential contribution of persistent environmental contaminants to the contamination of Resident Killer Whale habitat.	High	Environmental contaminants	5 years	Other agencies
<b>Approach 4: Reduce the introduction into the environment of pesticides and other chemicals that have the potential to adversely affect the health of Resident Killer Whales and/or their prey, through measures such as municipal, provincial, national and international agreements, education, regulation and enforcement.</b>					
70*	Pursue an interagency contaminants working group to identify roles and responsibilities with respect to potential impacts of contaminants on Resident Killer Whales and their environment.	High	Environmental contaminants	2 years	Other agencies
71*	Incorporate knowledge of distribution, foraging behavior and contaminant bioaccumulation in Resident Killer Whales into pesticide and chemical regulation development and implementation overseen by provincial agencies, Health Canada and Environment and Climate Change Canada.	High	Environmental contaminants	5 years, ongoing	Other agencies
72*	Determine the efficacy of regulations for PBDEs under the Canadian Environmental Protection Act (CEPA) taking into account trends in indicator species in Resident Killer Whale habitat, and develop additional source control strategies if warranted.	High	Environmental contaminants	5 years; possibly ongoing	Other agencies
73*	Identify and support programs that identify and mitigate small scale and/or chronic contaminant spills and leaks.	High	Environmental contaminants	5 years; ongoing	NOAA ENGOS Stakeholders



#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
<b>Approach 5: Mitigate the impacts of currently and historically used “legacy” pollutants in the environment.</b>					
74*	Reduce the risk of lifetime contaminant exposure in Resident Killer Whales by incorporating knowledge of distribution, foraging behavior and their food web into assessment and remediation plans for contaminated sites.	High	Environmental contaminants	5 years	Other agencies Stakeholders
75*	Work with other government departments, non-governmental organizations, and industry to promote best practices, green design, mitigation protocols and outreach efforts for the protection of Resident Killer Whales and their habitat from urban pollution (e.g. sewage treatment, source control, combined sewer overflows, runoff).	High	Environmental contaminants	5 years; ongoing	NOAA Other agencies Stakeholders ENGOS
76*	Work with individuals, industries, agricultural operations, and other sectors in order to reduce the release of agricultural chemicals of concern into the habitat of Resident Killer Whales and their prey.	High	Environmental contaminants	5 years; ongoing	NOAA Other agencies Stakeholders
77*	Ensure that the protection of Resident Killer Whales and their habitat is included as a high priority in spill response and monitoring protocols within the Canadian Coast Guard’s Incident Command Structure.	High	Environmental contaminants	1 year; ongoing	Other agencies
78*	Prepare for oil or chemical spills to minimize impacts to Resident Killer Whales through the development of a spill response plan, including deterrence methods, training, drills and equipment.	High	Environmental contaminants	1 year; ongoing	NOAA Other agencies Stakeholders

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
79*	Review and, if appropriate, recommend refinement of policies and best management practices for ocean dredging and disposal at sea.	Medium	Environmental contaminants	Ongoing	Other agencies
80*	Refine and expand existing monitoring programs of municipal and industrial waste to minimize Resident Killer Whale exposure to legacy and emergent pollutants.	Medium	Environmental contaminants	Ongoing	Other agencies
<b>Approach 6: Reduce the introduction of biological pollutants, including pathogens and exotic species, into the habitats of Resident Killer Whales and their prey.</b>					
81*	Reduce the release of biological pollutants into the habitat of Resident Killer Whales and their prey by working with municipal, provincial and federal agencies tasked with domestic, agricultural and industrial discharges (including ballast water).	Medium	Environmental contaminants	5 years	Other agencies Stakeholders ENGOS
82*	Mitigate the release of biological pollutants into the habitat of Resident Killer Whales and their prey by working with individuals, industries, agricultural operations, and other source sectors to develop or improve protocols and guidance.	Medium	Environmental contaminants	5 years	NOAA Other agencies Stakeholders ENGOS
<b>Broad Strategy 5: Protect critical habitat for Resident Killer Whales and identify additional areas for critical habitat designation and protection.</b>					
<b>Approach 1: Identify key feeding areas and other critical habitat of Resident Killer Whales intra and inter-annually.</b>					

