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Recovery Strategy Series

Recovery Strategy for the Offshore Killer Whale (*Orcinus orca*) in Canada

Offshore Killer Whale

2018

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 a recovery strategy for species listed as extirpated, endangered, or threatened, and are 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, Oceans, and the Canadian Coast Guard and the Minister responsible for Parks Canada Agency are the competent ministers under SARA for the Offshore Killer Whale (*Orcinus orca*), and have prepared this strategy, as per section 37 of SARA. In preparing this recovery strategy, 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, it 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 United States' National Oceanic and Atmospheric Administration (NOAA) as per section 39(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 set out in this strategy and it will not be achieved by Fisheries and Oceans Canada, the Parks Canada Agency, or any other jurisdiction alone. The cost of conserving species at risk is shared among different constituencies. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Offshore Killer Whale and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Fisheries and Oceans Canada, the Parks Canada Agency, other jurisdictions, and/or organizations involved in the conservation of the species. Implementation of this recovery strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

Acknowledgments

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This document also benefited tremendously from the insight provided by participants in the 2013 Offshore Killer Whale technical workshop (Appendix C). Fisheries and Oceans Canada is also grateful to those who gave further input that was integral to the evolution of this document: Lance Barrett-Lennard (Vancouver Aquarium); Phil Morin (National Oceanic and Atmospheric Administration's (NOAA) Southwest Fisheries Science Center); Stephen Raverty (Province of British Columbia Ministry of Agriculture and Lands' Animal Health Centre); and Jackie King, Steve Wischniowski and Greg Workman (Fisheries and Oceans Canada's Science Branch).

Executive summary

The Offshore population of Killer Whales is dissimilar from its sympatric Resident and Transient ecotypes in behaviour, diet, morphology, acoustics and genetics. Encounters with Offshore Killer Whales have been relatively infrequent, and efforts to catalogue members of this population have been challenging given sparse sightings, their large group sizes and more pelagic habitat.

Offshore Killer Whales are wide-ranging, long-lived apex predators, considered to be at risk because of their small population size, low reproductive potential, and propensity towards accumulating elevated concentrations of chemical contaminants that are persistent, bioaccumulative and that have been shown to cause harm to marine mammals (Ross et al. 2000; COSEWIC 2008). The population occurs throughout Canadian Pacific waters, representing approximately one-fifth of their known range, from the southern Bering Sea to southern California. The Offshore Killer Whale was assessed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2008, and then listed as such under the Species at Risk Act in 2011.

Offshore Killer Whales face both anthropogenic and natural threats, limitations or vulnerabilities, including: reductions in prey availability; contaminant exposure from prey; spills of substances harmful to the marine environment; acute and chronic acoustic disturbance; physical disturbance; interactions with commercial fisheries and aquaculture; direct killing; climate change; disease agents; fixed dietary preferences and natural decreases in prey supply; inbreeding depression; tooth wear; and mass stranding or natural entrapment. The small population size and typically large groupings of Offshores makes the population particularly vulnerable to stochastic events.

The population and distribution objectives defined in this recovery strategy are:

- population objective: achieve a stable or increasing trend in the abundance (i.e., increased birthrate and/or decreased death rate) and genetic diversity of the Offshore Killer Whale population.

- distribution objective: ensure continued use of Canadian Pacific waters by the Offshore Killer Whale population.

Given the significant knowledge gaps regarding Offshore Killer Whales, this recovery strategy recommends broad strategies and general approaches to fill these gaps, and to mitigate threats according to what is currently known.

Given the lack of information currently available on Offshores' seasonal distribution in outer coast waters, and the prey resources that may determine the quality of their habitat (Ford et al. 2014), it is not possible to identify critical habitat at this time. Identification of critical habitat to meet the population and distribution objectives will be addressed in one or more action plans, or a revised version of this recovery strategy.

The action plan or plans to implement this recovery strategy will be completed within five years of the posting of the final recovery strategy on the Species at Risk Public Registry.

Recovery feasibility summary

Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

Yes. Killer Whales (*Orcinus orca*) have a naturally low reproductive potential, characteristic of large mammals with long lifespans, and long intervals between the calving of single offspring (Olesiuk et al. 2005). With a current population abundance estimated at 300 animals (Ford et al. 2014), it is further calculated that there are approximately 130 mature, reproductively-capable individuals in the Offshore Killer Whale population (DFO Cetacean Research Program (CRP), unpubl. data[1]). It is unknown whether there is a sex-related bias in survival, mortality or demography of this portion of the population; however, based on other Killer Whale populations in British Columbia, one may expect a natural bias towards mature females due to the difference in life expectancies between sexes. The overall Offshore Killer Whale population size appears to be stable, with high estimated survival each year (Ford et al. 2014). All of these factors suggest that the current rate of recruitment in the Offshore Killer Whale population is adequate to sustain the population at its current level.

Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

Yes, inside Canadian waters; but unknown outside of Canadian waters (e.g. other countries' management of prey species, and regulation and management of substances harmful to the marine environment). It does not appear that the Offshore Killer Whale population is currently excluded from any habitat typical of Killer Whales in Canadian Pacific waters. Offshore Killer Whales seem to predominantly inhabit continental shelf-edge waters along the British Columbia coast, though they have been visiting inshore waters more frequently in recent years (Ford et al. 2014).

Perhaps the most important aspect of habitat for Offshore Killer Whales is the abundance and availability of their prey. Of the five confirmed prey species found in Canadian Pacific waters, North Pacific Spiny Dogfish, Chinook Salmon, and Pacific Halibut are monitored and actively managed by Fisheries and Oceans Canada (DFO). The Pacific Sleeper Shark and Blue Shark are surveyed by DFO, but data are not analyzed to monitor population trends or health. Canada is, however, a signatory to the Food and Agricultural Organization of the United Nations' (FAO) International Plan of Action for the Conservation and Management of Sharks (FAO 1999), and has its own related National Plan of Action for the Conservation and Management of Sharks (DFO 2007a).

In theory, through careful management and conservation of these prey species, and other potential prey species yet to be discovered – both inside and outside Canadian waters – Offshore Killer Whale habitat degradation may be mitigated. Sufficient suitable habitat should remain available to support the Offshore Killer Whale population, barring any physical or non-physical (e.g. acoustic) obstruction or deterrent to their use of shelf-edge and inshore waters, or any detrimental decline in the abundance and availability of their prey both inside and outside Canadian waters.

[1] Calculated from same data set used to determine the current population abundance estimate in Ford et al. 2014, utilizing the same method as outlined in COSEWIC 2008.

The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

Yes, for threats inside Canadian waters; but unknown for threats outside Canadian waters (e.g. foreign contaminant sources; Californian billfish fisheries; interaction with offshore industry and transport). Notable threats to the Offshore Killer Whale population and its habitat, as described by COSEWIC (2008), are “high levels of contaminants, acoustical and physical disturbance, and potential oil spills”. Through appropriate regulation and management of substances harmful to the marine environment, and the transport of these anthropogenic inputs to the marine environment, including safety measures and timely and thorough spill response, the detrimental effect of contaminants and oil spills on the Offshore Killer Whale population and their prey may be mitigated within Canadian waters. With implementation and enforcement of the Fisheries Act, it’s associated regulations, and the application of best practices (e.g. DFO 2007b for seismic sound; DND 2008 for sonar use), as well as additional stewardship guidelines currently in place, acute noise and vessel disturbance may be mitigated. It is presently unknown whether chronic noise disturbance could be mitigated throughout the range of the Offshore Killer Whale population, and there are currently no chronic noise mitigation measures in effect in Canadian Pacific waters. Though Offshore Killer Whales are not listed under the United States of America’s (US) Endangered Species Act, they are protected by US federal Marine Mammal Regulations and associated threat mitigation measures that are comparable to the protections offered by Canada’s Marine Mammal Regulations.

Through all these methods, as well as avoidance of competition for prey with fisheries through industry management, the primary threats to the Offshore Killer Whale population may be avoided or mitigated. Given the wide-ranging nature of Offshore Killer Whales, jurisdiction to avoid or mitigate threats outside Canadian waters is limited and the ability to understand the impacts of those threats is challenging. Monitoring likely occurs at an acceptable level throughout their range, though some threats are better monitored than others and mitigation is variable. As anything beyond natural mortality could jeopardize the recovery of the Offshore Killer Whale population (i.e. potential biological removal is calculated to be less than one individual) (Ford et al. 2014), continued monitoring and improved mitigation of threats across their range is imperative.

Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

Unknown. Recovery techniques to actively promote the growth of Killer Whale populations do not exist, but impediments to their recovery may be reduced through threat mitigation. Though threats to the prey, habitat, and individuals of the Offshore Killer Whale population are theoretically mitigatable, it is not yet clear how effective these measures would be in practice. However, research actions, stewardship programs and management regulations exist to encourage and monitor the recovery of this population.

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1 COSEWIC assessment summary

Date of assessment: November 2008

Common name (population): Killer Whale (Offshore population)

Scientific name: *Orcinus orca*

COSEWIC status: Threatened

Reason for designation: This population has a very small number of mature individuals (~120). It is subject to threats from high levels of contaminants, acoustical and physical disturbance, and potential oil spills. However, the population is monitored and appears to be stable.

Canadian occurrence: Pacific Ocean

COSEWIC status history: The “North Pacific resident populations” were given a single designation of Threatened in April 1999. Split into three populations in November 2001. The Offshore population was designated Special Concern in November 2001. Status re-examined and designated Threatened in November 2008. Last assessment based on an update status report.

2 Species status information

As a species, Killer Whales are cosmopolitan, widely distributed throughout the world’s oceans and common to many coastal areas, especially at high latitudes (Leatherwood and Dahlheim 1978). The species is composed of discrete regional populations, genetically and socially isolated from one another, often with distinct ecological specializations (Bigg et al. 1990; Hoelzel et al. 1998; Barrett-Lennard and Ellis 2001). Some of these populations may be further designated as separate species or subspecies and may require listing at higher risk designations (Reeves et al. 2004; Morin et al. 2010; Taylor et al. 2013). Due to this taxonomic uncertainty, the International Union for the Conservation of Nature (IUCN) considers *Orcinus orca* to be Data Deficient (Taylor et al. 2013).

The northeastern Pacific Offshore Killer Whale population has been repeatedly encountered in waters off Alaska, British Columbia, Washington, and California, with Canadian Pacific waters comprising approximately one-fifth of their known range. As of 2013, just over 70% of their 240 documented encounters and passive acoustic detections have occurred in British Columbia waters. The Offshore Killer Whale population was initially assessed by COSEWIC in 2001, and then listed in 2004 as Special Concern in Canada under the Species at Risk Act (SARA), when the legislation came into force. As a result of that initial SARA listing, the *Management Plan for the Offshore Killer Whale (*Orcinus orca*) in Canada* (DFO 2009a) was developed and published, outlining the threats to, management goals, objectives and actions for the conservation of Offshore Killer Whales (“Offshores”). In November 2008, the population was re-assessed by COSEWIC as Threatened, and subsequently listed under SARA as Threatened in 2011. In

2011, Offshores were designated with a Provincial Conservation Status of S2 (Imperiled), putting them on the Province of British Columbia's Red List. The population is currently not listed under the United States of America's (US) Endangered Species Act.

3 Species information

The species information below complements the content found in the above mentioned COSEWIC assessment (COSEWIC 2008) and management plan (DFO 2009a). For further information, the reader is encouraged to review those related documents.

3.1 Species description

Killer Whales are the largest member of the dolphin family (*Delphinidae*) and one of the most widely-recognized marine species, with large dorsal fins and a distinct black and white colour pattern. At maturity, males are larger than females in size and weight, with taller, more erect dorsal fins, bigger pectoral flippers and tail flukes. To the untrained eye, it is difficult to distinguish between the three sympatric "ecotypes" of Killer Whales found in Canadian Pacific waters: Resident, Transient (Bigg's) and Offshore Killer Whales. Offshores tend to be smaller in stature, with many more nicks and notches in their dorsal fins than the two other ecotypes (Ford et al. 2000; Dahlheim et al. 2008). They have been found to be socially, acoustically and genetically distinct from the Residents and Transients (Bigg et al. 1990; Ford 1991; Morin et al. 2010). The diet composition of Offshore Killer Whales, though currently not fully understood, also differs from Residents and Transients, which are fish and mammal specialists, respectively. Offshores are believed to be fish-eaters, and specifically shark specialists (Dahlheim et al. 2008; Ford et al. 2011; Ford et al. 2014). Socially, Offshores have been found to be matrilineal, like Resident and Transient Killer Whales, but show a high degree of gregariousness, with social mixing occurring throughout the entire population (Ford et al. 2014). Offshores are mostly encountered in large aggregations, often in groups of 50 to more than 100 animals.

