PROPOSED

***Species at Risk Act***
Management Plan Series

# Proposed Management Plan for the Offshore Killer Whale (*Orcinus orca*) in Canada

## Offshore Killer Whale

**September 2009**

Fisheries and Oceans Canada
Pêches et Océans Canada
Canada

# Management Plan for the Offshore Killer Whale (*Orcinus orca*) in Canada [PROPOSED]

**September 2009**

# About the *Species at Risk Act* Management Plan Series

## What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is "*to manage species of special concern to prevent them from becoming endangered or threatened*."

## What is a species of special concern?

Under SARA, a species of special concern is a wildlife species that could become threatened or endangered because of a combination of biological characteristics and identified threats. Species of special concern are included in the SARA List of Wildlife Species at Risk.

## What is a management plan?

Under SARA, a management plan is an action-oriented planning document that identifies the conservation activities and land use measures needed to ensure, at a minimum, that a species of special concern does not become threatened or endangered. For many species, the ultimate aim of the management plan will be to alleviate human threats and remove the species from the List of Wildlife Species at Risk. The plan sets goals and objectives, identifies threats, and indicates the main areas of activities to be undertaken to address those threats.

Management plan development is mandated under Sections 65–72 of SARA (http://www.sararegistry.gc.ca/approach/act/default_e.cfm).

A management plan has to be developed within three years after the species is added to the List of Wildlife Species at Risk. Five years is allowed for those species that were initially listed when SARA came into force.

## What's next?

Directions set in the management plan will enable jurisdictions, communities, land users, and conservationists to implement conservation activities that will have preventative or restorative benefits. Cost-effective measures to prevent the species from becoming further at risk should not be postponed for lack of full scientific certainty and may, in fact, result in significant cost savings in the future.

## The series

This series presents the management plans prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as plans are updated.

## To learn more

To learn more about the *Species at Risk Act* and conservation initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/).

**Recommended citation:**

Fisheries and Oceans Canada. 2009. Management Plan for the Offshore Killer Whale (*Orcinus orca*) in Canada [Proposed]. *Species at Risk Act* Management Plan Series. Fisheries and Oceans Canada, Nanaimo. iv + 51pp.

**Additional copies:**

Additional copies can be downloaded from the SARA Public Registry (http://www.sararegistry.gc.ca/).

**Cover illustration:** B. Lewis

Également disponible en français sous le titre
« Projet de plan de gestion des épaulards du large (*Orcinus orca*) au Canada»


ISBN 978-1-100-12128-4
Catalogue no. En3-5/4-2009E-PDF

# PREFACE

The offshore killer whale is a marine mammal and is under the responsibility of the federal government. The *Species at Risk Act* (SARA, Section 65) requires the competent minister to prepare management plans for species listed as special concern. The offshore killer whale was listed as a species of special concern under SARA in 2003. The development of this management plan was led by Fisheries and Oceans Canada – Pacific Region, in cooperation and consultation with many individuals, organizations and government agencies, as indicated below. The plan meets SARA requirements in terms of content and process (SARA sections 65-68).

Success in the conservation 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 plan and will not be achieved by Fisheries and Oceans Canada or any other party alone. This plan provides advice to jurisdictions and organizations that may be involved or wish to become involved in activities to conserve this species. In the spirit of the Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all responsible jurisdictions and Canadians to join Fisheries and Oceans Canada in supporting and implementing this plan for the benefit of the offshore killer whale and Canadian society as a whole. The Minister will report on progress within five years.

# RESPONSIBLE JURISDICTIONS

Fisheries & Oceans Canada
Government of British Columbia
Environment Canada
Parks Canada
Transport Canada
Department of National Defence
Natural Resources Canada

# AUTHORS

Fisheries & Oceans Canada (DFO).

# ACKNOWLEDGMENTS

Fisheries & Oceans Canada would like to acknowledge all those who participated in the Cetacean Management Plan Technical Workshop (Appendix III), which provided valuable information on offshore killer whale biology, and threats to the population; to support the generation of this management plan.

# STRATEGIC ENVIRONMENTAL ASSESSMENT

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.

Management planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that plans 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 on non-target species or habitats. The results of the SEA are incorporated directly into the plan itself, but are also summarized below.

Through the development of this plan numerous factors that jeopardize or have potential to jeopardize the management of this population were evaluated and are presented. Principal among the anthropogenic threats are reductions in the availability or quality of prey, environmental contamination, and acute acoustic disturbance. In some cases these factors threaten the population; in other cases they affect offshore killer whales' habitat. It was concluded that some threats can be mitigated through the use of existing legislation, policies and programs and, in fact, there are numerous examples of mitigation measures that are currently employed. However, in other cases the threat and/or the potential mitigation measure(s) require further research or evaluation before recommendations on specific actions or activities can be formulated. The general type of research, evaluation and approaches for mitigation are presented in this management plan (see Section 2.3 'Actions').

Through the course of implementing actions, specific activities for management, recovery and mitigation will be evaluated and detailed for this population along with an evaluation of effects and costs for each activity or measure. Therefore, taking into account the general nature of the recommendations for new mitigation to manage these populations and that many of the recommendations to protect habitat fall under existing legislation and policies, this management plan will not entail any significant adverse effects.

# EXECUTIVE SUMMARY

Killer whales (*Orcinus orca*) are primarily black with a white-coloured abdomen, a large white patch behind each eye, and a grey saddle patch below and posterior to the black dorsal fin. The dorsal fin is large and distinctive in males, while small and curved in females and juvenile animals. To the untrained eye, it is extremely difficult to distinguish between the three 'assemblages' of killer whales found on the west coast of North America; resident, transient and offshore killer whales (also called 'offshores'). Compared with those of resident and transient killer whales, the tips of offshores' dorsal fins tend to be rounded on the leading edge and over the apex of the fin, giving the dorsal fin a blunt appearance. Dorsal fins tend to be less angled at the trailing edge and have many more nicks and notches than those of resident killer whales. The saddle patches are usually uniformly grey, although on some animals it may contain a black region (Black et al. 1997; Ford et al. 2000).

Offshores are a genetically distinct group, thought to be most closely related to resident rather than to transient killer whales due to similarities in appearance, vocalizations and genetics (Barrett-Lennard and Ellis 2001). They are most often observed in groups of 20 or more individuals (Barrett-Lennard and Ellis 2001) and based on photo-identification of these animals, there is believed to be a minimum of 280 animals in the British Columbia (B.C.) population (DFO-CRP unpublished data). Encounters with these whales have been few, and efforts to catalogue members of this population have been challenging given infrequent sightings, elusive behaviour, and their largely open ocean habitat. In recent years, sightings of offshores in coastal and inshore waters have increased (DFO-CRP unpublished data) suggesting that usage of coastal habitat is higher than in the past and it may reflect a shift associated with oceanographic conditions and distribution of prey.

Killer whales in general appear to have naturally small population sizes and low potential rates of increase. These intrinsic factors make the offshore killer whale population vulnerable to threats. The most significant of identified threats are reduction in prey availability due to regime shift or fisheries competition, chronic and acute toxic contamination, and acute noise stress. Natural factors and periodic events such as mass strandings or entrapments in narrow inlets also have the potential to drastically reduce local numbers (COSEWIC 2002).

There are significant knowledge gaps in nearly all aspects of the general biology and ecology of offshore killer whales, and an increase in research effort is necessary to address these deficiencies. Continued efforts to clarify population abundance, prey requirements, and seasonal occurrence in Canadian waters are essential for effective management of this population. The synchronization of multi-species management and research activities will facilitate comprehensive marine mammal conservation in B.C., and allow for effective use of available resources.

# TABLE OF CONTENTS

# TABLES



# FIGURES

# 1. SPECIES INFORMATION

## 1.1. Species Assessment Information from COSEWIC

The following information was obtained from the COSEWIC Status Report on killer whales in Canada (Baird 2001) and the COSEWIC website (COSEWIC 2002).

| | |
|---|---|
| **Date of Assessment:** | In November 2001, the northeast Pacific offshore killer whale population was designated as a species of 'Special Concern'. |
| **Common Name (population):** | Northeast Pacific offshore killer whale population |
| **Scientific Name:** | *Orcinus orca* |
| **COSEWIC Status:** | Special Concern |
| **Reason for Designation:** | The offshore population is small and has a low potential rate of increase. Little is known about the offshore population, and no population trend information is currently available. Killer whales are potentially at risk from anthropogenic influences in two primary ways; due to immunotoxic effects from persistent toxic chemicals, and due to reduction in prey availability. Growing commercial and recreational whale watch activities may impact the population, though impacts are not clear at this time. Natural factors and periodic events such as mass strandings or entrapments in narrow inlets have the potential to drastically reduce local numbers. |
| **Canadian Occurrence:** | Killer whales frequent outer continental shelf areas, coastal straits and channels, along the entire coast of British Columbia. |
| **COSEWIC Status History:** | In 1999, this population was assessed as 'Threatened'. In November 2001, the population was re-assigned as 'Special Concern'. It met the criterion for Endangered (D1), but not the definitions for 'Endangered' or 'Threatened' (i.e. not in danger of extinction). |

## 1.2. Description

Killer whales are primarily black with a white-coloured abdomen, a large white patch behind each eye, and a grey saddle patch below and posterior to the black dorsal fin. The dorsal fin is large and distinctive in males (often 1.8m tall), while small and curved in females and juvenile animals (less than 0.9m tall). Each killer whale has a uniquely shaped dorsal fin and saddle patch, with naturally acquired nicks and scars. To the untrained eye, it is extremely difficult to distinguish between the three 'assemblages' of killer whales found on the west coast of North America; resident, transient and offshore killer whales. The physical appearance of offshore killer whales (also called 'offshores') is considered most similar to that of resident killer whales (Ford et al. 2000). Compared with those of resident and transient killer whales, the tips of offshores' dorsal fins tend to be rounded on the leading edge and over the apex of the fin, giving the dorsal fin a blunt appearance. Dorsal fins tend to be less angled at the trailing edge and have many more nicks and notches than those of resident killer whales. The saddle patches are usually uniformly grey, although on some animals it may contain a black region (Black et al. 1997; Ford et al. 2000).

Killer whales are the largest members of the dolphin family, Delphinidae. In general, maximum recorded lengths for male killer whales are 9.0 m, whereas females are smaller at 7.7 m (Dahlheim and Heyning 1999). Yamada et al. (2007) recently recorded the maximum weight-to-length ratio for killer whales at 6600kg in a 7.65m male, and 4700kg in a 6.58kg female. In adult males, the paddle-shaped pectoral fins and tail flukes are noticeably longer and broader and fluke tips curl downward (Bigg et al. 1987).

Though they are a genetically distinct group, offshore killer whales are thought to be more closely related to resident killer whales than to transients due to similarities in appearance, vocalizations and genetics (Barrett-Lennard and Ellis 2001). Offshore killer whales are most often observed in groups of 20 or more individuals (Barrett-Lennard and Ellis 2001).

## 1.3. Populations and Distribution

The three assemblages of killer whales on the west coast are genetically distinct from one another, though preliminary genetic studies suggest that there may be some degree of mating between transient and offshore killer whales (Barrett-Lennard 2000). The transient and resident populations in British Columbia are well studied, while detailed information on the life history of offshore killer whales is lacking. Behavioural and cultural differences have been observed in the transient and resident populations. Resident killer whales live in stable, matrilineal associations (up to 50 individuals), while transient killer whales travel in small groups (5 to 7 individuals) that may have fluid membership (i.e. animals often immigrate to and emigrate from these groups). An additional distinction between transients and residents is dietary preference. Resident killer whales feed exclusively on fish and squid, with particular preference for chinook and chum salmon (Ford and Ellis 2006), while transients are mammal-eaters (Bigg et al. 1987).