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Partner(s)
83	Continue to undertake research activities to identify areas of habitat necessary for the survival and recovery of Resident Killer Whales.	High	Prey availability Disturbance Noise pollution	Ongoing	NOAA Other agencies ENGOS
84	Identify and account for the likelihood that changes in the relative strength of major salmon stocks may cause corresponding shifts in the geographic location of critical habitat for Resident Killer Whales.	Medium	Prey availability	Ongoing	Other agencies ENGOS Academia
85	Refine understanding of the functions, features and attributes of Resident Killer Whale habitat and identify what may constitute critical habitat destruction.	Medium	Prey availability Disturbance Noise pollution	Ongoing	Other agencies ENGOS Academia
<b>Approach 2: Protect the access of Resident Killer Whales to their critical habitat.</b>					
86	Continue efforts outlined in Broad Strategy 3 to ensure disturbance from human activities does not prevent access of Resident Killer Whales to their critical habitat.	High	Disturbance Noise pollution	Ongoing	Stakeholders Other agencies ENGOS
<b>Approach 3: Encourage trans-boundary cooperation in the identification and protection of critical habitat.</b>					
87	Continue dialogue with the NOAA to encourage transboundary consistency of Southern Resident Killer Whale critical habitat protection.	High	Disturbance Noise pollution	Ongoing	NOAA

**Table 3: Measures that represent opportunities for other jurisdictions, organizations or individuals to lead**

Measures noted by an asterisk (\*) have been identified as also likely to provide benefits to Transient (Bigg's) and Offshore Killer Whales (9 of 11, or 82% of measures).

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Suggested Other Jurisdictions or Organizations
<b>Broad Strategy 2: Ensure that Resident Killer Whales have an adequate and accessible food supply to allow recovery.</b>					
<b>Approach 1: Determine the seasonal diet, feeding areas and energetic requirements of Northern and Southern Resident Killer Whales.</b>					
88	Use historical fishing records to identify potential Resident Killer Whale feeding areas.	Medium	Prey availability	Uncertain	Academia ENGOS
<b>Approach 4: Develop prospective actions to be taken during poor Chinook return years to ensure sufficient prey availability for Resident Killer Whales.</b>					
89	Analyze historical data to identify environmental correlates with Chinook abundance and Resident Killer Whale mortality trends.	Medium	Prey availability	Uncertain	Academia Other agencies
<b>Broad Strategy 3: Ensure that disturbance from human activities does not prevent the recovery of Resident Killer Whales.</b>					
<b>Approach 2: Determine the short and long-term effects of chronic and immediate forms of disturbance, including vessels and noise, on the physiology, foraging and social behaviour of Resident Killer Whales.</b>					
90*	Research the effects of other vessel-based impacts (e.g. fish finders, air quality issues related to engine exhaust, disposal of waste and bilge water).	Medium	Disturbance Noise pollution Environmental contaminants	Unknown	Stakeholders Academia

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Suggested Other Jurisdictions or Organizations
91*	Develop a means of differentiating nutritional vs. disturbance-induced stress (via hormone response and other methods).	Medium	Disturbance Noise pollution	Unknown	Academia Other agencies
<b>Approach 3: Develop and implement regulations, guidelines, sanctuaries and other measures to reduce or eliminate physical and acoustic disturbance of Resident Killer Whales.</b>					
92*	Expand the Be Whale Wise flag program to notify other mariners when whales have been observed in order to reduce risk of collision and acoustic disturbance.	Medium	Disturbance Noise pollution	Ongoing	Stakeholders ENGOS
93*	Improve public awareness of recovery activities for Resident Killer Whales through Parks Canada Agency's educational programs (e.g. the BC Ferries Coastal Naturalist Program).	Medium	Disturbance Noise pollution Prey availability	5 years	Parks Canada Agency
<b>Broad Strategy 4: Ensure that chemical and biological pollutants do not prevent the recovery of Resident Killer Whale populations.</b>					
<b>Approach 1: Investigate the health and reproductive capacity of Resident Killer Whales using scientific studies on free-ranging and stranded individuals, as related to chemical and biological pollution.</b>					
94*	Develop, evaluate, and apply new tools to assess the effects of contamination and pollution on the health of free-ranging Resident Killer Whales.	Medium	Environmental contaminants	Unknown	Other agencies ENGOS Academia
<b>Approach 2: Monitor the chemical and biological pollutant levels in Resident Killer Whales, their prey, and their habitat.</b>					