3.2 Population and distribution

Offshore Killer Whales are believed to be the widest-ranging type of Killer Whale found in northeastern Pacific waters (Dahlheim et al. 2008; Ford et al. 2014). Individuals identified off British Columbia have also been seen from the southern Bering Sea to southern California (Figure 1). Genetics and stranding data suggest that the population's range likely extends into Mexican waters as well (Guerrero-Ruiz et al. 2006; Morin et al. 2006; Morin et al. 2010). The true extent of their range relative to shore is currently unknown, though it appears to be, at minimum, from coastal waters to the continental shelf-edge. The population is referred to as "Offshore" due to its range relative to inshore waters; compared to Residents and Transients, Offshores are infrequently encountered in inshore waters, and are therefore thought to spend the majority of their time in more pelagic or shelf-edge waters (Ford et al. 2014).

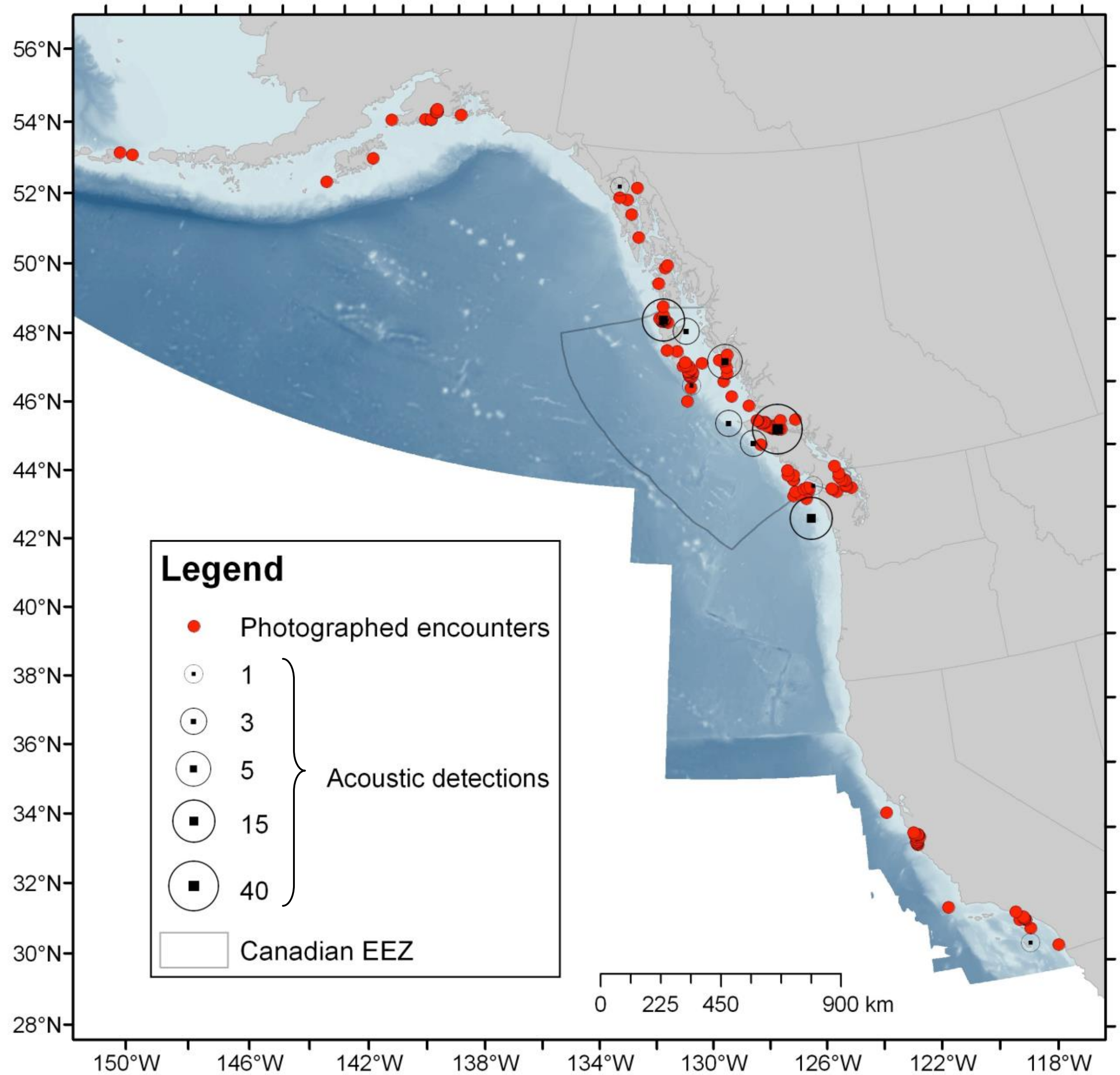

Figure 1. Distribution of encounters with Offshore Killer Whales (red dots) between 1988 and 2012, and total number of days on which Offshores were detected acoustically at fixed monitoring sites (squares surrounded by open circles) between 2006 and 2012. Encounters (n=157) and detections (n=83) as documented by Fisheries and Oceans Canada's Cetacean Research Program (CRP) and American collaborators. Canada's Exclusive Economic Zone is outlined in grey. Relative water depths are shown with shades of blue, where the continental shelf and seamounts have the lightest colouration (from Ford et al. 2014).

As of 2014, Offshores had been photographically or acoustically documented on 172 occasions throughout Canadian Pacific waters, and approximately 240 times within their entire known range (Ford et al. 2014). First identified in Canadian waters in 1988, almost 15 years after the study of Killer Whales in British Columbia first began, the appearance of this ecotype in inshore waters of British Columbia appears to be a relatively recent phenomenon (Ford et al. 1992; Heise et al. 1993). Notably, their first observed visit to the waters inside of Vancouver Island was in 1992 (Ford et al. 2014). Although it is thought that their seemingly recent presence in inshore waters may reflect a shift associated with oceanographic conditions and/or distribution of prey, the data are also confounded by gradually increasing survey effort and public interest.

Offshore Killer Whales are rarely encountered, but when sighted, they are typically found in large aggregations, spread out across large areas, often in open seas and unfavourable conditions. These logistical challenges mean that unlike other Killer Whale populations in Canadian Pacific waters, the population size cannot be counted by traditional methods, such as annual censusing, to monitor abundance and demographics. Instead, the Offshore Killer Whale population size must be estimated using photographic mark-recapture techniques. In 2013, the population abundance of Offshore Killer Whales was estimated to be approximately 300 animals (range of 257 to 373); the population trend appears to be stable, with apparently high survival and relatively low mortality rates (Ford et al. 2014).

3.3 Needs of the Offshore Killer Whale

3.3.1 Dietary requirements

Although much is still unknown about their diet, Offshore Killer Whales are believed to be predominantly fish eaters. Observations in the wild, acoustic behaviour, dentition and toxicology studies, stomach sampling during necropsies, and genetic analyses of prey all strongly suggest a fish-based diet, with a specialization in long-lived fishes such as sharks (Herman et al. 2005; Krahn et al. 2007; Dahlheim et al. 2008; Ford et al. 2011; Ford et al. 2014). In British Columbia, Offshores are known to prey on Pacific Sleeper Shark (*Somniosus pacificus*), Blue Shark (*Prionace glauca*), North Pacific Spiny Dogfish (*Squalus suckleyi*), Chinook Salmon (*Oncorhynchus tshawytscha*), and Pacific Halibut (*Hippoglossus stenolepis*) (Ford et al. 2011; Ford et al. 2014). The exact dietary composition of the Offshore Killer Whale is currently unknown, though it is apparent that sharks comprise a significant portion of their diet. These species provide valuable sources of calorie-rich lipids that are an important component of many Killer Whale populations' diets.

Killer Whales have high metabolic requirements, not solely because of the physiological consequences of their size, but also due to their extensive movement (Williams et al. 2004). It has been estimated that a typical adult male Resident Killer Whale – a fish-eater, like Offshores – may require up to approximately 254,000 kilocalories[2] each day, or approximately 23 Chinook Salmon (Ford et al. 2010). This energetic requirement is roughly equivalent to the consumption of three Pacific Sleeper Shark livers, which appears to be an important food source for Offshore Killer Whales (Ford et al. 2011).

Offshore Killer Whales require a stable abundance of available prey species that are of adequate quality (e.g. from a low-contaminant environment), to satisfy the dietary needs for the population. Reduction in the availability of prey could result in reduced survival and productivity of the population.

3.3.2 Acoustic requirements

Acoustics comprise a significant component of a Killer Whale's physical environment, serving as an important cultural, social, and foraging mechanism. At its most basic, the acoustic

[2] A kilocalorie is a thermochemical unit equivalent to one human nutritional calorie.

environment of Killer Whales is important for navigation and foraging. Through the use of echolocation (also known as biosonar) and passive listening, Killer Whales detect and hunt their prey, and may use these abilities to map their immediate physical environment (Bain and Dahlheim 1994; Bain 1995; Barrett-Lennard et al. 1996). Offshore Killer Whales appear to have slightly lower frequency echolocation clicks than those of sympatric Resident Killer Whales (DFO CRP, unpubl. data). The significance of this difference is currently unknown, though it is hypothesized that it may be a product of the Offshore Killer Whale's regular occurrence in deeper waters than its Resident counterpart, or due to differences in prey preference (Ford pers. comm. 2013).

Communication within a Killer Whale population represents a more complex acoustic matter, fundamental to the social structure, survival and productivity of each population. The three Killer Whale ecotypes found in British Columbia each have distinct repertoires of calls (Ford and Fisher 1982; Bigg et al. 1990; Ford 1991; Ford and Ellis 2014). Offshores appear to have a large acoustic repertoire and have been observed to be highly vocal, comparable to Resident Killer Whale acoustic behaviour (DFO CRP, unpubl. data). In Resident Killer Whales, the cultural transmission of group-specific calls over generations leads to a system of dialects that reflect genetic lineage. These dialects appear to serve as an inbreeding avoidance mechanism (Barrett-Lennard 2000; Barrett-Lennard and Ellis 2001). Preliminary analyses suggest that Offshore Killer Whales may have some degree of group-specific calling, which may possibly serve the same function (DFO CRP, unpubl. data).

At a minimum, Offshore Killer Whales require a marine environment that allows transmission and reception of sound sufficient for communication, prey resource exploitation and effective reproduction.

3.3.3 Population size and genetic diversity

It is thought that due to their naturally low reproductive potential and overall low genetic diversity, Killer Whales tend to have inherently small populations that are socially and reproductively isolated from one another, even when occurring sympatrically (Barrett-Lennard 2000). In theory, this trait is not an impediment to recovery, so long as the population has adequate genetic diversity and a sufficient breeding population. It is estimated that the current Offshore Killer Whale population has roughly 130 individuals of breeding age (DFO CRP, unpubl. data; see footnote 1 on page v). Preliminary genetic analyses suggest the population is as genetically diverse as both the Northern and Southern Resident Killer Whale populations combined (Morin et al. 2010). Offshore Killer Whales seem to have relatively high genetic diversity that may reflect a larger historical population size and/or past gene flow with adjacent populations (Morin pers. comm. 2014). This may also mean that inbreeding is not a significant concern in this population, so long as there are an adequate number of mature, breeding individuals available.

Continuity of the small population of Offshore Killer Whales requires that minimal mortality be incurred by the breeding portion of the population, and that high recruitment into that portion take place in future generations. Maintaining as much genetic diversity as possible is imperative, to avoid genetic bottlenecks that could impede the population's recovery.

3.3.4 Continuous range

As previously noted, Offshores are the most wide-ranging Killer Whales known to occupy British Columbia waters. With many photo-identified matches of individuals and genetic evidence of

Offshores spanning the waters of three countries, whales in this population appear to be highly mobile, spending the majority of their time in offshore, open waters. This tendency towards travelling in open waters may make Offshore Killer Whales vulnerable to natural entrapment and mass stranding when they travel closer to the coast or within confined, unfamiliar waters. The increase in inshore water visits by Offshores seen in recent years may be increasing the population's exposure to more concentrated human activity and the associated disturbances and risks. When encountered in inshore waters, Offshores often remain for extended periods of time and have been known to gravitate to the heads of inlets (Ford et al. 2014). It is unknown whether this is due to disorientation or confusion, or purposeful actions such as the exploitation of prey patches. Regardless, any impediment to their passage through these types of waterways could prove detrimental.

Offshore Killer Whales require, at a minimum, obstruction- and deterrent-free use of continental shelf waters and passage into inshore, protected waters, as well as to and from waters under foreign jurisdiction.