There are no abundance estimates for any killer whale populations in British Columbia prior to 1976. Since the early 1970's, studies of resident and transient killer whales have increased our understanding of killer whale distributions and population dynamics. Offshore killer whales were only recently described and review of historic records shows that the first offshore killer whale sighting in Canada was in 1979 off the Queen Charlotte Islands (Ford et al. 1992).

The current known range of offshore killer whales is from southern California to the southeastern Aleutian Islands (Black et al. 1997; Matkin et al. 2007), with documented occurrence in marine waters along the continental shelf off the coast of British Columbia (Figure 1). Encounters with offshore killer whales have occurred mostly around the Queen Charlotte Islands; however in recent years, sightings of offshores in coastal and inshore waters have increased (e.g. in the lower Strait of Georgia and western Johnstone Strait (Ford et al. 1992; DFO-CRP unpublished data)) suggesting that usage of coastal habitat may be higher than in the past. It is likely that distribution is influenced by oceanographic conditions and distribution of prey.

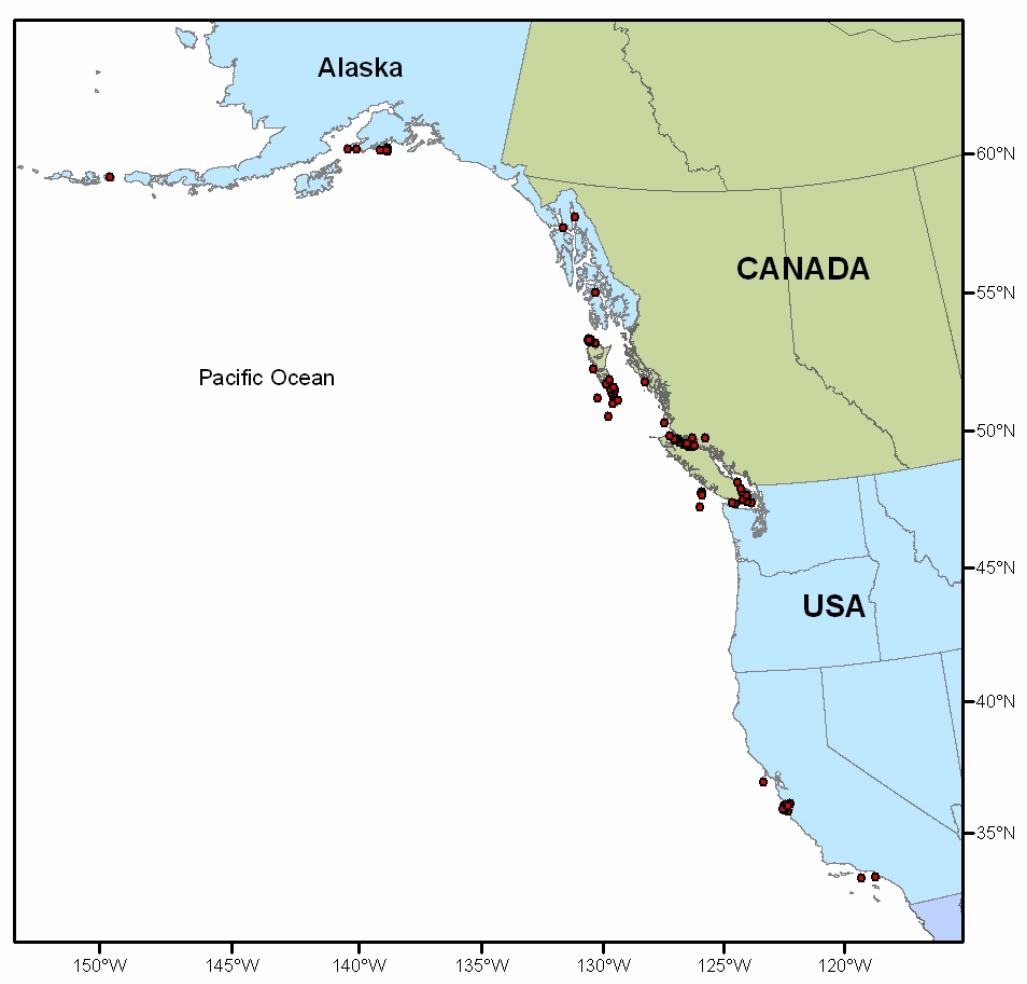


**Figure 1.** Offshore killer whale sightings recorded within the Pacific coastal waters of North America from 1988 to 2007 (DFO-CRP unpublished data). Sightings are not corrected for survey effort, therefore concentrations of occurrence cannot be inferred from this map.

Based on photo-identification of animals, there is believed to be a minimum of 280 animals in the B.C. population (DFO-CRP unpublished data). The rate of discovery of new, unidentified offshore killer whales is slowing, while the rate of re-sights of known offshores is increasing (DFO-CRP unpublished data). This suggests that much of the population in B.C. has been catalogued. Reliable population estimates for offshore killer whales throughout the northeast Pacific are unavailable at this time, and currently there is no evidence of occurrence outside of northeast Pacific waters.

Under the federal *Species at Risk Act* (SARA), this population is designated as 'special concern', meaning it is vulnerable to decline (i.e. becoming threatened or endangered) due to a combination of biological characteristics and identified threats. Provincially, the northeast Pacific offshore killer whale population in B.C. is blue-listed with an S3 ranking (CDC 2007). With this ranking the population is considered vulnerable to extirpation or extinction, as a result of a low number of populations, widespread, recent declines, or other factors (CDC 2007). Since October 1998, the international conservation status for offshore killer whales is G4G5TUQ, indicating that there is some uncertainty regarding the species global abundance (i.e. ranges from somewhat abundant to abundant), and some question regarding taxonomic status. Thus the population is unable to be globally ranked in further detail (CDC 2007).

## 1.4. Requirements of the Offshore Killer Whale

### 1.4.1. Habitat and Biological Needs

In general, there are serious data deficiencies in our knowledge of offshore killer whale biology and habitat needs. Documentation of core areas or home ranges is not yet possible given these data gaps. However, as with all species, adequate availability of high-quality prey and freedom of movement within valuable habitat areas is necessary for survival. Echolocation and social vocalizations are an important aspect of killer whale behaviour for all three assemblages, and an acoustic environment that allows for successful communication and foraging is undoubtedly important.

### 1.4.2. Ecological Role

Killer whale populations around the world often have highly specialized foraging strategies, and target very specific prey species (Hoelzel 1991; Simila and Ugarte 1993; Guinet and Bouvier 1995; Ford et al. 1998; Visser 1999; Saulitis et al. 2000; Pitman and Ensor 2003; Ford and Ellis 2006). On the west coast of B.C., transient killer whales feed on marine mammals, while resident killer whales are salmon-eaters (Bigg et al. 1987; Ford et al. 1998).

Recent studies including feeding observation (Jones 2006), analysis of stomach contents (Heise et al. 2003), fatty acid and isotope analysis of blubber (Herman et al. 2005; Krahn et al. 2007) suggest that the diet of offshore killer whales is fish-based, and includes halibut and sharks. At this time, it is unclear whether mammals or other species also comprise a portion of their diet. Crude examination of the dentition of dead offshores indicates that the teeth of this type of killer whale are more worn and blunt than those of the other assemblages (G. Ellis pers. comm.), which coupled with chemical isotope analysis from Krahn et al. (2007) indicate a diet distinct from that of the resident or transient killer whales.

Though there was no documented distinction between killer whale assemblages, First Nations peoples have long held killer whales in high cultural and spiritual regard as protectors of the oceans. Killer whales were not traditionally hunted by First Nations, though killer whale bones were discovered at an Ozette midden (J. Scordino pers. comm.). At present, some First Nations groups are developing initiatives to monitor marine mammals and gather traditional knowledge on historic occurrence of killer whales within traditional territories.

### 1.4.3. Limiting Factors

The factors limiting population growth of apex predators such as the northeastern Pacific offshore killer whale population, can be broadly categorized as intrinsic, bottom-up processes mediated by the availability and quality of prey. Factors that are intrinsic to the biology of the species can not be mitigated or managed. However, human activities may contribute pressures which alter the balance of these limiting factors, and thus threaten the population. In such cases, actions are necessary to ensure that human activities do not place undue stress on limiting factors.

Resident killer whales are the most intensively studied killer whale assemblage in British Columbia (Ford et al. 2005). Since there is a paucity of information on offshore killer whales, general information on life span and reproductive parameters gathered from resident killer whales was used for the purposes of illustrating potential environmental and biological limiting factors for offshore killer whales (Table 1). Life history parameters of offshore killer whales could be similar to those limiting other killer whale assemblages, but caution should be taken when inferring similarities between different killer whale assemblages.

**Table 1.** Biological and environmental factors which may potentially limit the northeast Pacific offshore killer whale population.

| Limiting Biological Factor | Specific Attributes | Description |
|---|---|---|
| Longevity* | | Females: 50 years, maximum 80-90 years<br>Males: 29 years, maximum 50-60 years |
| Reproduction | Late age of sexual maturity* | Approximately 15 years for both males and females, though males do not reproduce until over 20 years of age |
| | Long gestation period* | 16 to 17 months |
| | Low number of calves per pregnancy* | One calf per pregnancy |
| | Low rate of reproduction* | Interval between calving is typically 5 years, but can range from 2 to 12 years, thereby limiting population growth |
| | Reproductive senescence* | Females' reproductive period is about 25 years, with last calf born at approx. 40 years of age<br>i.e. Most females only give birth to a total of 5 calves in their lifetimes, thereby limiting the potential rate of population growth |
| Neonate mortality* | | Possibly up to 50% between 0 and 6 months of age |
| Limited dispersal | Physical dispersal | Dispersal of offshore killer whales from family groups is unknown |

| Limiting Biological Factor | Specific Attributes | Description |
|---|---|---|
| | Genetic dispersal | Breeding behaviours are unknown at this time, though genetic study suggests some mating may occur between transient and offshore killer whales |
| Small population | | 280 individuals are currently identified in this genetically-distinct population |
| Learned behaviour(s) (i.e. traditional or cultural) | | Unique vocalizations, likely accompanied by highly structured social behaviours |
| Prey | Type | Top predator, specific prey species are unknown at this time. However, preliminary observations include feeding on halibut and shark<br>May acquire diseases through prey, esp. if they are feeding on high trophic level animals |
| | Availability | There is evidence that prey limitation reduced survival and reproductive success in resident killer whales (Ford et al. 2005)<br>As offshore killer whales are a top predator, limitation of food supply is a primary threat to population growth & survival<br>Prey may be limited by an ecosystem regime shift, climate change, and/or by harvesting |
| Disease | | Naturally occurring diseases within the population can affect population viability<br>Diseases may also be acquired through prey, esp. if they are feeding on high trophic level animals (see 'Diet')<br>Extensive tooth wear observed in offshore killer whales may increase the risk of infection by prey-based pathogens |
| Stranding or Entrapment | | Animals may accidentally beach themselves, or become entrapped in coves, lagoons or saltwater lakes (e.g. Bain 1994) |
| Ecosystem Regime Shift | | Natural shift in ecosystem processes may affect offshore killer whales (e.g. via changes to prey abundance or quality, occurrence of disease) |
| *References used for information presented in this table: Ford 1989; Bigg et al. 1990; Olesiuk et al. 1990;, Ford 1991; Bain 1994; Barrett-Lennard 2000; Ford et al. 2000; Herman et al. 2005; Jones 2006; DFO-CRP unpublished data.*<br>** Description utilizes data from studies on resident killer whales.* | | |

## 1.5. Threats

Threats may either be of anthropogenic origin, such as incidental-take in fishing gear or toxic contamination, or they may be natural processes, such as an ecosystem regime shift, resulting in population decline. Limiting factors are environmental or biological factors (e.g. longevity) that may naturally limit population size or slow population growth, and are typically not considered a threat unless altered by human activities (EC 2007). Threat assessments (Table 2) allow for prioritization of recommended management and other actions to prevent this population from becoming threatened or endangered, and provide an indication of the mitigation feasibility for a threat. Definitions of the terms used for rankings are available in Appendix I (Table 5).