#	Recovery Measures	Priority	Threats or Concerns Addressed	Timeline	Suggested Other Jurisdictions or Organizations
95*	Quantify the current levels of contaminant concentrations in Resident Killer Whale prey and refine the analysis of contaminant intake by Resident Killer Whales using current information on their feeding ecology.	High	Environmental contaminants	Uncertain	Stakeholders ENGOS
<b>Approach 3: Identify and prioritize the sources of key chemical and biological pollutants affecting Resident Killer Whales and their habitat.</b>					
96*	Evaluate the risks of bioaccumulation related to mercury (Hg) contamination in Resident Killer Whale food webs.	Medium	Environmental contaminants	Uncertain	Stakeholders Other agencies ENGOS
<b>Approach 4: Reduce the introduction into the environment of pesticides and other chemicals that have the potential to adversely affect the health of Resident Killer Whales and/or their prey, through measures such as municipal, provincial, national and international agreements, education, regulation and enforcement.</b>					
97*	Support new, proposed, or existing bans on the use of pesticides for cosmetic purposes, and re-establish a comprehensive inventory of pesticide sales and use in British Columbia.	High	Environmental contaminants	Uncertain	ENGOS General public
98*	Incorporate knowledge of Resident Killer Whale distribution, foraging behavior and contaminant bioaccumulation into federal technical reviews on chemicals of concern.	High	Environmental contaminants	Uncertain	Other agencies

## **2. Critical Habitat**

### **2.1 Identification of the Species' Critical Habitat**

#### **2.1.1 General Description of the Species' Critical Habitat**

Critical habitat is defined in SARA as “...*the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a recovery strategy or in an action plan for the species.*” [s. 2(1)]

Also, SARA defines habitat for aquatic species as “... *spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced.*” [s. 2(1)]

Critical habitat for the Northern and Southern Resident Killer Whale is identified to the extent possible in Section 3.1 of the Recovery Strategy (Fisheries and Oceans Canada, 2011). The Recovery Strategy also contains details about the identified critical habitat including geographic location and biophysical functions, features and attributes. The critical habitat identified in the Recovery Strategy is insufficient to achieve the species' population and distribution objectives. There are likely other areas that are necessary for survival or recovery of Killer Whales, and studies are underway to identify further areas of habitat necessary for the survival and recovery of these populations.

### **2.2 Activities likely to Result in the Destruction of Critical Habitat**

Examples of activities likely to result in destruction of critical habitat may be found in Section 3.2 of the Recovery Strategy.

### **2.3 Proposed Measures to Protect Critical Habitat**

Under SARA, critical habitat must be legally protected from destruction within 180 days of being identified in a recovery strategy or action plan. For the Northern and Southern Resident Killer Whale critical habitat, a SARA Critical Habitat Order was made under subsections 58(4) and (5), which invokes the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

### 3. Evaluation of Socio-Economic Costs and of Benefits

The *Species at Risk Act* requires that an action plan include an evaluation of the socio-economic costs of the action plan and the benefits to be derived from its implementation (SARA 49(1)(e), 2003). This evaluation addresses only the incremental socio-economic costs of implementing this action plan from a national perspective as well as the social and environmental benefits that would occur if the action plan were implemented in its entirety, recognizing that not all aspects of its implementation are under the jurisdiction of the federal government. It does not address cumulative costs of species recovery in general nor does it attempt a cost-benefit analysis. Its intent is to inform the public and to guide decision making on implementation of the action plan by partners.