4 Threats

4.1 Threat assessment

Table 1 Threat assessment table

Category	Threat	Level of concern[3]	Extent[4]	Occurrence[5]	Frequency[6]	Severity[7]	Causal certainty[8]
Anthropogenic threat: Prey availability	**Reduction in prey availability**	High	Widespread	Unknown	Unknown	High	High
Anthropogenic threat: Environmental contaminants	**Contaminant exposure from prey**	High	Widespread	Historic, Current and Anticipated (depending on specific contaminant)	Continuous	High	Medium
Anthropogenic threat: Environmental contaminants	**Spills of substances harmful to the marine environment**	High	Localized	Historic, Current, Imminent and Anticipated	Recurrent	High	High
Anthropogenic threat: Acoustic disturbance	**Acoustic disturbance (acute)**	High	Localized	Historic, Current, Imminent and Anticipated	Recurrent	High	Medium

[3] 'Level of concern' signifies that managing the threat is of (High, Medium or Low) concern for the recovery of the species, consistent with the population and distribution objectives. This criterion considers the assessment of all the information in the table.
[4] The 'Extent' identified for each threat, limitation or vulnerability is considered across the species' range.
[5] 'Historic' means that the threat has or may have historically *affected the population*, but not necessarily contributed to its decline; 'Imminent' means that the threat is expected to affect the population very soon, whereas 'Anticipated' means that the threat may affect the population in the future.
[6] 'Recurrent' means that the threat reoccurs from time-to-time, but not on an annual or seasonal basis.
[7] 'Severity' reflects the population-level effect (High: very large population-level effect; Moderate, Low or Unknown).
[8] 'Causal certainty' reflects the degree of evidence that is known for the threat (High: available evidence strongly links the threat to stresses on population viability; Medium: there is a correlation between the threat and population viability, e.g. expert opinion; Low: the threat is assumed or plausible).

Category	Threat	Level of concern[3]	Extent[4]	Occurrence[5]	Frequency[6]	Severity[7]	Causal certainty[8]
Anthropogenic threat: Acoustic disturbance	**Acoustic disturbance (chronic)**	Medium	Widespread (with localized high intensity, e.g. Juan de Fuca Strait)	Current, Imminent and Anticipated	Continuous	High	Low
Anthropogenic threat: Physical disturbance	**Physical disturbance**	Medium	Localized	Current, Imminent and Anticipated	Recurrent	Low	Low
Anthropogenic threat: Physical disturbance	**Interactions with commercial fisheries and aquaculture**	Low	Localized	Unknown	Unknown	Unknown (but potentially High)	Low
Anthropogenic threat: Physical disturbance	**Direct killing**	Low	Localized	Historic, and Unknown in the future	Unknown	High	High
Anthropogenic threat: Climate change	**Changing oceanographic conditions**	Uncertain	Widespread	Anticipated	Unknown	Unknown	Medium
Anthropogenic threat: Climate change	**Changes in acoustic propagation**	Uncertain	Widespread	Anticipated	Unknown	Unknown	Medium
Anthropogenic threat: Climate change	**Shifting prey distribution**	Uncertain	Widespread	Anticipated	Unknown	Unknown	Medium
Natural limitations and vulnerabilities[9]	**Disease agents**	Uncertain	Widespread	Unknown	Unknown	High	High

[9] Natural limitations and vulnerabilities identified here are those that are exacerbated by anthropogenic activities, and that if realized, will have a population-level effect.

Category	Threat	Level of concern[3]	Extent[4]	Occurrence[5]	Frequency[6]	Severity[7]	Causal certainty[8]
Natural limitations and vulnerabilities	**Fixed dietary preferences and natural decreases in prey supply**	n/a[10]	Widespread	Unknown	Unknown	High	Medium
Natural limitations and vulnerabilities	**Inbreeding depression**	n/a	Widespread	Unknown	Unknown	High	Medium
Natural limitations and vulnerabilities	**Tooth wear**	n/a	Widespread	Unknown	Continuous	Unknown (but potentially High)	Low
Natural limitations and vulnerabilities	**Mass stranding or natural entrapment**	n/a	Localized	Historic, and Unknown in the future	Recurrent	High	High

[10] n/a in this column means that the Level of concern is not applicable, because management of those particular vulnerabilities is not feasible (i.e. they are natural processes that humans cannot directly influence).

4.2 Description of threats

Due to the small population size and typically large groupings of individual Offshore Killer Whales, at least one third of the entire known population may be present at a given time and location (Ford et al. 2014). This grouping behaviour makes this population particularly vulnerable to stochastic events like oil spills, acute noise and infectious disease events, which have the capability of causing population-level effects. Such a perturbation could severely reduce the population's size or alter its demographic composition should a significant group of reproductively-capable individuals be lost. Though the grouping behaviour may lessen the probability of Offshores being present at stochastic events, it also significantly increases the probability of population-wide consequences should a large group be impacted by a stochastic event. As there is not much Killer Whale-specific research on many of the threats discussed below, in many cases weight of evidence from research performed on other cetacean species is used.

4.2.1 Anthropogenic threats

Prey availability

Reduction in prey availability

As apex predators, Killer Whales are limited by "bottom-up" forces – that is to say they are ultimately limited by the availability of their preferred prey – making reduction in prey availability and changes in diet composition of concern, as clearly demonstrated in the sympatric Resident Killer Whale population. Of the five confirmed Offshore Killer Whale prey species in Canadian Pacific waters, North Pacific Spiny Dogfish, Chinook Salmon, and Pacific Halibut are subject to actively managed fisheries in these waters. This direct fishery competition has the potential to reduce the abundance of prey resources available to the Offshore population.

Of the three shark species known to be consumed by Offshores in Canadian waters, only the Spiny Dogfish is monitored and managed solely by DFO. Although this species is considered to be relatively abundant in Canadian Pacific waters, it has been assessed as Special Concern by COSEWIC (COSEWIC 2011). Recent assessments of the two stocks of Spiny Dogfish recognized in Canadian Pacific waters show the relative abundance of those stocks to be stable (King and McFarlane 2009; Wallace et al. 2009; DFO 2010). In particular, the "outside stock" (continental shelf waters, excluding the Strait of Georgia), which is likely to be consumed by Offshore Killer Whales, is healthy and fishing pressure is considered to be low relative to the estimated size of the population (Wallace et al. 2009).

Chinook Salmon is part of a jointly-managed fishery in Canada and the US. The current abundance of Chinook in the Northeast Pacific is significantly lower than historic levels, with noted shifts in many populations toward younger age and smaller adults (Myers 2011). From 1979 to 2012, trends of total Chinook abundance along the west coast, from British Columbia to California, showed an overall decrease of roughly 16% (Kope and Parken 2011). Currently, nine Evolutionary Significant Units in Washington, Oregon and California are considered Endangered or Threatened under the US Endangered Species Act (ESA) (Ford et al. 2011a; Williams et al. 2011). British Columbia's Okanagan population was assessed by COSEWIC (2006b) to be Threatened, but ultimately was not listed under SARA.

The third active fishery overlapping with Offshore Killer Whale prey interests is for Pacific Halibut, which is regulated and managed by the International Pacific Halibut Commission. Pacific Halibut has delayed maturity but high fecundity, making it moderately resilient to fishing pressure (Schmitt and Skud 1978). Stock assessments over the past decade suggest that the population has been continuously declining as a result of decreasing size-at-age and poor recruitment, with exploitable biomass estimated to have declined approximately 50% in the 2000s (Hare 2010). With catch limits set in response to this decline, the latest assessments and projections show that the population decline has slowed and that the stock trajectory is currently relatively flat (Stewart et al. 2013). This species has not been assessed by COSEWIC, the IUCN, or under the US' ESA.

Perhaps the greatest uncertainty concerning the remaining known Offshore Killer Whale prey species is the lack of knowledge of their historical and current abundance, and the absence of assessments. Neither the Pacific Sleeper Shark nor the Blue Shark are targets of directed fisheries in Canadian Pacific waters, but bycatch of these species in trawl and longline fisheries is monitored by DFO. The Pacific Sleeper Shark is noted to be relatively common in the North Pacific, but no biomass or trend estimates exist for Canadian Pacific waters and the species remains unassessed by COSEWIC (Ebert et al. 2009). The Blue Shark, too, has no Canadian Pacific biomass or trend estimates, though recent US assessments suggest that the current North Pacific population levels are comparable to those 40 years ago, and that the species is being fished well below its maximum sustainable yield (Kleiber et al. 2009). The Blue Shark is thought to be "regularly present" in Canadian Pacific waters, with low rates of removal through bycatch, and considered Data Deficient by COSEWIC (2006a). Despite these two species not being actively managed, Canada is a signatory to the FAO's International Plan of Action for the Conservation and Management of Sharks (1994), implemented through Canada's National Plan of Action for the Conservation and Management of Sharks (DFO 2007a).

These gaps in knowledge and fundamental population assessments of key Offshore Killer Whale prey species could allow changes in prey abundance and availability to go unnoticed, which could be detrimental to the Killer Whale ecotype if said changes are deleterious. However, there is no evidence that the abundance of the three shark species that dominate the known diet of Offshore Killer Whales has declined in recent years or is likely to in the foreseeable future.

That said, the comprehensive diet composition of Offshore Killer Whales is currently unknown. There is a strong possibility that additional prey items important to Offshores are not yet known, and fluctuations in the availability of these additional important prey items could have significant population level impacts on Offshore Killer Whales. Considering Offshores' apparent preference for large shark prey, Basking Sharks (*Cetorhinus maximus*) may have historically been a significant prey item; the severe decline of Basking Sharks in Canadian Pacific waters (DFO 2009b) may have had an impact on the Offshore Killer Whale population.

Environmental contaminants

Contaminant exposure from prey:

The Offshore Killer Whale population is affected by the quality of their prey. Due to the long-lived nature and high trophic level of most of their prey, Offshores are likely exposed to large concentrations of bioaccumulated contaminants. These contaminants may be in the form of legacy and emerging persistent bioaccumulative substances, heavy metals or biological pollutants. The consumption of prey containing harmful substances raises concerns of adverse health effects in Offshore Killer Whales.

a. Legacy and emerging contaminants

Legacy contaminants refer to those that are largely disused and often banned from the marketplace, but still persist in the environment (e.g. insecticide dichlorodiphenyltrichloroethane (DDT); polychlorinated biphenyls (PCBs)). Emerging contaminants refer to harmful substances with similar properties to legacy contaminants, but which remain in use and are not yet regulated or withdrawn from the marketplace (e.g. polybrominated diphenyl ethers (PBDEs)). These contaminants, considered Persistent Bioaccumulating Toxins (PBTs) or Persistent Organic Pollutants (POPs), are persistent, toxic and bioaccumulative, rendering long-lived, high trophic level organisms like Killer Whales particularly vulnerable to severe contamination and associated health risks (Grant and Ross 2002). Disrupting endocrine function and acting as ‘hormone mimics’, these contaminants have been shown to have chronic and slow-acting detrimental effects on individuals’ growth, development, and immune function, leading to decreased reproductive capability, and increased incidence of disease, skeletal abnormalities and neurological impairment (Reijnders 1986, 1994; Ross et al. 2000; Darnerud 2003; Hall et al. 2003; Mos et al. 2006; Ross 2006; Tabuchi et al. 2006).

Offshore Killer Whales have been found to have elevated concentrations of legacy and emerging contaminants. Though Offshores are known to have a fish-based diet, concentrations of PCBs in Offshores have been found to be more comparable to mammal-eating Transient Killer Whales than fish-eating Residents (Herman et al. 2005; Krahn et al. 2007). This is likely due to the Offshores’ distinct diet, specializing in longer-lived fishes, such as sharks, that have higher concentrations of bioaccumulating substances. Offshores also have significantly higher concentrations of DDT and PBDEs relative to Residents and Transients (Herman et al. 2005; Krahn et al. 2007). A high DDT to PCB ratio is found in Offshores, characteristic of waters and sediments off the California coast, where DDT comprises a more significant portion of contaminants and where prey may be exposed to elevated concentrations of contaminants relative to higher latitude waters (Brown et al. 1998); this shared characteristic ratio is thought to be an indication of Offshore Killer Whales’ frequent occurrence off California (Herman et al. 2005; Krahn et al. 2007). There are many sources of these persistent substances, often from urban and agriculture runoff, along the west coast of North America. Runoff from urban areas is especially troubling in California (Krahn et al. 2007), where Offshores are regularly sighted in the winter, often near large urban centers (e.g. San Francisco; Monterey Bay; Santa Barbara; Los Angeles).

b. Heavy metals

No information currently exists on the concentrations of heavy metals, such as lead, mercury and cadmium, in Killer Whales occupying the northeastern Pacific Ocean. Very little information exists on levels of heavy metals in cetaceans in general (Endo et al. 2003), and though there are minimal data available on effects on marine mammals, it is suspected that heavy metals may cause an inadequate immune response in individual Beluga Whales (*Delphinapterus leucas*) from the St. Lawrence River Estuary population (De Guise et al. 1996). Like the contaminants previously described, heavy metals are often discharged into the marine environment from urban runoff and are bioaccumulative in nature. This bioaccumulative behaviour suggests that a high trophic level predator like the Offshore Killer Whale receives significant heavy metal input from its prey, particularly from long-lived fishes like sharks.