### 1.5.1. Threat Classification

Threats were assessed based on their current likelihood of occurrence and severity of effect to the offshore killer whale population. In addition, the certainty of a population-wide effect was incorporated into the assessment to provide a measure of confidence in the rating of 'level of concern' and provide an indication of areas where further monitoring or study may be useful in addressing uncertainties or knowledge gaps (Table 2). Where certainty of effect on the offshore killer whale population is not demonstrated, weight of scientific evidence for other cetaceans may be deemed adequate to contribute to the assessment of the level of concern for a threat.

Mitigation potential refers to the likelihood that measures (future or existing) will adequately mitigate or prevent negative effects to the population. It should be noted that the level of concern rating reflects the current concern for impacts from a threat at this time, and future assessments may result in levels of concern which differ from those presented here. Therefore the importance of long-term monitoring of the population can not be overstated.

**Table 2.** Summary of threat classifications and mitigation potential for identified threats to the northeast Pacific offshore killer whale population. Mitigation potential refers to the likelihood that measures (future or existing) may mitigate or prevent negative effects to the population. This assessment is a current view of the state of threats to the population, and as such assessment ratings may change over time. (*) are naturally occurring threats to the population (i.e. limiting factors whose effects can be increased by human activities).

| Category | Stress to the Population | Severity of population-level impacts | Uncertainty | Current Level of Concern | Mitigation Potential |
|---|---|---|---|---|---|
| Prey Reduction<br>• Competition for resources<br>• Ecosystem Regime Shift* | Prey availability<br>Reproductive rate<br>Mortality<br>Disease<br>Synergistic effects of threats | Potentially High | Low, based on weight of evidence on prey limitation for resident killer whales | **Currently, UNKNOWN**<br>**Potentially HIGH** | None, if due to natural fluctuation<br>Moderate to High, if due to anthropogenic effects |
| Toxic Spills | Reproductive rate<br>Mortality<br>Disease | High, but is dependent on location & timing | Low, based on weight of evidence for resident killer whales | **HIGH** | Moderate |
| Chemical Contamination | Reproductive rate<br>Mortality<br>Disease | Moderate | Medium | **MEDIUM-HIGH** | Low to Moderate |
| Acute Noise | Displacement<br>Stranding? | Moderate | Medium-High | **MEDIUM** | High |
| Chronic Noise | Displacement<br>Prey availability (e.g. foraging success) | Unknown | High | **LOW** | Low |
| Physical Disturbance | Displacement | Unknown | High | **NEGLIGIBLE** | Moderate to High |
| Boat Collisions | Mortality | Unknown, dependent on vessel size & speed | High | **UNKNOWN** | Low |
| Entanglement & | Mortality | Unknown | High | **UNKNOWN** | Unknown |

| Category | Stress to the Population | Severity of population-level impacts | Uncertainty | Current Level of Concern | Mitigation Potential |
|---|---|---|---|---|---|
| Entrapment | | | | | |
| Climate Change | Ecosystem regime shift<br>Prey availability<br>Disease | Unknown | High | **UNKNOWN** | Unknown |
| Biological Pollutants | Disease<br>Reproductive rate<br>Mortality<br>Stranding? | Unknown | High | **UNKNOWN** | Low to Moderate |
| Naturally occurring Disease Agents* | Disease<br>Reproductive rate<br>Mortality<br>Stranding? | Unknown, usually Low | High | **UNKNOWN** | None |
| Mass Stranding or Natural Entrapment* | Mortality | Has potential to impact local abundance | High | **UNKNOWN** | On a case-by-case basis |

### 1.5.2. Description of Threats

*Prey Reduction*

The potential for altered prey availability for this apex predator is one of the key attributes which prompted designation of this population as special concern by COSEWIC (Baird 2001). For resident killer whales, a decline in prey abundance is believed to have caused reduced survival and reproductive success (Ford et al. 2005), providing weight of evidence for effects to other killer whale assemblages.

There remains high uncertainty regarding the diet of offshore killer whales. If dietary requirements for offshores are found to include significant proportions of commercially important fish such as halibut (Jones 2006), competition with fisheries could become an important threat (Table 2). However, this threat could be mitigated by Fisheries & Oceans Canada through updating the integrated fishery management plan(s) for relevant species to recognize the feeding needs of offshore killer whales. The potential for mitigation of fisheries competition is moderate to high, as fisheries extractions are managed directly by Fisheries & Oceans Canada. As offshore killer whales and likely their prey, are trans-boundary species, additional collaboration and cooperation with U.S. fisheries management may be necessary for effective management of the population.

Natural shifts in ecosystem processes (also termed 'regime shifts') as a result of large scale events, such as El Niño or the Pacific decadal oscillation, occur on a recurrent basis and may affect species composition, or other intrinsic processes within offshore killer whale habitat (Francis et al. 1998; Hare & Mantua 2000). Significant effects to marine mammals due to regime shifts have not been observed in B.C., and as such effects on prey supply and quality are largely speculative. The mitigation potential for prey limitation as a result of an ecosystem regime shift is nonexistent.

The proposed effect of food limitation on the resident killer whale population in B.C. (Ford et al. 2005) and Jones' (2006) observation of an offshore consuming market-sized halibut, suggest that fisheries competition may be a potentially important threat to the population. It should be noted that synergistic effects on prey availability due to changing ocean conditions coupled with fisheries competition, have the potential to result in more significant effects than either factor acting alone. Due to the high degree of uncertainty regarding prey, the current level of concern for general reduction in prey availability has been rated unknown, but potentially high (Table 2).

*Toxic Spills*

Killer whales do not avoid toxic spills and have been observed traveling through oil slicks (Matkin et al. 1999; DFO 2007, 2008). After the Exxon Valdez oil spill (1989), there was a dramatically higher than normal observed mortality within the killer whale group that encountered spilled oil (Matkin et al. 1999, 2008). Analyses from Matkin et al. (2008) reveal that two killer whale groups that encountered the spill, one resident and one transient group, exhibited losses of 41 and 33%, respectively. To date, neither killer whale group has recovered their numbers, and the transient group has been listed as 'depleted' under the U.S. Marine Mammal Protection Act (Matkin et al. 2008). The loss of many reproductive-aged females from

a population can impede recovery from catastrophic events. Records from several encounters with offshores have estimated greater than 50 animals clustered in one area (DFO-CRP unpublished data), suggesting that a single spill could affect a significant percentage of this small population.

Given that spills are accidental in nature, they are likely to occur on a recurrent basis within Canadian waters. Offshore killer whales inhabit areas adjacent to major shipping routes (O'Hara and Morgan 2006; EC 2006) and increasing vessel traffic raises the likelihood of ship-based spills in offshore killer whale habitat.

Currently there are measures in place to minimize the risk of spills (e.g. *Transportation of Dangerous Goods Act*) as well as multi-jurisdictional spill response plans (e.g. Can-US Dix Plan, B.C. Marine Oil Spill Contingency Plan) to implement clean-up and other mitigation measures. However, ships carrying mixed goods (i.e. toxic and non-toxic goods) are not required to provide Canadian authorities with ships' manifests, and therefore transport of toxic materials through Canadian waters may not always be recorded. Spills which occur far offshore may be under-reported and are typically more difficult to coordinate responses for mitigation.

The data on killer whale mortalities and population recovery following the Exxon Valdez oil spill (Matkin et al. 1999, 2008), and clustering behaviour of offshore killer whales, illustrates high concern (Table 2) regarding potentially severe population-wide effects. Measures to prevent and mitigate effects of spills are currently in place, but once a spill occurs the effectiveness of clean up measures typically falls between 5 to 15% (Graham 2004). Mitigation potential for prevention and clean-up of spills is considered to be moderate.

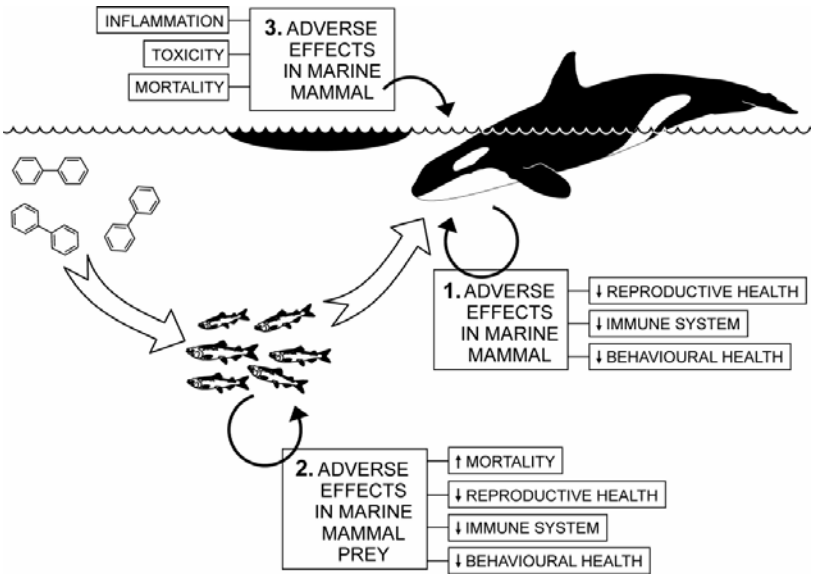


**Figure 2.** Effects of chemicals on killer whales may occur by 1) consuming contaminated prey, 2) impacts on the quality or quantity of their prey, and/or 3) direct exposure to a toxic spill (e.g. oil). This figure is courtesy of Dr. P. Ross, DFO Institute of Ocean Sciences.

*Chemical Contamination*

Preliminary sampling suggests that offshores contain very high levels of the persistent bioaccumulative toxic chemicals (PBTs), such as DDT[1] and PBDE (Krahn et al. 2007). These contaminants are of particular concern as they persist for long periods in the environment and bioaccumulate within food webs (Christensen et al. 2005; Ross 2006). Chronic contamination by PBTs is linked to long-term health effects and reduced reproduction in marine mammals (Ross 2000; Ross et al. 2004). Killer whales' long life span and role as top predator make them vulnerable to PBT contamination (Rayne et al. 2004; Ross 2006), and they are some of the most contaminated mammals on the planet (Ross et al. 2000; Ross 2002).

'Legacy pollutants' include those PBTs whose use and production has been discontinued, but which continue to persist in the environment. High concentrations of these chemicals are found in the environment (Ross et al. 2000; 2004; Garrett and Ross, in press), long after local production has been terminated. Therefore, reversal of contamination is likely to occur over several decades (Hickie et al. 2007).