The protection and recovery of species at risk can result in both benefits and costs. The Act recognizes that “wildlife, in all its forms, has value in and of itself and is valued by Canadians for aesthetic, cultural, spiritual, recreational, educational, historical, economic, medical, ecological and scientific reasons” (SARA 2003). Self-sustaining and healthy ecosystems with their various elements in place, including species at risk, contribute positively to the livelihoods and the quality of life of all Canadians. A review of the literature confirms that Canadians value the preservation and conservation of species in and of themselves. Actions taken to preserve a species, such as habitat protection and restoration, are also valued. In addition, the more an action contributes to the recovery of a species, the higher the value the public places on such actions (Loomis and White, 1996; DFO., 2008). Furthermore, the conservation of species at risk is an important component of the Government of Canada’s commitment to conserving biological diversity under the *International Convention on Biological Diversity*. The Government of Canada has also made a commitment to protect and recover species at risk through the [Accord for the Protection of Species at Risk](#). The specific costs and benefits associated with this action plan are described below.

#### Efforts for Recovery to date

The Action Plan for this species captures activities from 2017 onwards. However, efforts for Killer Whale recovery have been underway prior to listing under SARA. Since 1973, an annual census has been undertaken to locate, photograph, and identify individual Killer Whales found in Canadian waters. Since 2002, to determine recovery status and further the understanding of distribution, abundance and seasonal occurrence of these whales, DFO’s Cetacean Research Program (CRP) has completed over 2,000 hours of dedicated ship-based surveys. In addition, collaborations with other groups, organizations and partners have provided significant advances in acoustic monitoring networks, sightings, identification methods and identification of important habitat (e.g. the BC Parks Warden Program at the Robson Bight (Michael Bigg) Ecological Reserve). First Nations have contributed to recovery efforts through stewardship and guardian programs, and identification efforts. Finally, education, stewardship and enforcement programs have also contributed to recovery efforts.

#### Benefits

The impacts of the recovery measures in this plan on Resident Killer Whale populations are unknown but likely positive. As indicated above, Canadians value such actions for a number of



reasons, including non-market benefits (i.e. existence, bequest and option values).<sup>5</sup> Activities that positively affect the recovery of these species may result in positive benefits to Canadians.

The recovery measures are also likely to provide broader benefits, as some of the threats to this species are common to other marine mammals and sea turtles. Actions that mitigate those threats may also provide benefits to other species. In addition, ocean research surveys generally collect information on other marine mammals, sea turtles and other species of interest when encountered, if feasible and appropriate. In particular, Transient and Offshore Killer Whales, as well as other species of whales may benefit from the research activities in this plan, specifically research related to acoustic disturbance and contaminants. Consequently, many of the activities identified in this Action Plan will have positive impacts on other SARA listed species and provide overall benefits to the aquatic ecosystem.

## Costs

The Implementation Schedule separates recovery measures into three categories in three tables. Table 3 activities have not been assessed; while these activities are identified as important for species recovery, limited information is available in terms of participants, activities and timelines.

Very few of the identified costs are associated with recovery measures that would be completed in the short-term (1-2 years). The majority of the recovery measures will result in some level of annual costs over the anticipated timeframe for the plan (i.e. >25 years) and completion dates are not specified. This long-term level of costs is similar to expenditures in support of these species prior to this plan.

The majority of activities in the plan focus on research. The coast-wide distribution of these populations requires extensive survey effort resulting in higher costs than for more localized populations. Research and monitoring activities to reduce threats are closely linked to cooperation and engagement activities with a number of partners providing in-kind support to meetings and discussions. Education and engagement may include in-kind support from environmental organizations. Compliance promotion and enforcement activities would likely be funded through a re-allocation of existing government funds.

Cost estimates for DFO activities in Tables 1 and 2 are expected to be low<sup>6</sup>. There is a high degree of uncertainty regarding cost estimates for partner contribution towards Table 2 activities. As well, the costs for Table 3 activities were not considered as information on project specifics, participants and/or timelines are not available. Annual DFO costs related to Tables 1 and 2 are low on the national scale. The inclusion of financial and in-kind costs for Canadian partners for Table 2 and 3 activities would increase the total; however, overall costs are unlikely to meet the medium threshold.<sup>6</sup> Costs to international partners have not been included in the assessment.