Of particular concern is Offshore Killer Whales' apparent targeting of the liver of at least one of their preferred prey, the Pacific Sleeper Shark. The liver is a lipid-rich meal, but is also a reservoir of heavy metals. All three shark species known to be consumed by Offshores have high mercury contents (Forrester et al. 1972; Branco et al. 2004; McMeans et al. 2007), likely increasing the severity of heavy metal consumption and accumulation in Offshore Killer Whales.

Killer Whales are thought to have evolved the ability to detoxify heavy metals such as mercury (Martoja and Berry 1980); however, it is unknown whether detoxification in Offshore Killer Whales functions effectively enough to deal with their apparent diet preference for livers from intermediate-to-high trophic level prey, and exposure to an elevated contaminant environment. Unlike legacy and emerging contaminants, only minor amounts of heavy metals are transferred to Killer Whale calves through the placenta or milk ingestion (Endo et al. 2006, 2007).

c. Biological pollutants

The third class of prey-mediated contaminants in Killer Whales are biological pollutants. These pollutants are composed of naturally-occurring compounds, whose amplification in the environment due to human activity often results in harmful effects to wildlife. Biological pollutants can be directly introduced to the marine environment through urban outfall and agricultural runoff (e.g. hormones; antibiotics) or can be generated by nutrient loading from those anthropogenic inputs (e.g. toxic algal blooms).

Pharmaceutical compounds (e.g. hormone regulators; antibiotics) have the potential to act as hormone mimics and endocrine disruptors, having adverse effects on animals' organ development, immune function and sexual maturation, sometimes causing cancer and malformations (Slater et al. 1995; Liney et al. 2006; Vajda et al. 2008; Bjerregaard 2012). These compounds make their way to the marine environment through sewage treatment plants, septic systems, and agricultural runoff and leaching. Though the bioaccumulation of natural and synthetic hormones has been observed in marine vertebrates, the bioaccumulation and effects of these compounds have not been tested in any aquatic animals higher than low trophic level fish (Lai et al. 2002; Nagpal and Meays 2009). The concentration of these compounds and their effects in cetaceans are relatively unexplored, and completely unknown in Killer Whales.

Harmful algal blooms (HABs) are periodic proliferations of high densities of toxin-producing algae. While these blooms are naturally occurring, anthropogenic activities contribute to HABs through nutrient loading (Anderson et al. 2002), inadvertent transport and introduction of harmful species (Hallegraeff 1998), overfishing (Eriksson et al. 2009) and climate change (Van Dolah 2005; Hallegraeff 2010). Unlike the previously discussed contaminants, algal toxins are fast-acting and potent. Though marine mammals can suffer exposure to algal toxins through direct respiration, prey most often act as vectors of these toxins which can accumulate in the tissues of species that ingest them and are magnified up the food chain. While HABs have been associated with high mortality and suppressed reproduction in some marine mammals (Durbin et al. 2002; Van Dolah 2005), no Killer Whale has been found to have died as a direct result of algal toxins.

Levels of heavy metals are moderately documented in Offshore Killer Whale shark prey species, but levels of legacy and emerging contaminants, and biological pollutants in these prey species are relatively unknown. It remains unknown whether the high toxicity observed in Offshores' tissues is currently limiting the population, or whether it will have an effect in the future. There remains the possibility that contaminant levels may have a delayed effect on the population. The abundance of anthropogenic sources of contaminants in areas of frequent Offshore Killer Whale occurrence underscores the pertinence of this threat to this population.

Spills of substances harmful to the marine environment

Spills of substances harmful to the marine environment are a paramount concern for Killer Whales in British Columbia. There is currently no evidence that whales can detect and avoid spills. As Killer Whales do not possess a sense of smell, they are unlikely to perceive a spill as they swim through it; they have been observed to seemingly not avoid spills and could incur direct mortality from inhalation of vapours. This is best exemplified by 1989's Exxon Valdez oil spill in Prince William Sound, Alaska, through which groups of Alaskan Resident and Transient Killer Whales were seen travelling, and after which an unprecedented number of mortalities occurred in their populations (Matkin et al. 1998, 1999, 2008, 2012).

Spills of substances harmful to the marine environment not only present a source of direct mortality for some animals through adhesion, inhalation, mutagenic and carcinogenic effects (Samanta et al. 2002), as well as physiological and endocrine disruptions (Bilbao et al. 2010), but they also have potential indirect effects through the degradation of Killer Whale prey and habitat. Oil pollution potentially affects whales through contaminated prey ingestion, skin and eye irritation, inhalation of fumes, and abandonment of polluted foraging areas (Clapham et al. 1999).

The 2010 Deepwater Horizon oil spill, in the Gulf of Mexico, was associated with 101 cetacean carcasses that washed up on the northern shores of the Gulf (Antonio et al. 2011). Taking into account the low rate of recovery due to sunken, scavenged or drifting carcasses, cetacean mortalities caused by the spill could be up to 50 times higher (Williams R., et al. 2011). In addition to direct mortalities, certain species have been shown to be displaced by the spill (Ackleh et al. 2012), and others are thought to have suffered from cumulative stressors (Carmichael et al. 2012). As recovery from this spill event is currently ongoing, long-term effects of the oil – and the surfactants and dispersants used in the spill's control – on the health of cetacean populations and individual animals is yet unknown. Research to date has focused on larger, catastrophic spills and their potential effects. There has been little research associating impacts from exposure to both intentional and accidental small-scale discharges that may occur more frequently (National Research Council (NRC) 2003; O'Hara pers. comm. 2014).

As described previously, the threat of oil spills and discharges holds risk for Offshore Killer Whales, due to their grouping behaviour. With multiple current proposals involving increased marine transport of petroleum products and other hazardous substances to and from British Columbia, an increase in large vessel traffic (e.g. tankers) in these waters heightens the risk of potential spills of substances harmful to the marine environment, and to Offshores and their prey.

Acoustic disturbance

Acute noise

Acute anthropogenic noise in the marine environment can be generated by numerous sources, including: military sonar and ordnance; seismic surveying; marine construction, pile driving and blasting; and acoustic deterrent devices. This noise is characterised by loud, intense and impulsive sounds that can travel large distances underwater (from 10 to more than 100 km). Though the effects of these severe noises on Killer Whales are currently unknown, they have been shown to respond to acute noise in general through avoidance behaviour (Bain 1995). Anthropogenic acute noise has also been shown to produce adverse effects in many other cetacean species. Effects include behavioural changes, disorientation, displacement from habitat, physical damage to hearing structures, temporary or permanent hearing impairment, and direct and indirect mortality, both in whales and their prey (Nowacek et al. 2007).

Naval mid-frequency (1-14 kHz) active sonar (MFAS) has been strongly associated with many toothed whale (suborder *Odontoceti*) strandings and mass mortalities, especially in deep-diving beaked whales (of the family *Ziphiidae*) (Balcomb and Claridge 2001; Evans and England 2001). Recent studies show that the particular bathymetry at the location of naval activity is likely an important factor in the occurrence of sonar-related strandings (Filadelfo et al. 2009). It has been suggested that areas of steep bathymetry close to an adjacent coastline, with military sonars used seaward, are most highly correlated with these stranding events (D'Amico et al. 2009). Though not all MFAS systems use the same frequency range, output power or waveforms, and despite efforts to reduce mid-frequency sonar levels, it has been found that MFAS can still disturb and displace whales, even when the signals are lower than those currently permitted to the US Navy (Tyack et al. 2011; DeRuiter et al. 2013; Goldbogen et al. 2013). MFAS has not only been shown to alter animals' movements, but also affects their acoustic behaviour. Humpback Whales (*Megaptera novaeangliae*) have been observed to extend the length of their song in the presence of MFAS (Miller et al. 2000), while Blue Whales (*Balaenoptera musculus*) showed a reduced probability of producing calls when MFAS was present (Melcón et al. 2012).

Killer Whales have been observed to alter their behaviour in reaction to active MFAS. On May 5, 2003, a group of Southern Resident Killer Whales were exposed to a MFAS signal for just over three hours in the presence of the American destroyer *USS Shoup*, which was in an active sonar training exercise. The Killer Whales were seen to display abnormal behaviours that suggested a strong avoidance reaction (National Marine Fisheries Service (NMFS) 2005). It is believed that the sonar exposure likely resulted in auditory masking to some degree, but it is unknown whether this event resulted in temporary changes in hearing sensitivity, and is considered unlikely that permanent changes in hearing sensitivity or injury of the Killer Whales present occurred (NMFS 2005). Tagging experiments have also shown Killer Whales to alter behaviour in the presence of sonar transmissions, resulting in the cessation of foraging, prolonged cessation of vocal behaviour and swift displacement from the ensonified area (Miller et al. 2012).

Seismic surveying involves intense blasts of sound from airgun arrays, whose noise is concentrated in low frequencies (less than 1 kHz) but often detectable up to 100 km away. Although there are currently no data for Killer Whales, Pacific Harbour Porpoises (*Phocoena phocoena vomerina*) and Steller Sea Lions (*Eumetopias jubatus*) in British Columbia have shown significant avoidance responses to seismic activity, even at relatively low levels of sound and at long distances (Bain and Williams 2006). Whales have also been observed to be displaced due to seismic activity, showing strong avoidance of the ensonified areas (Malme et al. 1983; Richardson and Williams 2004; Castellote et al. 2012). There are many cases of impacts on baleen whales from seismic surveys, primarily causing changes in vocalization behaviour and displacement from habitat. Blue Whales have been shown to increase their calling rate in the presence of intense seismic noise (Di Iorio and Clark 2010), while Humpback and Fin Whales (*Balaenoptera physalus*) have ceased singing for the duration of seismic operations, often lasting several weeks (Clark and Gagnon 2006).

Also notable is the potential sensitivity of some of the Offshore Killer Whale's prey to acute and low-frequency sound. Some teleosts (bony fishes) have been shown to be highly sensitive to acute noise events, showing displacement or mortality (Skalski et al. 1992; Engås et al. 1996), temporary or long-term hearing loss (e.g. Scholik and Yan 2002), and physical damage to ear structures (McCauley et al. 2003). Elasmobranchs (cartilaginous fishes; e.g. sharks) are thought to have a relatively narrow, low-frequency (20 Hz to 1 kHz) hearing range (Casper and Mann 2009) and do not appear as sensitive to sounds in these bandwidths as teleosts (Casper et al. 2012). Numerous shallow-water and epipelagic shark species have been found to be attracted to low-frequency pulse trains (Myrberg et al. 1972). Such pulse trains are commonly made by injured or dying fish, suggesting the reason behind sharks' attraction to this sound. Conversely, studies have shown sharks to startle and leave a location when a sudden, loud (20 to 30dB above ambient noise levels) sound is played (Myrberg 2001). It must be noted that none of these studies looked specifically at species known to be consumed by Offshore Killer Whales, but the marked sensitivity of related species does raise the possibility of acute noise events affecting Offshores' prey.

With anticipated increased development in and around British Columbia's marine environment, it is expected that sources of acute noise will increase in these waters due to the marine construction required by these projects. Given these anticipated increases in acute noise, as well as ongoing military sonar and ordnance activity, seismic survey practices and the general sensitivity of cetaceans to acute noise, this threat is of high concern for the Offshore Killer Whale population, whose large group sizes make them particularly vulnerable to stochastic events.

Chronic noise

Ambient noise levels in the world's oceans have risen significantly in the past few decades. This increase has occurred across low and mid-frequencies, and is driven by increasing anthropogenic noise – particularly shipping traffic (McDonald et al. 2006). It is generally accepted that increasing numbers and speeds of vessels likely have the cumulative effect of reducing the quality of habitat for cetaceans by increasing the level of underwater noise. Though no data currently exist on the effects of chronic noise on Killer Whales, effects have been noted in various other cetacean species. Chronic vessel noise has been shown to alter swimming and foraging behaviour in beaked whales (Pirotta et al. 2012) and has resulted in physical damage to the internal ear of Sperm Whales (*Physeter macrocephalus*) (André et al. 1997). Shipping noise has also been correlated with elevated stress in North Atlantic Right Whales (*Eubalaena glacialis*) (Rolland et al. 2012), as well as changes in song behaviour in Fin Whales (Castellote et al. 2012).