New generations of PBT chemicals are currently produced locally, nationally and on a global scale. These chemicals have similar properties to legacy pollutants (Ross 2006) and their use and production is increasing, while remaining inadequately regulated (DFO 2008). The main current concern for emerging pollutants stems from the polybrominated di-phenyl ethers (PBDEs), and their presence in B.C. ecosystems is rapidly increasing (Rayne et al. 2004; Elliott et al. 2005). The toxic effects of PBDEs are still unclear, but there is growing scientific evidence to suggest that these chemicals may have similar environmental persistence and toxic effects to that of polychlorinated bi-phenyls (PCBs) (Ross 2006).

The widespread historic and current use of PBT chemicals has resulted in chronic contamination of the environment. Preliminary research findings of high levels of contamination in offshores (Krahn et al. 2007) support this theory. The persistent nature of legacy chemicals and the increased presence of new emerging persistent chemicals leads to medium-high concern for impacts to the offshore killer whale population. Though point sources of contamination can be regulated and monitored, the potential to implement mitigation measures for this threat is rated low to moderate (Table 2), due to the difficulty in mitigating or managing non-point sources of contamination. Additionally, sources of contamination which originate in Canada may be mitigated, whereas for contamination that originates from international waters, the mitigation potential is very low from a Canadian management perspective.

*Acute Noise*

Acute noise typically refers to impulsive sounds produced in the mid to low frequency range, including those produced during military tactical sonar use, seismic surveying, explosions, and the use of acoustic deterrent devices[2]. Many of these impulsive sounds are capable of traveling great distances through unrestricted open ocean areas (Nieukirk et al. 2004). Offshore habitats may be more vulnerable as military sonar exercises and seismic activity may occur more frequently in these areas. Sonar sounds, such as those produced during the USS *Shoup* incident

[1] Naming and properties of chemicals are available in Appendix I (Table 6).
[2] Use of acoustic deterrent devices in British Columbia is no longer permitted.

have been documented to cause behavioural changes in resident killer whales (Fromm 2006; J. Ford pers. comm.). Globally, acute noise is implicated in disturbance of other marine mammal species including behavioural changes, displacement from habitat and in extreme cases, injury and mortalities (e.g. Crum and Mao 1996; Schrope 2002; Jepson et al. 2003; Fernández et al. 2004; Buck and Calvert 2005). Predicting sound propagation using models is strongly dependent on adequate data regarding bottom type and sound speed profiles (Lawson and McQuinn 2004). While care must be taken when extrapolating effects between species or populations, the lack of specific information requires use of the growing weight of evidence from other cetaceans in order to estimate effects on offshore killer whales.

Currently, there is a Canadian military testing range off the west coast of Vancouver Island, within the known range of the population in Canada. Should the generation of explosive, seismic, or sonar noise occur coincidently with the presence of offshore killer whales, the severe nature of the stress could result in displacement from habitat, physical damage to hearing structures, or in extreme cases, mortalities.

Seismic and sonar activity currently occur in Pacific Canadian waters on a recurrent basis, and protocols are still in draft form, or have not been reviewed to ensure effectiveness. The weight of evidence from other cetaceans, and the 'clustering' behaviour of offshores, suggests an expected and demonstrated certainty for moderate population wide effects. Therefore, overall concern is rated medium for this threat (Table 2). Requirements for permitting and protocols for generation of acute noise result in high mitigation potential for this threat.

*Chronic Noise*

Shipping pressure is increasing along the B.C. coast (O'Hara and Morgan 2006), and existing shipping lanes and occurrence of offshore killer whales tend to overlap (See 'Populations & Distribution'; O'Hara and Morgan 2006; EC 2006). Thirty years of data on underwater sound off the coast of California show an average increase of 10dB from the 1960s to the 1990s (which is a two-fold increase in noise level), most of which is attributed to increased shipping activity (Andrew et al. 2002). Some mitigation of tanker traffic-related noise is provided by Canada's Economic Exclusion Zone (EEZ), which requires that large tanker traffic remain at minimum 200nm off Vancouver Island and the mainland coast of B.C., and 80nm off the west coast of the Queen Charlotte Islands[3]. However, many other large vessels (e.g. cruise ships, commercial goods traffic to Alaska, Department of National Defence vessels) frequently travel within the EEZ boundary.

Determining the specific effects of chronic noise on wild marine mammals is difficult, and these effects often cannot be separated from those resulting from other stimuli (Morton and Symonds 2002). Williams et al. (2002a; b) observed altered behaviour patterns of resident killer whales in the presence of whale watching vessels, but could not separate responses due to physical versus acoustic disturbance. Killer whales are a vocally rich species, known to rely on echolocation or passive listening for effective foraging (Barrett-Lennard et al. 1996, Deecke et al. 2005). Any noise that masks this ability may result in killer whales being unable to detect communication

[3] 80nm EEZ limit is based on the vessel traffic requirements for the protected area surrounding Bowie Seamount.

signals required for effective foraging, or for socializing (Erbe 2002). This could lead to decreased ability to capture prey, attract mates, or maintain cohesion of social groups.

Concern for chronic noise impacts is rated low at present (Table 2). Though this threat occurs currently and continuously in Canada's EEZ, the certainty and severity of population level impacts are unknown. Mitigation potential is quite low, given that traffic density in offshore areas is difficult to monitor or mitigate the noise effects of, particularly for large vessels (e.g. tankers).

*Physical Disturbance*

The majority of whale watching activities in British Columbia focus on resident killer whales in the Georgia, Haro and Johnstone Straits. Offshores are seldom observed by researchers, or by whale watchers in British Columbian waters. However, the rate of encounters with offshore killer whales in coastal areas has increased in recent years (DFO-CRP unpublished data), and should this trend continue, animals may be exposed to whale watch pressure, or other physical disturbance from small vessels. Williams et al. (2006) recorded altered activity budgets of resident killer whales in the presence of vessel traffic, indicating some level of energetic cost of disturbance. As offshores are unaccustomed to close or targeted approaches by vessels, there remains some concern for the safety of boaters and whales alike, should such circumstances arise. The *Fisheries Act* Marine Mammal Regulation (MMR) legally protects all marine mammals from disturbance. Additionally, the 'Be Whale Wise: Marine Wildlife Guidelines for Boaters, Paddlers and Viewers' guidance for a minimum viewing distance of 100m may not be sufficient to mitigate potential impacts from small vessels, given offshores' naiveté to targeted small boat disturbance.

Currently, the rare exposure of offshores to targeted vessel disturbance in coastal waters results in negligible level of concern for this threat at the present time. The potential for mitigation of this threat is moderate to high (Table 2) given that guidelines and regulations are currently in place to dictate targeted vessel behaviour around whales, and occurrence of whale watching disturbance is primarily near coastal, urban centres that are relatively easy to monitor.

*Boat Collisions*

Large vessels (e.g. passenger ships) travel at high speeds within Canada's EEZ on the West Coast. As offshore killer whales also inhabit these regions, there is potential for interactions with vessels. While the MMR legally protects marine mammals from disturbance, monitoring vessel interactions in offshore areas is not feasible.

Historically, there are few reports of collisions between killer whales and vessels. However, from 2003 to 2007 there were six collisions reported in B.C., three of which were fatal for resident killer whales (DFO-CRP unpublished data). In 2005, DFO cetacean research surveys encountered a previously identified offshore killer whale, whose dorsal fin was completely severed at the base (DFO-CRP unpublished data). This individual survived, and its injuries are consistent with those that could be sustained from a propeller blade. As offshores do not typically utilize habitat near urban areas, they are not exposed to high densities of small vessel traffic on a regular basis (as resident killer whales are). Therefore these whales may behave

quite differently around small boat traffic than other killer whale assemblages (see 'Physical Disturbance').

As there is no information regarding the frequency of vessel strikes, nor a complete census of the population, it is unclear what level of threat to population viability is posed by vessel strikes. The observed injury indicates that vessel strikes currently impact at least individual offshores, and the recorded mortalities of other killer whales indicate that impacts can be severe. At present, several knowledge gaps regarding the occurrence of this threat remain unaddressed; therefore level of concern for this threat remains unknown. Vessel strikes are accidental and once an animal is struck, mitigation of effects to that individual is not feasible; however regulations and guidelines aim to increase awareness of killer whales and dictate vessel behaviour in the presence of whales. Therefore, mitigation potential for this threat is rated as low (Table 2).

*Entanglement*

Seine-, gill-, or driftnet fisheries may pose threat to offshores by way of potential interaction and entanglement in fishing gear. Entanglement or entrapment within fishing gear or other man-made devices may cause harm to individual animals, and in rare cases may result in death. While there have been no recorded incidents of entanglement involving offshore killer whales, there is one recorded incident involving natural entrapment of offshores. In 1994, a group of offshore killer whales was trapped in semi-tidal Barnes Lake, Alaska for 2 to 3 months (Bain 1994), ultimately exiting the area only as a result of human intervention.

Gillnet, driftnet and long-line fishing currently occurs within the known range of offshore killer whale (DFO 2007a). Information on any occurrences of offshore killer whales outside of the northeastern Pacific may address knowledge gaps on interactions with offshore or foreign fisheries, as well as potential range for these animals. Further insight into the current rate of entanglement, prey, habitat use and range of offshore killer whales will address the high degree of uncertainty regarding this threat to the population of offshore killer whales in B.C.

As a result of extreme data deficiency surrounding both entanglement rates and the certainty and severity of effects to the population, the level of concern for this threat is unknown (Table 2). Modification of fishing gear has been successful in mitigating entanglement rates for cetaceans elsewhere (i.e. U.S. or Atlantic Canada); recommendations to enact cost-effective modifications to gear should be considered.

*Climate Change*

Changes in global climate may affect distribution of offshore killer whales and their prey, within and outside Canadian political boundaries. Global climate change has the potential to alter oceanographic conditions, as well as predator-prey dynamics. Macdonald et al. (2005) suggests that large changes in natural processes may affect the behaviour of chemicals in the environment, as well as the potential for alterations in vectors for transmission of disease. In addition, other contaminants and stressors can have interactive effects resulting in decreased ability to counteract effects of biological pollutants (Sih et al. 2004).

Level of concern for this threat is unknown (Table 2). However, environmental changes such as climate change should be considered in the context of potential interactive or synergistic effects.

The mitigation potential for addressing effects of climate change on the population is unknown; further study is required to understand the potential effects of this threat on offshore killer whales.

*Biological Pollutants*

Nutrient loading from terrestrial runoff may create environments where naturally occurring diseases or harmful algal blooms flourish in greater density. Urban and agricultural runoff often contain antibiotics, hormones, viruses or biological materials that have the potential to affect marine mammals, such as offshore killer whales. Introduction of foreign diseases into a population of highly social cetaceans, like killer whales, may result in disease outbreaks leading to population decline (Guimarés et al. 2007). The occurrence of large aggregations of offshore killer whales makes them particularly sensitive to virulent disease outbreaks. Some terrestrially based pathogens are known to affect marine mammals (Raverty et al. 2007, Conrad et al. 2005), though presence of biological pollutants in the offshore population has not been extensively studied, leaving significant uncertainty regarding potential population-scale impacts. The mitigation potential for this threat is considered low to moderate for point-sources of pollution within Canada (Table 2). For further detail on effects of disease and pathogens on killer whales, see 'Naturally occurring Disease Agents'.

### 1.5.3. Natural Threats

Natural threats are those limiting factors whose effects on offshores may be exacerbated by anthropogenic activities (EC 2007). For example, disease effects may be compounded by acute or chronic biological or toxic pollution. While natural threats are unlikely to be managed or mitigated, in and of themselves, they can impact the population viability for offshore killer whales, and thus should be monitored to detect trends and additional research needs.