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<sup>5</sup> Non-market benefits include bequest values (the value placed on conservation for future generations), existence values (the value people place on the existence of a species) and option values (the amount someone is willing to pay to keep open the option of future use of the species).

<sup>6</sup> Guidance provides scales in terms of present values, as well as annualized values. The annualized scale is: Low \$0-\$1 million, Medium \$1-\$10 million, High >\$10 million. Source: Government of Canada. *Guidelines for Completing Action Plan Templates (Federal)*. Draft (2.2.). June 2012.

While DFO is identified as the lead for several recovery measures for Resident Killer Whales, most actions are in Tables 2 and 3 which are to be undertaken collaboratively. A number of partners and collaborators are identified and/or have participated in similar activities in the past. These partners include other federal departments and agencies, environmental organizations, academic institutions and programs, First Nations and other foreign governments who may contribute financial and in-kind support. Potential funding sources for DFO costs include existing federal resources, as well as supplemental funds from annual programs such as the Habitat Stewardship Program (HSP).

## 4. Measuring Progress

The performance indicators presented in the associated recovery strategy provide a way to define and measure progress toward achieving the population and distribution objectives. A [Report on the Progress of Recovery Strategy Implementation for the Northern and Southern Resident Killer Whales \(Orcinus orca\) in Canada for the Period 2009-2014](#) is posted on the SARA registry (Fisheries and Oceans Canada, 2016).

Reporting on implementation of the action plan, under s. 55 of SARA, will be done by assessing progress towards implementing the recovery objectives and strategies identified in the Recovery Strategy (Fisheries and Oceans Canada, 2011).

Reporting on the ecological and socio-economic impacts of the action plan, under s. 55 of SARA, will be done by assessing the results of monitoring the recovery of the species and its long term viability, and by assessing the implementation of the action plan.

## 5. References

Fisheries and Oceans Canada. 2008. Estimation of the Economic Benefits of Marine Mammal Recovery in the St. Lawrence Estuary. Policy and Economics Regional Branch, Quebec 2008.

Fisheries and Oceans Canada. 2011. Recovery Strategy for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada. *Species at Risk Act* Recovery Strategy Series, Fisheries & Oceans Canada, Ottawa ix + 80 pp.

Fisheries and Oceans Canada. 2016. Report on the Progress of Recovery Strategy Implementation for the Northern and Southern Resident Killer Whales (*Orcinus orca*) in Canada for the Period 2009-2014. *Species at Risk Act* Recovery Strategy Report Series. Fisheries and Oceans Canada, Ottawa. iii + 51 pp.

Loomis, J.B. & White, D.S. 1996. Economic Benefits of Rare and Endangered Species: Summary and Meta-analysis. *Ecological Economics*, 18: 197-206.

Towers, J.R., Ellis, G.M. and Ford, J.K.B. 2015. Photo-identification catalogue and status of the northern resident killer whale population in 2014. *Can. Tech. Rep. Fish. Aquat. Sci.* 3139: iv + 75 p.

## Appendix A: Effects on the Environment and Other Species

In accordance with the [Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals](#) (2010), SARA recovery planning documents incorporate strategic environmental assessment (SEA) considerations throughout the document. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or achievement of any of the [Federal Sustainable Development Strategy](#)'s goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the Action Plan itself, but are also summarized below in this statement.

The recovery measures are also likely to provide broader benefits, as some of the threats to this species are common to other marine mammals and sea turtles. Actions that mitigate threats to the aquatic environment (e.g. acoustic disturbance, contaminants) may also provide benefits to other species. In addition, ocean research surveys generally collect information on other marine mammals, sea turtles and other species of interest when encountered, if feasible and appropriate. All cetacean species, and Transient and Offshore Killer Whales in particular, will likely benefit from measures identified in this Action Plan. Consequently, many of the activities identified in this Action Plan will have positive impacts on other SARA listed species and provide overall benefits to the aquatic ecosystem.