The acoustic environment of a Killer Whale is an integral component of its habitat. Noise may mask a whale's ability to communicate, echolocate, and passively listen, thereby affecting its ability to capture prey, navigate, and maintain social cohesion. Very little is known about how chronic noise affects Killer Whales or their adaptability to changes in ambient noise levels. The Killer Whale's effective range of calling for several areas of coastal British Columbia has been postulated to be reduced by the presence of chronic anthropogenic noise, potentially making it more difficult for effective communication between groups and/or individuals (Williams et al. 2013). Chronic acoustic noise that impedes the animals' ability to detect intraspecific communication signals may cause stress and possibly alter Killer Whale behaviour, or reduce efficiency in coordinating foraging events where animals are commonly spread out over large distances (Williams et al. 2006; Holt 2008; Holt et al. 2012). Resident Killer Whales have been shown to alter calling behaviour in the presence of persistent vessel noise, by increasing the amplitude, frequency of calls, and/or rate of calling (Erbe 2002; Foote et al. 2004; Holt et al. 2008).

The Offshore Killer Whale's geographic range overlaps with high-volume shipping routes (e.g. Los Angeles; San Francisco; southwest Vancouver Island), underscoring the concern for their exposure to chronic noise. However, shipping noise in pelagic and shelf-edge waters, where these Killer Whales are thought to spend the majority of their time, is likely less concentrated than in waters closer to originating ports or coastal passages – though no studies have been undertaken to specifically assess the exposure of Offshore Killer Whales to anthropogenic noise in their habitat. Shipping traffic in British Columbia is increasing (Nuka Research 2013; PMV 2013), and chronic underwater noise is expected to increase due to other sources as well, such as possible wind and tidal power generation projects, and possible marine kinetic energy projects. Of concern are the potential cumulative impacts of these existing and potential sources of chronic noise on Killer Whales.

Physical disturbance

Physical disturbance

Physical disturbance to Killer Whales in the Canadian Pacific is an ongoing concern, in terms of vessel encroachment and strikes, as well as potential industrial development (e.g. offshore wind farms; tidal turbines; offshore oil platforms). Until recently there have been relatively few reports of Killer Whales being struck by boats, but between 2004 and 2016, there were at least eight reliable reports of collisions between vessels and Killer Whales in British Columbia (Spaven pers. comm. 2017). Two of these collisions were fatal for the whales. The recent mortality of J34, a prime age male found to have died from large blunt force trauma, highlights this threat (DFO 2016).

Disturbance due to vessel proximity is a concern for Killer Whales in British Columbia, especially given the growth of the commercial whale watching industry in these waters (Osborne et al. 2003; O'Connor et al. 2009). The largest concentrations of whale watching vessels occur at both the northeast and southeast ends of Vancouver Island, where we also find large, conspicuous groups of Offshore Killer Whales; it is likely that most visits to these waters by Offshores have been documented and accompanied by intense, day-long vessel traffic. With the potential to interrupt foraging behaviour and with concerns about inhalation of exhaust, vessel proximity to Killer Whales is not an insignificant threat (Williams et al. 2002, 2006; Lusseau et al. 2009; Lachmuth et al. 2011).

There are no records or documented reports of vessel strikes on Offshore Killer Whales in Canadian Pacific waters. Only one individual Offshore Killer Whale has been observed with physical injuries suggesting an interaction with a vessel; a female was seen in 2005 with her dorsal fin missing, a clean cut suspected to have been made by a propeller strike sometime within the previous three years (DFO CRP, unpubl. data). .

Perhaps the greatest concern regarding Killer Whale-vessel interactions is the propensity of Killer Whales, including Offshores, to "prop inspect". This behaviour involves the animals following a boat and playing in the wash of its propeller. This curious behaviour may be reflected in the history of the confirmed vessel strike records in British Columbia: half of the cases involve death or injury inflicted specifically by a vessel's propeller.

Offshore Killer Whales' large group sizes make them quite conspicuous when entering nearshore waters. This attention makes them particularly vulnerable to vessel disturbance. Though the infrequency with which they enter waters regularly used by boaters should minimize the threat of physical disturbance by vessels, their lack of habituation to vessel traffic is of concern. Traffic from large vessels travelling outside protected waters at high speeds, such as commercial and cruise ships, has increased over the past decade and will likely continue to grow, increasing the risk of this threat.

Man-made structures in the marine environment also have the potential to displace Killer Whales and create barriers to passage. There are currently several investigative projects in British Columbia exploring the possible installation of tidal turbines in narrow passages and other tidal waters. Though these devices cause concern as a potential source of physical injury or mortality due to blade strikes, they also have the potential to obstruct passage or displace Killer Whales as their physical presence, coupled with the underwater noise that they generate, may cause the whales to avoid areas where these devices are present.

Avoidance of an area by Killer Whales due to the physical presence of a novel device is not without precedence. On multiple occasions Killer Whales have been observed to be impeded by objects that, though not completely physically obstructing a passage, create enough of an imagined barrier that the whales are hesitant to pass. This sort of "psychological" barrier has been observed involving man-made objects in the past; most notably, a floating bridge in Hood Canal, Washington, which is thought to be the reason for two separate long-term entrapments (59 and 172 days) of two different groups of Transient Killer Whales in 2003 and 2005 (London 2006; Ford et al. 2013). With the increasing development of various marine industries in the range of the Offshore Killer Whale, there lies a significant concern that portions of their habitat will become subject to physical disturbances obstructing their use by Offshores.

Interactions with commercial fisheries

There are no records or documented reports of entanglements or entrapments specifically of Offshore Killer Whales in commercial fishing or aquaculture gear, or derelict and discarded gear, nor have any individuals been photographed with evidence of any previous interactions with fisheries (e.g. scars; trailing gear). Killer Whales are rarely entangled in fishing gear, based on anecdotal accounts and an absence of net marks in identification photographs, but the actual number of whales caught are unknown (Baird 2001).

There have been seven documented and confirmed records of Killer Whale entanglements in commercial fishing gear in Canadian Pacific waters (DFO Marine Mammal Response Program, 2012). Of the seven confirmed entangled animals, most were from the Northern Resident Killer Whale population and five survived, apparently unharmed. The remaining two records involved the mortalities of two unidentified Killer Whales in 1986, taken in the experimental Neon Flying Squid (*Ommastrephes bartrami*) fishery, a commercial driftnet fishery active between 1979 and 1987 in eastern Pacific Ocean waters far off the coast of British Columbia (Jamieson and Heritage 1987). The records from this high seas fishery only summarize mortalities; therefore it is unknown whether more animals were affected but escaped alive, healthy or injured. In 2014, Northern Resident Killer Whale I103 became severely entangled in a gill net and despite being released quickly, died the following winter. Several stranded Killer Whales have been found with gear from commercial or recreational line fisheries in their stomachs and the possibility of mortality as a result is unknown (Ford et al. 1998). A few entanglements have been reported from BC, Alaska and California, but they usually have not resulted in death (Pike and MacAskie 1969; Barlow et al. 1994; Heyning et al. 1994; Guenther et al. 1995).

Depredation, where animals remove and eat captured fish from nets or lines, has been documented in Resident Killer Whales in British Columbia and Alaska (Ellis pers. comm. 2013). This activity is a threat as it can result in animals incidentally getting entangled in nets or swallowing hooks, which might lead to internal abrasion and infection. To date, there are no records of depredation by Offshore Killer Whales. However, depredation is thought to be a learned behaviour, and once known to a given portion of the population, may quickly spread throughout the rest.

Of the five confirmed Offshore Killer Whale prey species in Canadian Pacific waters, two are targets of active hook-and-line fisheries, and the remaining three have been known to be bycaught in various hook-and-line fisheries. Broken-off hooks within prey present another possible source of hook ingestion observed in Resident Killer Whales, which could result in internal infection.

Offshore Killer Whales' range in pelagic and shelf-edge waters in British Columbia may make them less susceptible to the risk of interactions with commercial fisheries, compared to the more nearshore Killer Whale ecotypes. However, the overlap between Offshores' prey base and three large-scale commercial fisheries increases the chances of spatial-temporal overlap, potentially resulting in entanglement, entrapment, or depredation incidents.

Direct killing

There have been no reports or records of any direct killing (e.g. shooting) of Offshore Killer Whales since they were identified as a distinct ecotype in 1988, nor have they been observed to have any scarring that suggests injury from any attempt. In 1955, one Offshore Killer Whale was taken during the whaling period in British Columbia (Ford et al. 2011), another Offshore was live-captured and died two days later in 1961 (Caldwell and Brown 1964), and two Offshores were harpooned off the California coast in 1964 and 1966 for research purposes (Morin et al. 2006). Until the mid-1980s, Killer Whales were commonly thought of as nuisance animals in competition with fisheries in Canadian Pacific waters and were often shot by fishermen. There are no records of the extent of resultant mortality; however, some older Resident Killer Whales bear scars that were likely sustained from shootings. Offshore Killer Whales' apparent absence from nearshore waters during that time may have prevented them from incurring any death or injury from these shootings.

With the increasing presence of Offshores in protected waters and their overlap with multiple commercial and sport fisheries' interests, and the potential for depredation by Offshore Killer Whales, this threat remains a possibility. However, due to Canada's Marine Mammal Regulations and US federal regulations prohibiting killing of animals interfering with fishing operations, no historical record of killing attempts on Offshores and changing social values, direct killing is considered of little concern to the Offshore Killer Whale population.

Climate change

Anthropogenically-driven climate change is a significant threat faced by marine wildlife and ecosystems today (Pachauri 2007; Hoegh-Guldberg and Bruno 2010). It is associated with: changing oceanographic conditions (e.g. ocean acidification, increased frequency of algal blooms; Orr et al. 2005; Van Dolah 2005; Cao et al. 2007; Doney et al. 2009; Hallegraeff 2010; Johnson and White 2014); changes in acoustic propagation (Munk and Forbes 1989); and shifting prey distributions (Stachowicz et al. 2002; Ling 2008). Climate change likely acts synergistically with many of the other existing threats to Offshore Killer Whales. The pathways through which this threat can affect Offshore Killer Whales are numerous, complex, and poorly understood, creating great uncertainty in how exactly climate change may affect Offshore Killer Whales.

4.2.2 Natural limitations and vulnerabilities

Disease agents

Disease agents refer to pathogens – viruses, bacteria and parasites that can cause disease and that can often spread quickly throughout and across susceptible species. Disease agents may affect Offshore Killer Whales directly by interfering with their ability to successfully forage or reproduce, or indirectly by infecting and impacting their prey. Though there have been no disease-related mass mortalities observed to date in marine mammals in the Canadian Pacific, numerous disease agents have been identified in Canadian Killer Whale populations and shown to cause mass mortalities in other marine mammal species. At present there are almost no data on pathogens present in Offshores, but one can assume that they are exposed to and infected by many of the same pathogens detected in sympatric Killer Whale populations.

Of particular concern are 'emerging' pathogens, those foreign to the marine environment and introduced by human activities (e.g. through sewage effluent and agricultural runoff, or airborne pathogens). Exposure to novel pathogens is of particular concern because an animal's immune system likely does not have the appropriate antibodies to combat infection and therefore is at greater risk of lethal infection.

Pathogens

Four infectious pathogens have been detected in wild Killer Whales: *Brucella spp.*, *Edwardsiella tarda*, cetacean poxvirus, and *Salmonella* Newport.

Bacterial pathogens of *Brucella* enter the marine environment through urban and agricultural runoff, and were first detected in marine mammals in the mid-1990s. Exposure to *Brucella* has been detected in Killer Whales (Jepson et al. 1997; Raverty pers. comm. 2014a), but to the best of our knowledge, no Killer Whale mortalities are known to have been caused by *Brucella* infection. However, other species of cetaceans have shown adverse effects from *Brucella*, such as abortion, brain infection and swelling, pneumonia, skin infection (e.g. blubber abscesses), and bone infection. There is also concern of reduced fecundity in Killer Whales due to *Brucella* infection (Gaydos et al. 2004).

Edwardsiella tarda is an opportunistic bacterial pathogen carried in fecal matter and as part of the normal flora in a Killer Whale's intestine. It can cause intestinal infection, abscessing, septicaemia and meningitis when introduced to the blood stream because of debilitation or immunosuppression of an animal. *E. tarda* was found to be responsible for the mortality of a Southern Resident Killer Whale (Ford et al. 2000).

Cetacean poxvirus is a viral infection that results in skin lesions and is thought to increase mortality risk of young animals (Van Bressem and Van Waerebeek 1996). It has been observed in a free-ranging Killer Whale in the southeast Pacific (Van Bressem et al. 1999), but is not known to have caused mortality in any Killer Whales. This virus has yet to be detected in cetaceans of the North Pacific.

Salmonella Newport is a bacterial pathogen that has been observed in humans and cattle, most notably in the past decade, but has rarely been detected in wild marine mammals. It is a virulent strain of the bacteria *Salmonella*, a gastro-intestinal pathogen that can spread to the bloodstream and can cause death, especially to individuals with already compromised immune systems. This terrestrially-sourced pathogen was found in and suspected to play a role in the stranding and death of an Offshore Killer Whale neonate in California in 2005, the first *Salmonella* Newport case in a wild Killer Whale (Colegrove et al. 2010). The bacteria was also observed in a Killer Whale euthanized in Hawaii in 2008, though following necropsy, the animal was deemed an asymptomatic carrier (Raverty pers. comm. 2014b).