*Naturally occurring Disease Agents*

Naturally occurring diseases and pathogens affect cetaceans around the world. These diseases, while endemic to populations, may be exacerbated by synergistic or compounding effects with other threats or limiting factors. See 'Biological Pollutants'.

Preliminary investigation of infectious diseases indicates that *Salmonella newport* septicemia, *Edwardsiella tarda* septicemia, *Erysipelothrix rhusiopathiae*, and marine *Brucella* are present in killer whales on the west coast of North America (Raverty et al. unpubl.). Marine *Brucella* and cetacean poxvirus may have particular significance as infection may result in decreased fecundity, reproductive success and increase neonate mortality (Gaydos et al. 2004).

In addition, offshores may also be exposed to naturally occurring diseases through transmission from prey species. The cracks on offshores' teeth may allow bacteria to more easily enter the bloodstream making transfer of pathogens from prey to predator a possibility.

While the level of disease or infection within the offshore killer whale population is unclear, the weight of evidence provided for other killer whales, as well as overlapping distribution of the three populations, would suggest at minimum general exposure to a similar suite of naturally occurring diseases. Gaydos et al. (2004) recommends further study of four priority pathogens

likely to affect resident killer whale populations either through intra- or inter-specific interactions; marine *Brucella*, cetacean poxvirus, cetacean morbilliviruses and herpesviruses. While studies focusing on these four pathogens may address concerns regarding population level effects to killer whale assemblages, there are 16 other pathogens which have also been identified to potentially affect killer whales (Gaydos et al. 2004). Level of concern for this threat is unknown (Table 2), given the uncertainties surrounding disease prevalence in the offshore population.

*Mass Stranding & Entrapment*

Mass stranding or entrapment of killer whales in narrow inlets was listed by COSEWIC as a potential for drastic reduction in local abundance of offshore killer whales (Baird 2001). Since 1992, there have been three recorded strandings of killer whales in British Columbia (DFO-CRP unpublished data). While no strandings of offshores have been reported, the coastal habitat of B.C. is such that stranding events which occur outside of highly populated areas are less likely to be encountered. The cause of stranding events for cetaceans is poorly understood, however anthropogenic effects, such as tactical sonar noise, have been implicated in several mass stranding incidents involving beaked whales (e.g. Schrope 2002; Jepson et al. 2003), suggesting that anthropogenic pressures may contribute to mass stranding events.

In general, records of entrapment in inlets or bays indicate an inability of the group to adapt to effect an exit from the area (examples listed in Baird 2001). There is one recorded incident involving natural entrapment of offshore killer whales. In 1994, a group of offshore killer whales was trapped in semi-tidal Barnes Lake, Alaska for 2 to 3 months (Bain 1994). The group ultimately exited the area only as a result of human intervention. This event resulted in the mortality of one adult female and one sub-adult male (Bain 1994).

While mitigation measures were taken in the Barnes Lake incident, mitigation potential for stranding and entrapment events will be highly dependent on each individual situation, and will require assessment on a case-by-case basis, and involvement of trained personnel.

### 1.5.4. Cumulative or Synergistic Effects of Threats &/or Limiting Factors

The effects of threats and limiting factors can be difficult to distinguish from one another, making conclusions regarding causes of population decline often difficult to ascertain. Synergistic effects between multiple stressors on a population have been suggested to result in a ‘snowball effect’ enhancing the effects of otherwise benign limiting factors (e.g. Sih et al. 2004; Macdonald et al. 2005).

There is considerable uncertainty as to the occurrence and total impact of threats on the population in Canadian waters. Nonetheless a species, like killer whale, with a long maturation period and low reproductive rate would be expected to be sensitive to increases in human-caused mortality, particularly if oceanographic conditions deteriorate, or if combined with other threats.

## 1.6. Actions Already Completed or Underway

### 1.6.1. Current Management and Stewardship Actions

Canada's federal *Species at Risk Act* [SARA] requires that a management plan be developed for the management of a species of special concern, such as offshore killer whales. While no other management actions have been initiated to specifically address conservation of offshore killer whales, several existing actions to protect and preserve other marine species and ecosystems may prove useful for management of this population. These actions and initiatives may mitigate stresses, or provide valuable opportunities to gain knowledge or promote awareness of the population. Actions currently underway may also be listed in Section 2.3 ('Actions') in order to promote their completion, or to increase their effectiveness for protection of offshore killer whales.

Offshore killer whales are currently protected under the following legislation and guidelines:

- Protection from trade under the Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES], Appendix II;
- Canada's federal *Fisheries Act* contains provisions for protection of fish and marine mammal habitat (S. 35, 36), and the Marine Mammal Regulation, protects all marine mammals from disturbance and injury;
- Fisheries & Oceans Canada *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment* (DFO 2007)
- Department of National Defence [DND] 'Maritime command order: marine mammal mitigation procedures' (DND 2007) mitigates disturbance from tactical sonar use;
- Environmental Quality Guidelines for water, air, sediment and tissues are published by the Canadian Council of Ministers for the Environment [CCME] and the B.C. Ministry of Environment [MoE];
- By-laws, Codes of practice and Action groups are developed and implemented regionally and municipally for mitigation of environmental stresses;
- Regional Environmental Emergency Teams [REET], regional, national and international spill response programs manage toxic spills and monitoring of contaminated sites (e.g. Can-US Dix Plan, B.C. Marine Oil Spill Contingency Plan).

I. Regulatory development and review, currently underway

- *Fisheries Act* 'Marine Mammal Regulation' [MMR] is being amended to increase prevention and mitigation of disturbance to marine mammals
- Development of proposed Risk Management Strategy for PBDEs by Canadian Environment Protection Association [CEPA] and Environment Canada [EC]

- Pacific North Coast Integrated Management Area [PNCIMA] 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 B.C.

- Development of the proposed National Marine Conservation Area [NMCA] off Gwaii Haanas may protect potential habitat for offshore killer whales around the Queen Charlotte Islands

## II. Stewardship measures currently in place

- 'Be Whale Wise: Marine Wildlife Guidelines for Boaters, Paddlers & Viewers' provides guidelines for human behaviour and minimum vessel distances around wild marine mammals

- Information on sightings of marine mammals are collected by the B.C. Cetacean Sightings Network (1-866-I-SAW-ONE; www.wildwhales.org), a partnership between the Vancouver Aquarium and DFO

- Information on incidents (e.g. strandings, entanglements) and marine mammal sightings are collected by the DFO Marine Mammal Incident Response [MMIR] (1-800-465-4336) program and other organizations

- Straitwatch, Robson-Bight (Michael Bigg) Ecological Reserve Warden program, and the B.C. Cetacean Sightings Network, educate boaters on marine mammal viewing guidelines and threats to marine mammals

- Public and industry initiatives such as, 'Toxic Smart' or 'Clean Print B.C.', increase awareness of chemical stress to marine habitats

- Remediation programs can be carried out on a case-by-case basis for disturbed habitat

- Whale Watch Operators Association Northwest has implemented Best Management Practices (www.nwwhalewatchers.org) for all its members to ensure that operators behave in a manner which respects the spirit of the *Be Whale Wise*: Marine Wildlife Guidelines for Boaters, Paddlers and Viewers'

## III. Conservation strategies currently under development

With the legislation of the SARA in 2003, marine conservation strategies for 'at-risk' marine mammals have been drafted. These documents include recommended actions for protection of marine mammal species. In a larger context, these management actions may also benefit offshore killer whales. Please refer to Section 4.0 'Associated Plans' for specific recovery plans with actions relevant to the protection and management of offshore killer whales in British Columbia.

### 1.6.2. Current Research Actions

Due to the inherent difficulties of marine field research on wide-ranging and uncommon species, data are often collected on an opportunistic basis. Researchers with DFO, universities and other organizations[4], collect and share sightings and incident information for all marine mammals, including offshores, and necropsy work is completed when possible. During ship-based surveys, independent researchers and organizations collect information on cetaceans via:

- Photo-identification of individual whales
- Acoustic sampling of vocalizations
- Biopsy (tissue) sampling of individuals, when possible

Aerial surveys complement these processes by providing abundance estimates for many marine mammals. Fatty acid profiling of tissue samples address questions regarding prey types and contamination levels. Potential prey species are being acquired and analyzed, which may support field studies in identification of the prey of offshore killer whales via chemical isotope analysis (Krahn et al. 2007).

To date, relatively little targeted research on life history and ecology has been conducted on offshores. Their unpredictable patterns of occurrence and open ocean habitat have made directed research efforts impractical. Future research should address concerns and knowledge gaps regarding threats.

## 1.7. Knowledge Gaps

There is a considerable amount of detailed knowledge on the population dynamics and life history of the resident killer whale communities in British Columbia. It is unclear how much, if any, of these data are applicable to an understanding of the offshore killer whale population in Canada. Encounters with offshore killer whales have been relatively few, and efforts to catalogue members of this population have been challenging given infrequent sightings, elusive behaviour, and their largely open ocean habitat.

There are significant gaps in knowledge of nearly all aspects of the general biology and ecology of the offshore killer whale, and increase in research effort is necessary to address these deficiencies. The highest priority for research efforts are studies to address knowledge gaps on: diet (including nutritional needs), population abundance (e.g. long-term trends), demographics, distribution, range and seasonal occurrence, habitat requirements, and social organization.

Additional research programs on mating patterns, genetic associations and toxic or biological contaminant levels and magnitude of listed threats (Table 2), are also relevant.

[4] A list of organizations and independent researchers carrying out research programs on offshore killer whales are listed in Appendix II.

# 2. MANAGEMENT

## 2.1. Goal

*To maintain a population level that is viable over the long-term within the known range for the northeastern Pacific offshore killer whale population in Pacific waters of Canada*

As uncertainty surrounding population abundance and general biology is high, a conservative approach is warranted, and the need to address knowledge gaps should be recognized in order to meet this goal. As this population moves between U.S. and Canadian waters, the role of Canadian management will aim to protect the population within Canada and contribute to research and conservation initiatives in the U.S., where feasible.

## 2.2. Objectives

**Over the next ten years, the population and distribution objectives are to:**

P1 *Maintain the population at, or above its current level (averaged over 5 years)*

D1 *Maintain the population's current range of occupancy and distribution on the west coast of B.C.*

At present, many uncertainties remain regarding offshore killer whale demographics and distribution. However, a preliminary population census (DFO-CRP unpublished data) and sightings data have provided an initial estimate of 280 animals in this population, with members found throughout British Columbia's marine waters. Given that these data are preliminary, specific, quantitative population and distribution objectives in terms of increasing population size or distribution are not feasible at this time. A complementary research objective (R4) to determine levels of human-caused mortality that will not impede achievement of the population objective (P1) will assist in providing a benchmark to gauge the actual levels of anthropogenic mortality. Maintenance of current estimated population level and distribution are at present the most biologically-defensible objectives. From a Canadian management perspective, maintenance of distribution and population levels in B.C. waters is a priority.