## Appendix B: Record of Cooperation and Consultation

Northern and Southern Resident Killer Whales are listed as threatened and endangered respectively under SARA. As these whales occupy territorial waters off the coast of British Columbia, and have either been seen in or could possibly occupy waters administered by the Parks Canada Agency, the Minister of Fisheries and Oceans, and the Minister responsible for the Parks Canada Agency are the competent ministers for these species according to SARA. DFO established a small internal working group of technical experts to develop the draft of this action plan, including individuals from Parks Canada Agency. See Appendix C of this document for a list of Technical Team members.

### Initiation of the Action Plan Development process

At the initiation of the Resident Killer Whale Action Planning process, letters, emails and faxes were sent to all coastal First Nations, inviting their participation in the development of the Action Plan. Letters of invitation were sent to Environment and Climate Change Canada, Province of British Columbia, Department of National Defence, National Resources Canada, and Canadian Coast Guard, requesting their participation in the process.

### Action Plan Development

As part of the action planning process, a workshop was held on March 8-10, 2011 at Pender Island, BC to gather technical information required to develop measures for strategies related to prey availability and disturbance. Representatives from environmental groups, ecotourism industry, Canadian and United States government agencies were present.

In January and February of 2012, three public open houses and five First Nations meetings were held, and an online response form was set up to gather comments and opinions on the development of actions in support of the conservation of these two populations of Killer Whales. Feedback from these sessions was considered during the development of the first draft of the Action Plan. Public meetings were held in Victoria, Vancouver, and Port Hardy, BC. Meetings were held with First Nations in Williams Lake, Nanaimo, Campbell River, Abbotsford, and Kamloops, BC.

A series of three NOAA/DFO bilateral workshops were held in 2011-2012 to examine the effect of Chinook fisheries on Resident Killer Whales. An independent scientific panel was appointed to oversee the workshop process and report on the proceedings. These workshops were attended by scientists and technical experts, fisheries managers from United States and Canadian governments, stakeholders and environmental groups. Recommendations from this workshop informed the development of the Action Plan measures and increased the available science in support of recovery.

Action Plan Team meetings were held throughout the planning process and a draft Action Plan was developed. The draft and proposed versions of the Action Plan were reviewed by the interagency team with representatives from Transport Canada, Parks Canada Agency and the Department of National Defence prior to regional consultation.

### Draft Action Plan Regional Consultation – March 3 - April 16, 2014

The public was invited to comment on the draft Action Plan for the Northern and Southern Resident Killer Whale in Canada through the Pacific Region SARA Consultation website. Notifications of the consultation process were sent via emails to stakeholders and environmental

interest groups, government contacts, all coastal First Nations, and three Wildlife Management Boards. Groups and individuals were encouraged to provide feedback through the on line discussion guides and an open invitation to comment. Discussion guides consisted of five questions; 493 discussion guide comments were received from 144 individuals. In addition to online discussion guides, ten individuals provided comments via email, and ten letters (ranging from 1 to 27 pages in length) were received as email attachments from First Nations, stakeholder organizations, ENGOs, and concerned citizens. Two First Nations requested meetings to discuss actions that may occur within their territories.

**Proposed Action Plan National Consultation – June 15 - August 14, 2016**

The proposed Action Plan was posted on the Species at Risk Public Registry on June 15, 2016 for a 60-day comment period, as required under SARA. The public comment period closed on August 14, 2016. Pre-notification letters were sent to coastal First Nations, stakeholders, and others that had requested notification as interested or affected parties.

Letter writing campaigns initiated by four environmental non-governmental organizations (ENGOs) resulted in over 11,380 submissions. In addition to these form letters, individual letters and/or emails were received from 53 citizens, 12 letters from stakeholder organizations, two responses from First Nations, and one letter from the Lower Fraser Fisheries Alliance (representing over 30 Nations). Many respondents commended the Department for the changes in the Action Plan in response to the 2014 regional consultation process on the draft Action Plan. Feedback largely followed these themes: management options to support adequate and accessible prey, acoustic impacts of vessel traffic, on-water enforcement and education programs, marine mammal regulations, vessel approach distance, and roles and responsibilities with respect to contaminants. This feedback was considered during the consultation review and the Action Plan was modified where appropriate to reflect the comments.