Other pathogens of note are *Morbillivirus* spp. and *Toxoplasma gondii.* Morbilliviruses are viral pathogens that include canine distemper virus, phocin distemper virus, and dolphin and porpoise morbilliviruses. These pathogens have been shown to have adverse effects in other marine mammals, particularly affecting the lungs and the brain, often resulting in skin lesions, pneumonia, brain infections and swelling, and secondary or latent infections due to compromised immune systems from reduced lymphocyte production. Cases of *Morbillivirus* have been found in seals, sea otters, dolphins, pilot whales and beaked whales, causing mass mortalities in seals and dolphins (Rowles et al. 2011). Morbilliviruses spread rapidly, with epidemics in seals and dolphins observed to spread up to 6000 km per year (McCallum et al. 2003). It is not known if Killer Whales are susceptible to infection by morbilliviruses, but antibodies have been detected in Killer Whales from the western Pacific Ocean (Raverty pers. comm. 2014b), and these pathogens remain of concern as they have also been found in sympatric mammal species (Gaydos et al. 2004; Mos et al. 2003).

Toxoplasma gondii is a protozoal pathogen introduced to the marine ecosystem through terrestrial runoff. This pathogen has been documented in stranded Killer Whales, with no associated significant effect (Raverty pers. comm. 2014b). However, it is reported to cause brain and cardiac infection, neuromuscular disease and abortion in various other marine mammals (Miller et al. 2002; Dubey et al. 2003; Omata et al. 2006).

Vulnerability to Infection

Several characteristics of Offshore Killer Whales make this population particularly vulnerable to pathogens. Preliminary social analysis shows Offshore Killer Whales to be highly gregarious, with associations between individuals throughout their entire population (Ford et al. 2014). This highly social nature heightens the risk of rapid, pervasive infection and pathogen dispersal throughout the entire population. Susceptibility to infectious disease has also been linked to PCB contamination in cetaceans (Mos et al. 2006). As Offshores are known to be heavily contaminated, they could be immune-compromised, further amplifying their vulnerability to disease agents. With an extensive geographic range adjacent to many large urban centres and intensive agricultural activity, Offshore Killer Whales are exposed to numerous sources of emerging pathogens particularly near river and runoff outlets, where concentrations of infectious agents may be introduced into the marine environment. There are also concerns that exposed pulp cavities caused by the extreme tooth wear in Offshores may present an additional entryway for pathogens.

Fixed dietary preferences and natural decreases in prey supply

Dietary preferences in Killer Whales are thought to be learned attributes, just like their vocalizations. These preferences are apparently extremely rigid, with specialized foraging strategies designed to target specific prey species; cultural traditions that have likely evolved over many generations. Killer Whales seem limited in their ability to adapt and accept new prey items. This perhaps is best exemplified by the fate of three live-captured Transient Killer Whales in 1970. At the time, Killer Whales were not known to belong to distinct populations with specific diets and it was assumed that all Killer Whales ate fish. These three mammal-eating Killer Whales refused to eat fish dropped into their open-net pens for 79 days, until two of the animals finally accepted fish after the third died during an unsuccessful escape attempt. After the two surviving whales were released back into the wild, they returned to their natural diet of marine mammals (Ford and Ellis 1999).

Offshore Killer Whales may have just as inflexible a diet as their two sympatric ecotypes, thereby being resistant to “prey switching” should availability of primary prey become scarce. Reduced availability of their prey could likely occur through natural ecosystem regime shifts, which often result in dramatic changes in the distribution and/or abundance of many marine species (Hare and Mantua 2000). Should this occur, there is concern that Offshores could be significantly affected. The potential inflexibility of the Offshore Killer Whale diet is a biological vulnerability and therefore this threat is not considered mitigable.

Inbreeding depression

The small population size and cultural isolation of the Offshore Killer Whale raises the concern of inbreeding depression, the genetic deterioration of a population due to breeding of related individuals. Inbreeding depression is often experienced by populations with low genetic diversity and a small or sex-biased breeding population. This threat is of high concern to the sympatric Southern Resident Killer Whale population, whose genetic diversity is low and effective breeding population is very small (DFO 2008). Resident Killer Whales, however, have effective outbreeding mechanisms that seem to minimize this risk (Barrett-Lennard 2000; Ford et al. 2011b) but restrict the options for mating if the population becomes very small.

The Offshore Killer Whale population appears to have a relatively high genetic diversity (Morin et al. 2010) and has an estimated breeding population of roughly 130 individuals (DFO CRP, unpubl. data; see footnote 1 on page v). A proper assessment of the threat of inbreeding depression in Offshore Killer Whales is limited, as the social dynamics and mating patterns of Offshores remain unknown. It is assumed that Offshores, like Resident Killer Whales, have evolved effective outbreeding mechanisms. However, the broad genetic diversity seen in the Offshore Killer Whale population indicates that it could be a remnant of a historically larger population where such mechanisms were not necessary. A sudden loss of a significant portion of the population could result in a multi-generational population bottleneck, at which time inbreeding depression would present a credible threat.

The social isolation of the Offshore Killer Whale population plays a significant role in its risk of inbreeding depression. Offshore Killer Whales have a culture distinct from the three other sympatric Killer Whale populations that frequent Canadian Pacific waters. Their culture, defined by their dietary preferences, social structure and acoustic behaviour, isolates them from all other populations in their range. Like the other populations, Offshore Killer Whales exhibit ‘social xenophobia’, never having been observed to associate with any individuals of other sympatric Killer Whale populations. This cultural isolation is a concern as it limits the potential for the population to out-breed with sympatric populations. Though not currently of paramount concern, should the Offshore Killer Whale gene pool become extremely restricted, the absence of a “rescue effect” would be a considerable threat. Offshore Killer Whales have no culturally- or genetically-linked populations within their range with which they could expand their gene pool, if it were to become seriously reduced in size.

At present, considering the apparently broad genetic diversity of Offshore Killer Whales and the population's adequate breeding population estimate, the threat of inbreeding depression is of relatively low concern.

Tooth wear

Offshore Killer Whales have been found to exhibit extreme tooth wear, frequently worn down to the gumline and often exposing pulp cavities. This tooth wear is hypothesized to be a result of their predation on sharks, which have rough, sandpaper-like skin (Ford et al. 2011). There is currently no evidence of any deleterious effect of this extensive tooth wear at either the individual or population level, but this characteristic presents two potential issues.

First, there is concern that chronic gum abrasion and exposed pulp cavities may introduce pathways for infection, conceivably leading to abscessing, lowered immune function, and possibly death. At present, no Offshore Killer Whale is known to have died from an abscessed tooth, nor is an infection known to have been introduced through an exposed pulp cavity. It has also been suggested that as the exposure of pulp cavities is chronic in Offshores, it may not actually present a health issue for this species (Haulena pers. comm*.* 2013).

Second, tooth wear may be a limiting factor restricting an individual's foraging ability. With extreme tooth wear exhibited even in young, subadult individuals (Ford et al. 2011), an individual's ability to grasp and rip apart prey may be severely compromised. This may restrict their foraging to species for which teeth are not needed, and/or may make them dependent on other, younger Offshores whose teeth have not yet been so extensively worn.

As the history, source and effect of this extensive tooth wear in the Offshore Killer Whale population are uncertain, and because there is currently no evidence indicating that tooth wear is affecting the survival of individuals, this natural limitation is currently considered to present minimal risk to the population. That said, because extensive tooth wear is observed across most individuals in the population, should a consequential effect be determined in the future, the risk that tooth wear presents at the population level could be greater than currently considered.

Mass stranding or natural entrapment

There are two records of mass strandings of Killer Whales in British Columbia. The first occurred in 1941, when 11 Killer Whales stranded on a sandbar near Old Masset, Haida Gwaii (Cameron 1941). Though the population that these Killer Whales belonged to is still unconfirmed, based on photographs that show the whales to be flat-toothed, it is suspected that they were of the Offshore ecotype (Ford et al. 2011). The second mass stranding was of 20 Killer Whales, confirmed as Offshores by genetic analysis, stranded in 1945 at Estevan Point, Vancouver Island (Carl 1946). Offshores are also suspected to have mass-stranded on at least two other occasions outside of Canadian Pacific waters. In 2000, eight Killer Whales live-stranded and died in the Gulf of California, Mexico. Examined animals were found to have teeth "completely worn down", suggesting they were Offshores (Guerrero-Ruiz et al. 2006). In November 2013, two Killer Whales with extremely worn teeth were found stranded in Bristol Bay, Alaska, and were suspected to be Offshore Killer Whales (Jensen pers. comm. 2014).

Offshores appear to spend the majority of their time in open waters, and may be unfamiliar with nearshore, coastal waters. As a result, they may be particularly vulnerable to natural entrapment when they travel closer to the coast, within more enclosed waters. When in nearshore waters, Offshore Killer Whales have often been observed to travel deep into narrow inlets. Natural entrapment has been observed in one case involving Offshores: in 1994, nine were trapped in the tidal Barnes Lake, Alaska, for six to ten weeks, resulting in the mortality of two mature animals, and requiring a large rescue operation to usher the seven surviving animals back to open waters (Bain 1995). This incident again brings to light the susceptibility of Killer Whales to “psychological” barriers (see Physical disturbance section, above). In the Barnes Lake case, the barrier was a kelp forest at the mouth of the lake that was physically traversable, even at low tide, but which the animals were only willing to pass through when the current pushed the kelp down (Bain 1995). This type of “psychological entrapment” has also been observed in Transient Killer Whales (London 2006; Ford et al. 2013; DFO CRP, unpubl. data).

5 Population and distribution objectives

- Population objective: Achieve a stable or increasing trend in the abundance (i.e., increased birthrate and/or decreased death rate) and genetic diversity of the Offshore Killer Whale population.

- Distribution objective: Ensure continued use of Canadian Pacific waters by the Offshore Killer Whale population.

Given the unknown historical abundance and uncertainties regarding the size, demographics and spatial distribution of the population, defining quantitative population and distribution objectives may not be feasible. The rarity of encounters and the inability to fully census this population has led to a modeled population estimate with large uncertainty, presently making a change in population size or specific habitat use difficult to measure and detect. Genetic diversity is feasible to measure in this population and important to track because that diversity lends to the population’s resiliency, allowing it to adapt to changes within its environment.

The distribution objective is based on the assumption that Canadian Pacific waters provide important and beneficial habitat to the Offshore Killer Whale population, while at the same time recognizing Offshores’ changing use and occupancy of habitat.

6 Broad strategies and general approaches to meet objectives

6.1 Actions already completed or currently underway

Recovery-related actions have been underway since Offshore Killer Whales were first listed under SARA as Special Concern in 2004. The following is a summary of actions completed or initiated, though it is not meant to be an exhaustive list. DFO recognizes the contributions of many independent and international collaborators and colleagues in the achievement of these actions.

6.1.1 Regulatory and management measures

- Canada’s Species at Risk Act protects Threatened and Endangered species via its general prohibitions (s.32-36), and requires the preparation of recovery strategies (s.37), action plans (s.47) and reports on their implementation (s.46 and 55, respectively), with the goal of species recovery. The designation of critical habitat essential to Threatened and Endangered species' recovery is required in a recovery strategy (s.41(1)(c)-(c.1)) and/or action plan (s.49(1)(a)).

- The Offshore Killer Whale's previous listing as a species of Special Concern required the development of a management plan. Since the posting of the *Management Plan for the Offshore Killer Whale* (Orcinus Orca) *in Canada* (DFO 2009a), DFO, its partners and collaborators have been working to implement the plan's goal, objectives and actions.

- Recovery strategies for the sympatric Canadian Pacific Resident and Transient Killer Whale populations contain measures that also benefit the Offshore Killer Whale.

- Amendments to the Fisheries Act's Marine Mammal Regulations (MMR) have been proposed, to enhance prevention and mitigation of disturbance to marine mammals, in addition to the protections afforded by the existing MMR.

- Under Canada's Canadian Environmental Assessment Act, 2012, DFO is a federal authority (FA) that provides specialist or expert information or knowledge with respect to a designated project that is subject to an environmental assessment regarding DFO's regulatory and legislative mandate and responsibilities.

- Enacted under Environment Canada's Canadian Environmental Protection Act, Disposal at Sea Regulations and Regulations Respecting Applications for Permits for Disposal at Sea outline monitoring practices for the disposal of approved substances at sea, which minimize exposure of marine animals to introduced persistent pollutants and toxins (EC 1999).

- Canada is a signatory to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), thereby committed to ensuring that international trade of species at risk does not threaten their survival.