**Research & Monitoring Objectives:**

Over the next ten years, research objectives are to:

R1 *Complete numeric census of the population, and monitor demographics*

R2 *Support, foster and contribute to the clarification of general aspects of the biology and ecological role of offshore killer whales in Canada. Of particular importance are studies on foraging ecology, population abundance, and seasonal occurrence*

R3 *Support, foster and contribute to research addressing knowledge gaps regarding effects of entanglement, chemical and biological pollutants, and effects of other identified (Table 2) and non-identified threats to this population*

R4 *Assess available methods and estimate levels of annual human-caused mortality that the population can sustain and achieve objective P1*

Significant knowledge gaps remain regarding general biology of offshores, and addressing these knowledge gaps will aid in directing management efforts. Objective R1 will provide information on an ongoing basis in order to monitor population health, while R2 and R3 will address uncertainties on threats to the population. An estimate of level of human-caused mortality that will not jeopardize achieving objective P1, may provide a measure against which to assess the impact of threats. Efforts to monitor anthropogenic-related mortalities may assist in determining impacts of specific threats on this population. As there are general ecological questions regarding offshore killer whales, research to address these uncertainties is considered a higher priority at this time. Canadian research efforts will focus on the population within British Columbian waters, while collaboration with U.S. researchers will contribute to the body of knowledge on offshores in the larger context (i.e. on the west coast of North America). Over a ten year period, questions regarding the ecological role of offshore killer whales must be answered in order to support the described goal.

**Management Objectives:**

Over the next ten years, management objectives are to:

M1 *To reduce the risk of catastrophic spills impacting the offshore killer whale population in B.C.*

M2 *Minimize exposure of offshore killer whales to biological and chemical pollutants*

M3 *Minimize the exposure of offshore killer whales to acute or chronic sound levels in excess of those considered to cause behavioural or physical harm in cetaceans*

M4 *Minimize the degradation of realized, and potential habitat within Canada*

M5 *Promote and contribute to international collaboration, independent research, education and outreach on management and conservation initiatives*

Management objectives address threats rated at medium or high level of concern (Table 2) to prevent population decline and achieve the management goal (Section 2.1). Catastrophic toxic spills, prey reduction, contamination and acute noise were assessed to be the top threats to offshore killer whales (Table 2). As offshore killer whales are a trans-boundary population, education and collaboration with U.S. managers and researchers will aid in conservation and mitigation efforts.

Threats assessed at low or unknown level of concern (Table 2) do not have direct objectives; instead knowledge gaps will be filled by opportunistic or cost-effective means, where feasible. Effects of some threats impact individual whales, but do not constitute a population level effect. Where mitigation feasibility is high (Table 2) and resources are available it is prudent to manage and mitigate these threats.

## 2.3. Actions

The primary focus of this management plan is to recommend actions to close knowledge gaps and identify research needs to increase our understanding of the northeast Pacific offshore killer whale population. Despite uncertainty regarding species biology, management actions that may reduce the risk of population-level effects of threats should be undertaken. The ability of DFO to undertake and/or support the actions identified will be subject to the availability of required funding and other resources.

The following actions (not listed in order of priority) are recommended to support management goals and objectives outlined in Sections 2.1 and 2.2 in order to prevent offshores from becoming listed as threatened or endangered. Many of the actions listed below are currently underway (see Section 1.6 'Actions already completed, or underway'), and are identified in other recovery planning documents to date (See Section 4 'Associated Plans'). The synchronization of these listed activities for protection, management and research will facilitate a multi-species approach to marine mammal conservation in British Columbia, and allow for effective use of available resources. Actions have been recommended where implementation is deemed to be practical and feasible, and those most likely to result in successful protection of the offshore killer whale population in B.C..

Where responsibility for actions is determined to fall under Fisheries & Oceans Canada jurisdiction, actions will be implemented directly though collaboration with other responsible agencies and organizations, and successful coordination of efforts may be necessary in some cases to complete actions. If responsibility for actions falls outside of the mandate of Fisheries & Oceans Canada, or outside of its jurisdiction, support for implementation of the action(s) and contribution to effort(s) will be a priority, where feasible. Participating agencies and organizations and implementation timelines for each of the listed actions are presented in Table 4. Organizations currently involved in data collection on offshore killer whales are listed in Appendix II.

### 2.3.1. Protection

1. Continue to protect offshore killer whales from acute acoustic disturbance to effectively mitigate potential negative population level effects.

    a. Apply the Fisheries & Oceans Canada *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment* (DFO 2007) as well as associated regional implementation protocols to increase effectiveness in mitigation of seismic noise stress with respect to killer whales.

b. Review, and if necessary revise, the Canadian Department of National Defence 'Maritime command order: marine mammal mitigation procedures' (DND 2007) to minimize impacts of tactical sonar noise on offshore killer whales.

2. To protect offshore killer whales from physical disturbance, vessel interactions and chronic noise stress.

    a. Complete Marine Mammal Regulation [MMR] amendments under the *Fisheries Act* to reduce the risk of displacement from habitat, collisions with vessels, entanglement in gear, and the effects of acoustic disturbance.[5]

    b. Continue enforcement of MMR and regional guidelines for marine mammal viewing, as well as relevant regulations for marine industrial development.

### 2.3.2. Management

3. Continue to review project proposals that include the use of seismic and sonar surveying and provide project-specific advice for mitigation or avoidance.

4. Manage and reduce input of chemicals into habitat to reduce toxic loading in offshore killer whales, their habitat and prey species.

    a. Develop marine mammal-specific measures for inclusion into catastrophic spill response programs,

        *i.* Develop an emergency response plan to identify marine mammal expertise required in spill response initiatives, when triggered.

        *ii.* Develop a marine mammal-specific operational manual to be included into existing catastrophic spill response plan(s)[6] to identify data collection and response protocols required for mitigation of short and long-term effects to marine mammals and habitat.

    b. Review and routinely monitor point-source contamination in known offshore killer whale habitat in B.C.

        *i.* Review management of point-sources of toxic pollution to assess relevancy of current federal, provincial, and regional guidelines for thresholds for environmental contamination for specific chemicals listed in Appendix I, in terms of potential effects to offshore killer whales.

        *ii.* Routinely monitor these point-sources to assess compliance with federal, provincial, and regional guidelines regarding thresholds for

[5] To view the proposed amendments to the Marine Mammal Regulation, visit http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/marinemammals/mmr-update_e.htm

[6] Include in the operational manual, measures outlined in the Fisheries & Oceans Canada 'Marine mammal incident response' manual (draft) and 'Sea otter oil spill response plan for Canada's Pacific coast' (working document).

environmental contamination for the specific chemicals listed in Appendix I.

5. Continue the permitting of non-DFO research programs, monitoring and assessment (Sections 2.3.3 & 2.3.4) to address key knowledge gaps and clarify identified threats. This action will continue to support actions 8a through e, 9, 10a to c, and 11a to c.

6. Support the Marine Mammal Response Network, to facilitate standardized sample collection and necropsy of carcasses, and for collection and sharing of data to support a comprehensive understanding of identified threats catastrophic spills, noise and physical disturbance, vessel collisions, entanglement, entrapment and mass stranding. This action will support that listed in 11a.

7. Strengthen, support and foster, where feasible, the continued development of fisheries observer reporting standards and guidelines for marine mammal species identification and data collection to clarify the extent of fisheries interactions (i.e. entanglement, by-catch) and gather samples, where possible. This action would support actions 6, and 11b, where appropriate.

### 2.3.3. Research on Offshore Killer Whale Biology

8. The priority of this management plan is to outline research actions needed to increase our knowledge of offshore killer whales in B.C. and on the west coast of North America. Opportunistic data collection and multi-species research programs may be combined to provide a more cost-effective means of achieving research goals outlined in this management plan and others, including recovery strategies and action plans (See Section 4.0 ‘Associated Plans’). The following information on life history parameters of offshore killer whales are prioritized by order of importance in addressing knowledge gaps for this population.

    a. Conduct annual ship-based, multi-species marine mammal reconnaissance surveys. Complement ship-based surveys with aerial surveys, where and when feasible. This action will assist in determination of distribution, range and seasonal occurrence of offshore killer whales within B.C., and provide capacity to carry out actions 8b through 8e.

    b. Continue the sight-resight (photo-identification) program on killer whales to contribute to data for total population census, and allow for monitoring of population abundance, long-term trends, and demographics of offshore killer whales.

    c. Deploy remote acoustic monitoring packages annually to gauge the seasonal occurrence of offshore killer whales in key areas of the B.C. coast.

    d. Conduct field sampling to identify the foraging ecology and diet of offshore killer whales to support further understanding and monitoring of effects of prey limitation.

e. Collect tissue samples from both offshore killer whales and potential prey species, when feasible, to contribute to the determination of pathogen and pollutant profiles, and potential prey species. This action will complement that listed in 8d, and may be supported by action 11a, when appropriate.

### 2.3.4. Monitoring and Assessment

The population, as well as identified threats should be monitored on a long-term scale in order to gauge effectiveness of management of threats, as well as to prevent increases in stress to the population. Where effects of threats are unknown, effort should be focused to gathering additional data to address uncertainties. Such monitoring could also include identification and sampling at sources or vectors of stress.

9. Support efforts to monitor the distribution and occurrence of killer whales in B.C. to support research efforts.

10. Conduct ongoing assessments of the vulnerability of offshore killer whales to identified threats, as this population's distribution is further identified.

    a. Evaluate the need for risk assessment models (e.g. Barlow and Gisiner, 2006) to ascertain risk factors for toxic spills, vessel strikes, entanglement in fishing gear, exposure to biological pollutants, and prey limitation on offshore killer whales and/or their habitat in B.C. and range-wide. Actions 5 and 12c will contribute to this effort.

    b. Investigate the potential for increased risk of seismic noise stress, catastrophic spills and vessel disturbance to the offshore killer whale population that might result from lifting the moratorium on offshore fossil fuel exploration and extraction in B.C. Action 12c will contribute to this effort.

    c. Assess the likelihood of population level impacts from prey limitation on offshore killer whales. This action is contingent upon results from 8d and 8e.

11. Clarify the extent of threats to the offshore killer whale population.

    a. Perform necropsy of carcasses, where feasible, to determine pathogen loading. This action may assist 8e and action 6 will assist in providing capacity.

    b. Assess the potential for offshore killer whale-fisheries interactions, through depredation, entanglement in gear, or through competition for resources (i.e. prey). Action 7 will provide some capacity, and results from 8d and 8e may be required to evaluate potential competition for resources.

    c. Evaluate the feasibility of conducting an assessment of current sources of biological pollutants within known offshore killer whale habitat to assess the potential for population-level impacts to the population. This action may be conducted in concert with action 4b where appropriate, or feasible.

### 2.3.5. Outreach and Communication

12. Foster improved communication networks to increase awareness of offshore killer whale initiatives.

    a. Pro-actively build intra- and interagency networks for effective communication during catastrophic spill response to allow timely, effective and coordinated actions by responsible agencies and parties. This action will support 4a.

    b. Ongoing media communications, outreach and promotion of the Marine Mammal Regulation and 'Be Whale Wise: marine wildlife guidelines for boaters, paddlers and viewers' to reduce physical and acoustic disturbance.

    c. Support and contribute, where feasible, to trans-boundary and inter-jurisdictional collaboration on research and management initiatives to ensure a coordinated response to conservation of this population. This effort will assist and support all actions listed.

# 3. PROPOSED IMPLEMENTATION SCHEDULE

Fisheries & Oceans Canada encourages other agencies and organizations to participate in the conservation of the northeast Pacific offshore killer whale population through the implementation of this management plan. The agencies in Table 3 have been identified as partners for implementing the recommended actions.

Table 4 summarizes those actions that are recommended to support the management goals and objectives. The activities implemented by Fisheries & Oceans Canada will be subject to the availability of funding and other required resources. Where appropriate, partnerships with specific organizations and sectors will provide the necessary expertise and capacity to carry out the listed action. However, this identification is intended to be advice to other agencies, and carrying out these actions will be subject to each agency's priorities and budgetary constraints. Organizations currently collecting data on offshore killer whales are listed in Appendix II.