## Appendix C: Teams and Processes Contributing to the Development of this Action Plan

### Northern and Southern Resident Killer Whale Action Plan Team

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Lynne Barre	National Oceanographic and Atmospheric Administration
Lance Barrett-Lennard	Vancouver Aquarium
Paul Cottrell	Fisheries and Oceans Canada
Graeme Ellis	Fisheries and Oceans Canada
John Ford	Fisheries and Oceans Canada
Jeff Grout	Fisheries and Oceans Canada
Brian Reader	Parks Canada Agency
Peter Ross	Fisheries and Oceans Canada
Pippa Shepherd	Parks Canada Agency
Sheila Thornton	Fisheries and Oceans Canada

### Inter-Agency Working Group

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Paula Doucette	Transport Canada
Leslie James	Transport Canada
Cliff Robinson	Parks Canada Agency
Danielle Smith	Department of National Defence
Danielle Wensauer	Transport Canada



# TAB 3

## LIST OF AUTHORITIES

### Statutes, Regulations and Orders

- *Canadian Environmental Assessment Act, 2012*, SC 2012, c 19, s 52
- *Federal Courts Act*, RSC, 1985, c F-7
- *Species at Risk Act*, SC 2002, c 29
- *Critical Habitat of the Killer Whale (Orcinus orca) Northeast Pacific Southern Resident Population Order*, SOR/2018-278

### Case Law

- *Tsleil-Waututh Nation v Canada (Attorney General)*, 2018 FCA 153
- *Pembina Institute for Appropriate Development v Canada (Attorney General)*, 2008 FC 302
- *Taseko Mines Limited v Canada (Environment)*, 2017 FC 1099
- *David Suzuki Foundation v Canada (Fisheries and Oceans)*, 2010 FC 1233
- *Canada v David Suzuki Foundation*, 2012 FCA 40
- *R v Hape*, 2007 SCC 26
- *Environmental Defence Canada v Canada (Fisheries and Oceans)*, 2009 FC 878
- *Morton v Canada (Fisheries and Oceans)*, 2019 FC 143

### Government Policy

- Canadian Environmental Assessment Agency, *Determining Whether a Designated Project is Likely to Cause Significant Adverse Environmental Effects under CEAA 2012* (November 2015)
- Fisheries and Oceans Canada, *Canada's Policy for Conservation of Wild Pacific Salmon* (2005)

### International Documents

- *United Nations Convention on the Conservation of Biological Diversity*, 5 June 1992, 1760 UNTS 69 (entered into force 29 December 1993)
- *Transforming our World: the 2030 Agenda for Sustainable Development*, GA Res 70/1, UNGAOR, 70th Sess, UN Doc A/RES/70/1
- *Report of the World Commission on Environment and Development "Our Common Future"*, GA, 42nd Sess, Annex, Agenda Item 3, UN Doc A/42/427 (1987)
- *United Nations Framework Convention on Climate Change*, 9 May 1992, 1171 UNTS 107 (ratified by Canada 4 Dec 1992, entered into force 21 March 1994)
- *Framework Convention on Climate Change, Adoption of the Paris Agreement, FCCC Dec 1/CP.21, FCCC, 21<sup>st</sup> Sess, UN Doc FCCC/CP/2015/10/Add.1*

- Canada, *Canada's 2017 Nationally Determined Contribution Submission to the United Nations Framework Convention on Climate Change*, UNFCCC NDC Registry
- Pacific Salmon Commission, *Treaty Between the Government of Canada and the Government of the United States of America Concerning Pacific Salmon (including amendments provisionally applied as of January 1, 2019)* (January 2019)

### **Secondary Sources**

- Ruth Sullivan, *"Sullivan on the Construction of Statutes"*, 5th ed (Markham: LexisNexis Canada Inc, 2008)
- Natasha Affolder, *"The Legal Concept of Sustainability"* (Symposium on Environment in the Courtroom: Key Environmental Concepts and the Unique Nature of Environmental Damage, 23-24 March 2012) (Calgary: Canadian Institute of Resources Law, University of Calgary, 2012)