- Since 2008, DFO has operated a Marine Mammal Response Program, dedicated to: collecting information that provides insight on the types and magnitude of threats that marine mammals face (e.g. via necropsies); documenting and aiding where possible distressed or injured marine mammals, particularly those that are SARA-listed; and creating networks of coast-wide collaborators to maximize the ability to respond. As of 2013, Pacific Region's British Columbia Marine Mammal Response Network consists of over 250 volunteer supporters.

- The Operational Guidelines for the Conservation of Cetaceans (DFO 2013) provide guidance for decision-making around activities that may impact the sustainability of whales, dolphins and porpoises.

- The National Marine Conservation Area Reserve (NMCAR) off Gwaii Haanas National Park Reserve and Haida Heritage Site was established in 2010 along with an interim management plan and zoning plan. The interim management plan outlines six "Fully Protected Areas" within the NMCAR, some of which overlap with waters used by Offshore Killer Whales. The Multi-Species Action Plan for Gwaii Haanas National Park Reserve, National Marine Conservation Area, and Haida Heritage Site may further protect potential habitat for Offshore Killer Whales around Haida Gwaii.

- The Pacific North Coast Integrated Management Area (PNCIMA) plan aims to combine protection of habitat with sustainable use of resources in Queen Charlotte Basin and mitigate stress to species at risk found on the north coast of British Columbia. Under the Canada-British Columbia Marine Protected Area Network Strategy, the Governments of Canada and British Columbia are working together to build marine protected area networks to protect and maintain marine biodiversity, ecological representation, and special natural features including the habitats for marine species at risk and habitats of high biodiversity such as estuaries and upwellings.

- DFO's Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment outlines the steps taken during seismic surveys in order to limit exposure of harmful acute noise to inhabitants of the local marine area (DFO 2007b).

- The Department of National Defence's 'Maritime Command Order: Marine Mammal Mitigation Procedures' (MARCORD) looks to improve sonar and ordnance practices, in order to mitigate harmful effects of such activities on marine mammals (DND 2008).

- The Canada Shipping Act is the principal statute that governs safety in marine transportation and includes protection of the marine environment. Under this Act, the Vessel Pollution and Dangerous Chemicals Regulations implement many of the standards set out under the International Maritime Organization's International Convention for the Prevention of Pollution from Ships (MARPOL), the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes.

6.1.2 Stewardship measures

- DFO, NOAA and collaborators developed the 'Be Whale Wise: Marine Wildlife Guidelines for Boaters, Paddlers and Viewers' (NOAA 2011; updated 2016), which started as a promotional effort to inform residents of and visitors to the Pacific Northwest of their responsibilities while near cetaceans in the wild. In 2011, the US adopted regulations that formalize approach and viewing requirements for everyone on the water, under their Marine Mammal Protection Act and Endangered Species Act, to protect all Killer Whales in inland waters of Washington State. The same guidelines are recognized and largely followed as a best practice elsewhere along the US coast and in Canada.

- Regional groups of British Columbia and Washington state whale watching and eco-tourism businesses have come together to create their own viewing principles, such as the North Island Marine Mammal Stewardship Association's 'Code of Conduct' (NIMMSA 2012) and Pacific Whale Watch Association's 'Best Practices Guidelines' (PWWA n.d.).

- DFO and the Vancouver Aquarium collaborate to run the British Columbia Cetacean Sightings Network, consisting of over 3,600 observers across British Columbia who report sightings of cetaceans and sea turtles via the internet (http://wildwhales.org/), phone (1-866-472-9663) or logbooks. The program also aims to increase public awareness of Canadian Pacific cetaceans and sea turtles, and the threats to their survival.

- DFO operates two other tools that the public can use to report sightings of marine mammals: the Cetacean Research Program's Killer Whale Hotline (1-250-756-7253) which seeks real-time reports of mid-Georgia Strait sightings; and the Department's Marine Mammal Incident Reporting Hotline (1-800-465-4336), where the public can report their observations of sick, injured, distressed or dead marine mammals and sea turtles.

- The Coastal First Nations' Guardian Watchman Program maintains a network of stewards who monitor and protect territorial waters and lands of a number of First Nations communities across Haida Gwaii and the central and north coast of British Columbia. They provide a regular on-water presence, raising awareness of, and gathering data, on the ecosystems within their traditional territories.

- Additionally, there are a number of non-governmental organizations engaging in Killer Whale-specific stewardship and research initiatives along various parts of the British Columbia coast, such as: Cetus Research and Conservation Society, North Coast Cetacean Society, OrcaLab, Pacific Wild and Strawberry Isle Marine Research Society.

- Public and industry initiatives, such as 'Toxic Smart', 'Clean Print BC', 'Green Marine', 'Enhancing Cetacean Habitat and Observation (ECHO) Program' and the International Maritime Organization's guidelines for shipping noise can contribute to healthier waters for marine species, including Offshore Killer Whales.

6.1.3 Research measures

- Photo-identification of individual whales, for censusing and as a basis of mark-recapture analyses

- Acoustic monitoring, for examining seasonal presence and call type usage

- Biopsy sampling of individuals, for genetics, fatty acid and stable isotope profiling to assess prey type and contaminants

- Prey sampling, to determine diet and species composition

- Post-mortem examinations, to gather more information on species biology and ecology, and information on the condition and cause of death of the individual (e.g. stomach sampling for diet analysis; analysis of disease(s) present and contaminant load(s))

- Aerial and ship surveys, to study abundance and distribution of SARA-listed cetaceans in Pacific Canadian waters. Ship-based surveys also provide opportunity to conduct diet and biopsy sampling when focus species are encountered

- Spatial and seasonal analyses based on photograph and acoustic encounters, for movement and spatial use analysis

- Social analyses, to determine social structure and population organization

- Population abundance, survival and growth modeling, and satellite tagging (by Cascadia Research Collective, NOAA's National Marine Fisheries Service, and North Gulf Oceanic Society), for improved understanding of population dynamics and spatial use, respectively

6.2 Strategic direction for recovery

The broad strategies identified for Offshore Killer Whale listed in Table 2 are meant to: address substantiated threats to Offshore Killer Whales and their habitat; obtain credible evidence necessary to assess significance of unsubstantiated threats of concern; achieve a stable or increasing trend in abundance and genetic diversity of their population; ensure continued use of Canadian Pacific waters by Offshore Killer Whales; obtain baseline information about the population and its demographics and distribution; and address other key information needs for the purposes of recovery.

6.2.1 Broad strategies to recover Offshore Killer Whale

1. Monitor the population abundance and demographics of Offshore Killer Whales and refine knowledge of their use of Canadian Pacific waters

2. Ensure that Offshore Killer Whales have an adequate and accessible food supply to allow recovery

3. Ensure that disturbance from human activities does not prevent the recovery of Offshore Killer Whales

4. Ensure that chemical and biological pollutants do not prevent the recovery of Offshore Killer Whale populations

5. Identify critical habitat for designation and protection

The general approaches to support these broad strategies are identified in Table 2. The majority of approaches are to meet the need for foundational knowledge about the Offshore Killer Whale population. Additional approaches support the need to further understand and mitigate the identified anthropogenic and natural threats. Note that these strategies and approaches are complemented by the activities that make up the schedule of studies to identify critical habitat (Table 3).

Table 2 Recovery planning table

Broad Strategy	General description of research and management approaches	Priority[11]	Threat or concern addressed
1	1-1. Monitor abundance of Offshore Killer Whales and refine knowledge of population identity and structure in Canadian Pacific waters	High	Knowledge gaps – Natural limitations and vulnerabilities
1	1-2. Gain better understanding of the effects of isolation on Offshore Killer Whale culture	Medium	Knowledge gaps – Natural limitations and vulnerabilities
1	1-3. Investigate genetic diversity and evolutionary history of Offshore Killer Whales, to determine if they are a remnant of a historically larger population, and to monitor the trend over time	Low	Knowledge gaps – Natural limitations and vulnerabilities
1	1-4. Clarify the extent of the threat of disease to the Offshore Killer Whale population. Refine knowledge of general biology, physiology, and pathogen loads and profile of Offshore Killer Whales	Low, until certainty of concern about the threat is confirmed	Knowledge gaps – Natural limitations and vulnerabilities Environmental contaminants

[11] "Priority" reflects the degree to which the approach contributes directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species:
- "High" priority approaches are considered likely to have an immediate and/or direct influence on the recovery of the species.
- "Medium" priority approaches are important but considered to have an indirect or less immediate influence on the recovery of the species.
- "Low" priority approaches are considered important contributions to the knowledge base about the species and mitigation of threats.

Broad Strategy	General description of research and management approaches	Priority[11]	Threat or concern addressed
1	1-5. Determine the source/cause of this dentition condition and whether it presents a real limitation, threat or vulnerability to Offshore Killer Whales	Low	Knowledge gaps – Natural limitations and vulnerabilities
1	1-6. Investigate extent of the threat of stranding to the Offshore Killer Whale population	Low	Acoustic disturbance Physical disturbance Natural limitations and vulnerabilities
1	1-7. Increase understanding of how climate change might affect Offshore Killer Whales, either directly or indirectly	Medium	Climate change
2	2-1. Improve knowledge and understanding of Offshore Killer Whale foraging ecology	High	Prey availability
2	2-2. Identify primary prey species and improve knowledge of prey populations, abundances and distributions	High	Prey availability
2	2-3. Examine potential impacts of prey limitation on Offshores, and the likelihood of those impacts	High	Prey availability
2	2-4. Assess Offshore Killer Whale population level impacts resulting from changes to ecosystem dynamics	Low	Climate change Natural limitations and vulnerabilities Prey availability
3	3-1. Develop and implement regulations, guidelines, sanctuaries and other measures to reduce or eliminate acoustic disturbance to Offshore Killer Whales	High	Acoustic disturbance
3	3-2. Determine baseline natural and anthropogenic noise profiles and monitor sources and changes in the exposure of Offshore Killer Whales to underwater noise	High	Acoustic disturbance

Broad Strategy	General description of research and management approaches	Priority[11]	Threat or concern addressed
3	3-3. Determine the short- and long-term effects of chronic and immediate forms of disturbance, including noise, on the physiology, foraging and social behaviour of Offshore Killer Whales	High	Acoustic disturbance
3	3-4. Develop and implement regulations, guidelines, sanctuaries and other measures to reduce or eliminate physical disturbance to Offshore Killer Whales	Medium	Physical disturbance
3	3-5. Determine the short- and long-term effects of chronic and immediate forms of disturbance, including vessels, on the physiology, foraging and social behaviour of Offshore Killer Whales	Medium	Physical disturbance
4	4-1. Investigate the health and reproductive capacity of Offshore Killer Whales using scientific studies on free-ranging and stranded individuals, as related to chemical and biological pollution	High	Environmental contaminants
4	4-2. Monitor the chemical and biological pollutant levels in Offshore Killer Whales, their prey, and their habitat	High	Environmental contaminants
4	4-3. Identify and prioritize the sources of key chemical and biological pollutants affecting Offshore Killer Whales and their habitat	High	Environmental contaminants
4	4-4. Reduce the introduction into the environment of pesticides and other chemicals that have the potential to adversely affect the health of Offshore Killer Whales and/or their prey, through measures such as municipal, provincial, national and international agreements, education, regulation and enforcement	High	Environmental contaminants

Broad Strategy	General description of research and management approaches	Priority[11]	Threat or concern addressed
4	4-5. Mitigate the impacts of currently and historically used “legacy” pollutants in the environment	High	Environmental contaminants
4	4-6. Reduce the introduction of biological pollutants, including pathogens and exotic species, into the habitats of Offshore Killer Whales and their prey	High	Environmental contaminants
5	5-1. Identify key feeding areas and other critical habitat of Offshore Killer Whales	High	Prey availability
5	5-2. Protect the access of Offshore Killer Whale to their critical habitat	High	Physical disturbance
5	5-3. Encourage trans-boundary cooperation in the identification and protection of critical habitat	High	Acoustic disturbance
Broad Strategy	**General description of research and management approaches**	**Priority[12]**	**Threat or concern addressed**
1	1-1. Monitor abundance of Offshore Killer Whales and refine knowledge of population identity and structure in Canadian Pacific waters	High	Knowledge gaps – Natural limitations and vulnerabilities
1	1-2. Gain better understanding of the effects of isolation on Offshore Killer Whale culture	Medium	Knowledge gaps – Natural limitations and vulnerabilities
1	1-3. Investigate genetic diversity and evolutionary history of Offshore Killer Whales, to determine if they are a remnant of a historically larger population, and to monitor the trend over time	Low	Knowledge gaps – Natural limitations and vulnerabilities

[12] “Priority” reflects the degree to which the approach contributes directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species:

- "High" priority approaches are considered likely to have an immediate and/or direct influence on the recovery of the species.
- "Medium" priority approaches are important but considered to have an indirect or less immediate influence on the recovery of the species.
- "Low" priority approaches are considered important contributions to the knowledge base about the species and mitigation of threats.