**Table 3.** The management actions outlined in this plan are to be carried out, where and when appropriate, in partnership with the following organizations.

| Organization | Acronym |
|---|---|
| Fisheries & Oceans Canada | DFO |
| Marine Mammal Response Network | MMRN |
| Department of National Defence | DND |
| Environment Canada | EC |
| Transport Canada | TC |
| Natural Resources Canada | NRCan |
| Canadian Coast Guard | CCG |
| National Energy Board | NEB |
| First Nations | FN |

| | |
|---|---|
| B.C. Province | B.C. Prov |
| Ministry of Agriculture, Food & Fisheries | MAFF |
| Vancouver Aquarium Marine Science Centre | VAMSC |
| B.C. Cetacean Sightings Network | B.C.CSN |
| Straitwatch | Straitwatch |
| Post-secondary institutions carrying out relevant research activities | Universities |
| U.S. National Marine Fisheries Service, National Oceanic & Atmospheric Administration, National Marine Mammal Lab | NOAA |
| Environmental non-governmental organizations | ENGOs |
| To be determined | TBD |

**Table 4. Proposed Implementation Schedule**

| Action | Obj. | Priority | Threats or concerns addressed | Participating Agencies[7] | Timeline |
|---|---|---|---|---|---|
| ***Protection*** | | | | | |
| 1. Protect offshore killer whales from acute acoustic disturbance, and mitigate negative effects | | | | | |
| a) Apply the DFO *Statement of Canadian Practice with respect to Mitigation of Seismic Sound in the Marine Environment* | D1; M3; M4 | H | Displacement from habitat due to seismic noise disturbance; increase protocol effectiveness with respect to mitigation for killer whales | DFO, EC, NRCan, NEB | Ongoing |
| b) Review of DND *Maritime command order: marine mammal mitigation procedures;* revise where necessary | D1; M3; M4 | M | Injury to animals due to tactical sonar use; increase protocol effectiveness with respect to mitigation for killer whales | DFO, DND | 3 years |
| 2. Protect offshore killer whales from disturbance (physical and acoustic) | | | | | |
| a) Complete amendments to the MMR | M3; M4 | LM | Increase protection from physical & acoustic disturbance; vessel strikes | DFO | Ongoing, projected completion 1 year |
| b) Continue enforcement of MMR and regional guidelines | M3; M4 | LM | Continued protection from physical & acoustic disturbance; vessel strikes; development | DFO, CCG | Ongoing |
| ***Management*** | | | | | |

[7] Identification of government agencies and non-governmental organizations is intended to be advice and does not commit the agency or organization to implementing the listed action. Implementing actions will be contingent upon each organization's or agency's priorities and budgetary constraints.

| Action | Obj. | Priority | Threats or concerns addressed | Participating Agencies[7] | Timeline |
|---|---|---|---|---|---|
| 3. Review project proposals, provide advice for mitigation or avoidance | D1; M3; M4 | H | Seismic noise disturbance; tactical sonar use | DFO | Ongoing, enhance involvement where necessary |
| 4. Manage and reduce input of chemicals into habitat to reduce toxic loading in offshore killer whales, their prey and their habitat | | | | | |
| a) Develop marine mammal-specific measures for inclusion into catastrophic spill response programs | | | | | |

| Action | Obj. | Priority | Threats or concerns addressed | Participating Agencies[7] | Timeline |
|---|---|---|---|---|---|
| *i*) Develop emergency response plan to include marine mammal expertise into spill response initiatives | M1; M2; M4; M5 | H | Effective, coordinated response for toxic spills affecting marine mammals | DFO, EC, CCG, B.C. Prov, NOAA | 1 year |
| *ii* ) Develop a marine mammal-specific operational manual | M1; M2; M4; M5 | H | Effective, coordinated step-wise response to toxic spills & standardized data collection | DFO, EC, CCG | 1 year |
| b) Review and routinely monitor point-source contamination in known offshore killer whale habitat in B.C. | | | | | |
| *i*) Review management of point-sources of chemicals to assess relevancy of federal, provincial, regional thresholds for contamination (chemicals listed in Appendix I) | P1; R3; M2; M4 | M | Relevance of guidelines & thresholds in terms of contaminant loading in offshore killer whales, habitat & prey | EC, B.C. Prov, Municipalities | 3 years |
| *ii*) Routinely monitor these point-sources to assess compliance with federal, provincial, regional guidelines for thresholds (for chemicals listed in Appendix I) | P1; R3; M2; M4 | M | Compliance w/ guidelines & thresholds for environmental contamination; contaminant loading in offshore killer whales, habitat & prey | EC, B.C. Prov, Municipalities | 3 years |
| 5. Permitting of non-DFO research programs, monitoring and assessments | R1; R2; R3; R4 ; M5 | H | Fostering independent research programs to determine prey spp. | DFO, FN, ENGOs, Universities, NOAA, TBI | Immediate. Supports actions 8, 9, 10, 11 |
| 6. Support the MMRN program | R2; R3; M1 | MH | Standardized sample collection; incident reporting; necropsy analysis; clarify threats; share data | DFO, CCG, MAFF | Ongoing, will support and provide capacity for 11a |

| Action | Obj. | Priority | Threats or concerns addressed | Participating Agencies[7] | Timeline |
|---|---|---|---|---|---|
| 7. Continued development of fisheries observer reporting standards | R3 | L | Clarify extent of fisheries interactions; species identification; gather samples | DFO | 5 years<br>Will support actions 6 and 11b |
| ***Research on Offshore Killer Whale Biology*** | | | | | |
| 8. Research actions: opportunistic & targeted research | | | | | |
| a) Conduct annual ship-based, multi-species marine mammal surveys. Conduct aerial surveys, when feasible. | P1; D1; R1; R2; R3; R4; M5 | H | Distribution; range; seasonal occurrence in B.C. | DFO, NOAA, TBD | Ongoing<br>Will provide capacity to carry out 8b to 8e |
| b) Continue the photo-identification program for killer whales | P1; D1; R1; R2; R3; R4; M5 | H | Population census; monitoring of abundance, trends, demographics | DFO, NOAA, TBD | Ongoing |
| c) Deploy remote acoustic monitoring packages | R2 | H | Seasonal occurrence in key areas | DFO, TBD | Ongoing |
| d ) Field sampling research | P1; R2; R4; M4 | H | Identify foraging ecology, diet; potential impacts of prey limitation | DFO, ENGOs, Universities, NOAA, TBD | 1 year |
| e) Collect tissue samples from offshore killer whales and potential prey species | P1; D1; R2; R3; R4; M2; M4; M5 | M | Pathogen and pollutant profiles; potential prey species | DFO, NOAA, ENGOs, TBD | Opportunistic collections<br>Will complement 8d |
| ***Monitoring & Assessment*** | | | | | |

| Action | Obj. | Priority | Threats or concerns addressed | Participating Agencies[7] | Timeline |
|---|---|---|---|---|---|
| 9. Support efforts to monitor the distribution and occurrence of killer whales in B.C. to support research efforts | D1; R2; M5 | H | Distribution; occurrence; support for research; outreach and education | DFO, B.C.CSN, VAMSC, Straitwatch, WWOANW | Ongoing |
| 10. Conduct ongoing assessments of vulnerability to identified threats | | | | | |
| a) Evaluate need for risk assessment models | P1; D1; R3; M1; M2; M3; M4 | LM | Determine risk factors for spills, vessel strikes, entanglement, pollutants, prey limitation; potential impacts to habitat & individuals | DFO, EC, DND, TC, Industry, TBD | 4 years |
| b) Investigate increased risk associated with lifting of moratorium on offshore fossil fuel extraction | D1; R3; M1; M2; M3; M4 | M | Determine associated risk of oil spills; seismic and vessel noise; displacement from habitat | DFO, B.C. Prov | 3 years |
| c) Assess likelihood of prey limitation impacts | P1; D1; R2; M4 | H | Population level impacts resulting from changes to ecosystem dynamics | DFO, Fisheries industry | 3 years, this action is contingent upon results from 8d & 8e |
| 11. Clarify extent of threats to the population | | | | | |
| a) Perform necropsy analysis of carcasses, when feasible | R2; R3 | H | Determination of pathogen and chemical loads; general biology, physiology | DFO, MAFF, TBD | Opportunistic. May assist efforts in 8e |
| b) Assess potential for fisheries interactions | P1;D1; R3; M4 | M | Depredation; entanglement; competition for resources | TBD | 3 years, may be contingent on results from 8d & 8e |
| c) Evaluate the feasibility of conducting assessments of biological pollution sources | R3; M2; M4 | L | Exposure to biological pollutants ; contamination of habitat | EC, B.C. Prov | 5 years, may be carried out with 4b |

| Action | Obj. | Priority | Threats or concerns addressed | Participating Agencies[7] | Timeline |
|---|---|---|---|---|---|
| ***Outreach & Communication*** | | | | | |
| 12. Foster communication networks | | | | | |
| a) Pro-actively build intra- & inter-agency communication networks | M1; M2; M4; M5 | H | Effective communication; catastrophic spill response | DFO, EC, CCG, B.C. Prov, Municipalities, ENGOs, NOAA, TBD | Immediate<br>Will support 4a |
| b) Promotion of BWW guidelines | M3; M4; M5 | M | Mitigate physical & chronic acoustic disturbance; outreach; communication | DFO, VAMSC, B.C.CSN, WWOANW, Straitwatch, ENGOs | 3 years |
| c) Trans-boundary, inter-jurisdictional collaboration | All | H | Data sharing; foster collaborative programs | DFO NOAA, FN, ENGOs, WWOANW, TBD | Immediate<br>Will assist & support all actions |

# 4. ASSOCIATED PLANS

The following are recovery plans which identify similar threats to marine mammals at-risk, and contain similar recommendations for mitigation of threats or potential research activities identified in this Management Plan for Offshore Killer Whales in Canada. Implementation of actions listed in this (in Section 2.3), and the recovery plans listed below (e.g. DFO 2006; DFO 2007; DFO 2007b; DFO 2008; DFO 2008a,b,c) will provide a multi-species and multi-jurisdictional approach to conservation of marine mammals on the west coast of North America.

- Management plan for the Pacific harbour porpoise (*Phocoena phocoena*) in Canada [Proposed]
- Management plan for the northeastern Pacific grey whale (*Eschrichtius robustus*) in Canadian Pacific Waters. [Draft]
- Management plan for the Steller sea lion (*Eumetopias jubatus*) in Canada [Draft]
- Recovery Strategy for the Transient Killer Whale (*Orcinus orca*) in Canada [Final]
- Recovery Strategy for the Northern and Southern Resident Killer Whale (*Orcinus orca*) in Canada [Final]
- Recovery Strategy for the Sea Otter (*Enhydra lutris*) in Canada [Final]
- Action Plan for Blue, Fin and Sei Whales (*Balaenoptera musculus, B. physalus* and *B. borealis*) in Pacific Canadian Waters [Draft]

# 5. REFERENCES

Andrew R.K., B.M. Howe, J.A. Mercer and M.A. Dzieciuch. 2002. Ocean ambient sound: Comparing the 1960's with the 1990's for a receiver off the California coast. J. Acous. Soc. Am. 3(2): 65-70.

Bain D.E. 1994. Killer whales (*Orcinus orca*) in Barnes Lake, Alaska: a preliminary report. Available from http://whale.wheelock.edu/archives/whalenet95/0056.html Accessed 30 August 2007.