Broad Strategy	General description of research and management approaches	Priority[12]	Threat or concern addressed
1	1-4. Clarify the extent of the threat of disease to the Offshore Killer Whale population. Refine knowledge of general biology, physiology, and pathogen loads and profile of Offshore Killer Whales	Low, until certainty of concern about the threat is confirmed	Knowledge gaps – Natural limitations and vulnerabilities Environmental contaminants

Broad Strategy	General description of research and management approaches	Priority[12]	Threat or concern addressed
1	1-5. Determine the source/cause of this dentition condition and whether it presents a real limitation, threat or vulnerability to Offshore Killer Whales	Low	Knowledge gaps – Natural limitations and vulnerabilities
1	1-6. Investigate extent of the threat of stranding to the Offshore Killer Whale population	Low	Acoustic disturbance Physical disturbance Natural limitations and vulnerabilities
1	1-7. Increase understanding of how climate change might affect Offshore Killer Whales, either directly or indirectly	Medium	Climate change
2	2-1. Improve knowledge and understanding of Offshore Killer Whale foraging ecology	High	Prey availability
2	2-2. Identify primary prey species and improve knowledge of prey populations, abundances and distributions	High	Prey availability
2	2-3. Examine potential impacts of prey limitation on Offshores, and the likelihood of those impacts	High	Prey availability
2	2-4. Assess Offshore Killer Whale population level impacts resulting from changes to ecosystem dynamics	Low	Climate change Natural limitations and vulnerabilities Prey availability
3	3-1. Develop and implement regulations, guidelines, sanctuaries and other measures to reduce or eliminate acoustic disturbance to Offshore Killer Whales	High	Acoustic disturbance
3	3-2. Determine baseline natural and anthropogenic noise profiles and monitor sources and changes in the exposure of Offshore Killer Whales to underwater noise	High	Acoustic disturbance

Broad Strategy	General description of research and management approaches	Priority[12]	Threat or concern addressed
3	3-3. Determine the short- and long-term effects of chronic and immediate forms of disturbance, including noise, on the physiology, foraging and social behaviour of Offshore Killer Whales	High	Acoustic disturbance
3	3-4. Develop and implement regulations, guidelines, sanctuaries and other measures to reduce or eliminate physical disturbance to Offshore Killer Whales	Medium	Physical disturbance
3	3-5. Determine the short- and long-term effects of chronic and immediate forms of disturbance, including vessels, on the physiology, foraging and social behaviour of Offshore Killer Whales	Medium	Physical disturbance
4	4-1. Investigate the health and reproductive capacity of Offshore Killer Whales using scientific studies on free-ranging and stranded individuals, as related to chemical and biological pollution	High	Environmental contaminants
4	4-2. Monitor the chemical and biological pollutant levels in Offshore Killer Whales, their prey, and their habitat	High	Environmental contaminants
4	4-3. Identify and prioritize the sources of key chemical and biological pollutants affecting Offshore Killer Whales and their habitat	High	Environmental contaminants
4	4-4. Reduce the introduction into the environment of pesticides and other chemicals that have the potential to adversely affect the health of Offshore Killer Whales and/or their prey, through measures such as municipal, provincial, national and international agreements, education, regulation and enforcement	High	Environmental contaminants

Broad Strategy	General description of research and management approaches	Priority[12]	Threat or concern addressed
4	4-5. Mitigate the impacts of currently and historically used “legacy” pollutants in the environment	High	Environmental contaminants
4	4-6. Reduce the introduction of biological pollutants, including pathogens and exotic species, into the habitats of Offshore Killer Whales and their prey	High	Environmental contaminants
5	5-1. Identify key feeding areas and other critical habitat of Offshore Killer Whales	High	Prey availability
5	5-2. Protect the access of Offshore Killer Whale to their critical habitat	High	Physical disturbance
5	5-3. Encourage trans-boundary cooperation in the identification and protection of critical habitat	High	Acoustic disturbance

7 Critical habitat

7.1 Identification of the species' critical habitat

For Offshore Killer Whales, the identification of critical habitat is not possible at this time, given currently available information. Specifically, there is a lack of information on Offshores' seasonal distribution in outer coast waters and the prey resources that may determine the quality of their habitat (Ford et al. 2014). The schedule of studies outlines the research required to identify critical habitat.

Identification of critical habitat to meet the population and distribution objectives will be addressed in an amended version of this recovery strategy.

7.2 Schedule of studies to identify critical habitat

High resolution data on the seasonal distribution of Offshore Killer Whales, and an understanding of why they are present in those areas at those times, are required to identify critical habitat. The activities described below seek to satisfy these needs, with the goal of identifying at least a portion of the species' critical habitat for inclusion in the forthcoming action plan, or plans.

Table 3 Schedule of studies to identify critical habitat

Description of activity	Rationale	Timeline
Continue boat surveys in outer and inner coast waters, focused on areas where Offshore Killer Whales are suspected to occupy, also allowing for: a. photo-identification b. prey fragment and fecal collection c. biopsy sampling d. acoustic recording	Boat surveys increase data collection effort, informing distribution analyses, and growing understanding of both realized and potential habitat. Photo-identification of individuals allows investigation of population demographics, dynamics and abundance. Prey fragment and fecal collection is necessary for diet studies, in order to determine the importance and quality of each prey species. Biopsy sampling allows for genetic studies and contaminant analyses, fatty acid and stable isotope analyses. Acoustic recording enables: the identification of subsets of the population; understanding of if and how subsets use the range differently; possibly the linking of sounds to behaviour state; and determination of the role of vocalizations in foraging behaviour and social structure.	Five years, and then Ongoing

Deploy remote acoustic monitoring devices, and utilize recordings from real-time, cabled observatories, and other opportunistic new technologies being deployed (e.g. wave gliders).	For year-round monitoring of Offshore Killer Whales, to determine seasonality, help refine boat-based survey design, and gain a baseline quantification of noise in key habitats.	Three years, and then Ongoing
Deploy tags (e.g. satellite tags; suction dataloggers) on Offshore Killer Whales.	To facilitate the interception of Offshore Killer Whales by research vessels, to contribute to data collection and growing understanding of both occupied and potential habitat, as well as the further understanding of fine- and broad-scale movements and diving behaviour.	Five years, and then Ongoing
Collect data on key Offshore Killer Whale prey species in Canadian Pacific waters; undertake essential distribution, movement and population research, and stock assessments where possible, including the analysis of existing data that have yet to be analyzed and any new data collected.	To improve understanding of distributions, densities, movements and population statuses of key prey species, and factors that drive their distributions and availabilities (e.g. oceanographic processes).	Five years, and then Ongoing

8 Measuring progress

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives:

- Measures of population objective:
    - After increasing the precision of population size estimates, observe:
        - a stable or increased number of animals in the population
        - stable or decreased mortality and stable or increased recruitment
        - a stable or positive trend in an index subgroup of the overall population

    - After determining the age and sex structure of the population, understanding the population's baseline genetic diversity, and tracking it over time, observe a stable or increasing genetic diversity within the population.

- Measure of distribution objective: The rate of detection from long-term monitoring indicates continued use of Canadian Pacific waters.

9 Statement on action plans

One or more action plans to implement this recovery strategy will be completed within five years of the posting of the final recovery strategy on the Species at Risk Public Registry. When feasible, Canadian recovery efforts for this population will be coordinated with those measures outlined in other SARA marine mammal recovery strategies, action plans and/or management plans.

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Appendix A: Effects on the environment and other species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals. 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 any of the Federal Sustainable Development Strategy's (FSDS) 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 strategy itself, but are also summarized below in this statement.

This recovery strategy will clearly benefit the environment by promoting the recovery of Offshore Killer Whales, as maintaining biodiversity within Canadian Pacific waters helps to encourage the resiliency of various North Pacific Ocean ecosystems. As such, this recovery strategy positively contributes to the FSDS': Theme III (Protecting Nature and Canadians); Goals 4 (Conserving and Restoring Ecosystems, Wildlife and Habitat, and Protecting Canadians) and 5 (Biological Resources); and Targets 4.1 (Species at Risk), 4.4 (Improving the Health of National Parks), 4.5 (Marine Ecosystems) and 5.1 (Sustainable Fisheries). Specific activities identified within the Recovery strategy can also contribute to: Theme II (Maintaining Water Quality and Availability); Goal 3 (Water Quality and Water Availability); and Targets 3.8 (Marine Pollution – Releases of Harmful Pollutants), 3.9 (Marine Pollution – Disposal at Sea), 3.10 (Agri-Environmental Performance Metrics) and 3.11 (Wastewater and Industrial Effluent).

Because of shared threats, and similar techniques used to fill knowledge gaps and complement existing knowledge, many activities contained in this strategy can also benefit other marine mammal and sea turtle species, and recovery planning initiatives for those that are species at risk.

The potential for this recovery strategy to inadvertently lead to adverse effects on the environment and other species was considered. The SEA concluded that the recovery strategy brings a significant net benefit to the environment and other species, and will not entail any major adverse effects. What is gained from the use of airplanes and ships to perform research outweighs the relatively small negative impacts that recovery strategy-specific use of those research platforms have towards the achievement of the FSDS' broader theme of Shrinking the Environmental Footprint – Beginning with Government (Theme IV), and on air pollution (Theme I, Goal 2), water quality (Theme II, Goal 3), anthropogenic noise and disturbance due to vessel presence.

Appendix B: Record of cooperation and consultation

The Offshore Killer Whale (*Orcinus orca*) was listed as Threatened on Schedule 1 of the Species at Risk Act (SARA) in 2011. The Minister of Fisheries, Oceans, and the Canadian Coast Guard (DFO), and the Minister of Environment and Climate Change Canada are Competent Ministers under SARA for the Offshore Killer Whale and prepared the recovery strategy, as per section 37 of SARA.

In March 2013, DFO held a technical workshop to seek comments and input on the draft recovery strategy, and ensure the document incorporated the best technical and scientific expertise on this species. Representatives from Fisheries and Oceans Canada, Transport Canada, Parks Canada, Department of National Defence, the Province of British Columbia, National Oceanic and Atmospheric Administration, Vancouver Aquarium, the B.C. Cetacean Sightings Network, Hemmera, the Sea Mammal Research Unit, and the North Gulf Oceanic Society attended the workshop.

Consultations on the draft recovery strategy occurred between March 26 and April 27, 2015. Consultation activities included:

- on-line posting of the draft recovery strategy, background information and a comment form
- letters, e-mails and faxes with information on the draft recovery strategy consultations and offering opportunities for further discussions sent to 92 First Nation organizations
- e-mails regarding the draft recovery strategy consultations sent to 187 stakeholders including industry, academia, environmental non-government organizations, environmental consultants, and government representatives (municipal, regional, provincial, federal and United States federal and state)
- social media tweets notifying of consultations with links to the on-line postings

Six comment forms and two letters were received. Where appropriate, all feedback received was considered in the proposed recovery strategy.

Additional stakeholder, First Nations, and public input was sought through the publication of the proposed recovery strategy on the Species at Risk Public Registry for a 60 day public comment period from April 5 until June 4, 2018. No comments were received during this period and no changes were subsequently made to the Offshore Killer Whale recovery strategy during its finalization.

Appendix C: Teams contributing to development of this recovery strategy

2012-2015 Offshore Killer Whale Recovery Team

Robin Abernethy	Fisheries and Oceans Canada, Pacific Biological Station
Heather Bettger	Fisheries and Oceans Canada, Tofino
Paul Cottrell	Fisheries and Oceans Canada, Vancouver
Doug Cowen	Fisheries and Oceans Canada, Queen Charlotte City
Graeme Ellis	Fisheries and Oceans Canada, Pacific Biological Station
John Ford	Fisheries and Oceans Canada, Pacific Biological Station
Pippa Shepherd	Parks Canada Agency, Vancouver
Eva Stredulinsky	Fisheries and Oceans Canada, Pacific Biological Station
Jonathan Thar	Fisheries and Oceans Canada, Vancouver
Bob Tupniak	Fisheries and Oceans Canada, Bella Coola

2013 Offshore Killer Whale Technical Workshop participants:

Sandy Argue	Chad Nordstrom (Rapporteur)
Ken Balcomb	Stephen Raverty
Paul Cottrell	Hawsun Sohn
Volker Deecke	Danielle Smith
John Durban	Eva Stredulinsky
Graeme Ellis	Renny Talbot
John Ford	Jonathan Thar
Bud Graham	Dom Tollit
Annely Greene	Jared Towers
Alex Grzybowski (Facilitator)	Bob Tupniak
Marty Haulena	Svein Vagel
Jackie King	Emily Watson (Rapporteur)
Jeanette LaPointe	Rob Williams
Sarah Miller (Rapporteur)	Harald Yurk