Baird R.W. 2001. Status of killer whales, *Orcinus orca*, in Canada. Can. Field. Nat. 115(4):676-701.

Barlow J. and R. Gisiner. 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. J. Cetacean Res. Man. 7(3): 239-279.

Barrett-Lennard L.G. 2000. Population structure and mating patterns of killer whales (*Orcinus orca*), as revealed by DNA analysis. (PhD. thesis). University of British Columbia: Vancouver. 97p.+xi.

Barrett-Lennard L.G. and G.M. Ellis 2001. Population structure and genetic variability in northeastern Pacific killer whales: towards an assessment of population viability. DFO Can. Sci. Adv. Sec. Res. Doc. 2001/065.

Barrett-Lennard L.G., J.K.B. Ford and K. Heise. 1996. The mixed blessing of echolocation: differences in sonar use by fish-eating and mammal-eating killer whales. Animal Behav. 51: 553-565.

Bigg M.A., G.M. Ellis, J.K.B. Ford and K.C. Balcomb. 1987. Killer whales: a study of their identification, genealogy, and natural history in British Columbia and Washington State. Phantom Press: Nanaimo, B.

Bigg M.A., P.F. Olesiuk, G.M. Ellis, J.K.B. Ford and K. C. Balcomb. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Comm. Special Issue 12: 383-405.

Black N.A., A. Schulman-Janiger, R.L. Ternullo and M. Guerrero-Ruiz. 1997. Killer whales of California and western Mexico: a catalog of photo-identified individuals. . National Oceanic and Atmospheric Administration, National Marine Fisheries Service. U.S. Department of Commerce: Seattle, WA.

Buck E. and K. Calvert. 2005. Active military sonar and marine mammals: events and references. Congressional research science: Library of Congress. 17p.

B.C. Conservation Data Centre [CDC]. 2007. B.C. Species and Ecosystems Explorer. B.C. Min. of Environ: Victoria, B.C.. Available from http://srmapps.gov.bc.ca/apps/eswp/ Accessed 17 August 2007.

Christensen J.R., M. MacDuffee, R.W. Macdonald, M. Whiticar and P.S. Ross. 2005. Persistent organic pollutants in British Columbia grizzly bears: consequence of divergent diets. Environ. Sci. Technol. 39 (18): 6952–6960.

Conrad P.A., M.A. Miller, C. Kreuder, E.R. James, J. Mazet, H. Dabritz, D.A. Jessup, F. Gulland and M.E. Grigg. 2005. Transmission of *Toxoplasma*: Clues from the study of sea otters as sentinels of *Toxoplasma gondii* flow into the marine environment. Int. J. for Parasitol. 35: 1155-1168.

Committee on the Status of Endangered Wildlife in Canada [COSEWIC]. 2002. COSEWIC species database: whale, killer. Available from http://www.cosewic.gc.ca/eng/sct1/searchdetail_e.cfm Accessed October 04 2007.

Crum, L.A. and Y. Mao. 1996. Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. J. Acous. Soc. Am. 99: 2898-2907.

Dahlheim M.E. and J.E. Heyning. 1999. Killer whale *Orcinus orca* (Linnaeus, 1758). *in* S. Ridgway and R. Harrison (eds). Handbook of marine mammals. volume 6. Academic Press: San Diego, CA.

Deecke V.B., J.K.B. Ford and P.J.B. Slater. 2005. The vocal behaviour of mammal-eating killer whales: communicating with costly calls. Animal Behav. 69:395-405.

Department of National Defense [DND]. 2007. Maritime command order: marine mammal mitigation procedures [MARCORD]. unpublished. 46-13 (3A). 10p.

Fisheries and Oceans Canada [DFO]. 2005. Statement of Canadian practice on the mitigation of seismic noise in the marine environment (Draft). Fisheries & Oceans Canada: Ottawa.

DFO. 2006. Recovery Strategy for the Blue, Fin and Sei whales (*Balaenoptera musculus, B. physalus, and B. borealis*) in Pacific Canadian waters. *In* Species at Risk Act Recovery Strategy Series. Vancouver: Fisheries & Oceans Canada. vii + 53pp.

DFO. 2007. Recovery strategy for the transient killer whale (*Orcinus orca*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries & Oceans Canada, Vancouver. vi + 46pp.

DFO. 2007a. Fisheries Management – Pacific Region. http://www.pac.dfo-mpo.gc.ca/ops/fm/fishmgmt_e.htm. Accessed 07 September 2007.

DFO. 2007b. Recovery strategy for the sea otter (*Enhydra lutris*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries & Oceans Canada, Vancouver. vii + 56pp.

DFO. 2008. Recovery strategy for the northern and southern resident killer whales (*Orcinus orca*) in Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries & Oceans Canada, Ottawa. ix + 81pp.

DFO. 2008a. Management plan for the eastern Pacific grey whale (*Eschrichtius robustus*) in Canada [Draft]. *Species at Risk Act* Management Plan Series. Fisheries and Oceans Canada, Nanaimo. ix + 51pp.

DFO. 2008b. Management plan for the Steller sea lion (*Eumetopias jubatus*) in Canada [Draft].*Species at Risk Act* Management Plan Series. Fisheries and Oceans Canada, Nanaimo. V + 68pp.

DFO. 2008c. Management plan for the Pacific harbour porpoise (*Phocoena phocoena*) in Canada [Proposed]. *Species at Risk Act* Management Plan Series. Fisheries and Oceans Canada, Nanaimo. iv + 50pp.

Environment Canada [EC]. 2006. Species at risk: northeast Pacific offshore population.Available from http://www.speciesatrisk.gc.ca/search/speciesDetails_e.cfm?SpeciesID=700 Accessed 16 August 2007.

EC. 2007. DRAFT Guidelines on identifying and mitigating threats to species at risk. Government of Canada, Ottawa.

Elliott J.E., L.K. Wilson and B. Wakeford. 2005. Polybrominated diphenyl ether trends in eggs of marine and freshwater birds from British Columbia, Canada, 1979–2002. Environ. Sci. Technol. 39(15): 5584–5591.

Erbe C. 2002. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Mar. Mamm. Sci. 18:394-418.

Fernández A., M. Arbelo, M.R. Deaville, I.A.P. Patterson, P. Castro, J.R. Baker, E. Degollada, H. M. Ross, P. Herráez, A.M. Pocknell, F. Rodríguez, F.E. Howie, A. Espinosa, R.J. Reid, J. R. Jaber, V. Martin, A.A. Cunninghan and P.D. Jepson. 2004. Pathology: Beaked whales, sonar and decompression sickness (reply). Nature 428: 1038.

Ford J. K. B. 1989. Acoustic behaviour of resident killer whales (*Orcinus orca*) off Vancouver Island, British Columbia. Can. J. Zool. vol 67(3): 727-745.

Ford J. K. B. 1991. Vocal traditions among resident killer whales (*Orcinus orca*), in coastal waters of British Columbia, Canada. Can. J. Zool. 69: 1454-1483.

Ford J.K.B. and G.M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. Mar. Ecol. Prog. Ser. 316: 185-199.

Ford, J.K.B., G.M. Ellis and K.C. Balcomb. 2000. Killer Whales: the natural history and genealogy of *Orcinus orca* in British Columbia and Washington (second edition). UBC Press: Vancouver, B.C.. 104p.

Ford J.K.B., G.M. Ellis and L.M. Nichol 1992. Killer whales of the Queen Charlotte Islands: a preliminary study of the abundance, distribution and population identity of *Orcinus orca* in the water of Haida Gwaii. Prepared for South Moresby/Gwaii Haanas National Park Reserve, Canadian Parks Service. By: the Vancouver Aquarium. 26p+.

Ford J.K.B., G.M. Ellis, L.G. Barrett-Lennard, A.B. Morton, R.C. Palm and K.C. Balcomb 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Can. J. Zool. 76 (8): 1456-1471.

Ford J.K.B., G.M. Ellis and P.F. Olesiuk 2005. Linking prey and population dynamics: did food limitation cause recent declines in of resident killer whales (*Orcinus orca*) in British Columbia? DFO Can. Sci. Adv. Sec. Res. Doc. 2005/042.

Francis, R.C., S.R. Hare, A.B. Hollowed and W.S. Wooster. 1998. Effects of interdecadal climate variability on the oceanic ecosystems of the northeast Pacific. Fish. Oceanogr. 7(1): 1-21.

Fromm D.M. 2006. Acoustic analysis for the Haro Strait on 5 May 2003 (abstract). J. Acous. Soc. Am. 119 (5): 3404.

Garrett, C. and P.S. Ross. in press. Resident killer whale Recovery Planning Technical Workshop: Environmental contaminant source scoping document. Can. Tech. Rep. Fish and Aquat Sci. 58 pp.

Gaydos, J.K., K.C. Balcomb, R.W. Osborne and L. Dierauf. 2004. Evaluating potential infectious disease threats for southern resident killer whales, *Orcinus orca*: a model for endangered species. Biol. Conserv. 117: 253-262.

Graham, G. 2004. Expert systems for marine oil spill response operations. In: 2003 GeorgiaBasin/Puget Sound Research Conference Proceedings. Droscher T.W., Fraser, D.A. (eds). Puget Sound Action Team: Olympia, WA.

Grant S.C.H and P.S. Ross. 2002. Southern resident killer whales at risk: toxic chemicals in the B.C. and Washington environment. DFO Can. Tech. Rep. Fish. Aquat. Sci. 2412: xii + 111p.

Guinet C. and J. Bouvier. 1995. Development of intentional stranding hunting techniques in killer whale (*Orcinus orca*) calves at Crozet Archipelago. Can. J. Zool. 73:27-33.

Guimaraes, P.R., M. Argollo de Menezes, R. Baird, D. Lusseau, P. Guimaraes and S. F. dos Reis. 2007. Vulnerability of a killer whale social network to disease outbreaks. Phys. Rev. E 76:

Hall, A.J., O.I. Kalantzi and G.O. Thomas. 2003. Polybrominated diphenyl ethers (PBDEs) in grey seals during the first year of life – are they thyroid hormone endocrine disrupters? Environ. Poll. 126: 29-37.

Hare, Sr. and N.J. Mantua. 2000. Empirical evidence for north Pacific regime shifts in 1977 and 1989. Prog. Oceanogr. 47(2-4): 103-145.

Heise K., L.G. Barrett-Lennard, E. Saulitis, C. Matkin and D. Bain. 2003. Examining the evidence for killer whale predation on Stellar sea lions in British Columbia and Alaska. Aquat. Mamm. 29: 325-334.

Herman D.P., D.G. Burrows, J.W. Durban, C.O. Matkin, R.G. LeDuc, L.G. Barrett-Lennard and M.M. Krahn. 2005. Feeding ecology of eastern north Pacific killer whales (*Orcinus orca*) from fatty acid, stable isotope, and organochlorine analyses of blubber biopsies. Mar. Ecol. Prog. Ser. 302: 275-301.

Hickie B.E., P.S. Ross, R.W. MacDonald and J.K.B. Ford. 2007. Killer whales (*Orcinus orca*) face protracted health risks associated with lifetime exposure to PCBs. Environ. Sci. Technol. 41: 6613-6619.

Hoelzel A.R. 1991. Killer whale predation on marine mammals at Punta Norte, Argentina: food sharing, provisioning, and foraging strategy. Behav. Ecol. Sociobiol. 29:197-204.

Hooper, K. and T.A. McDonald. 2000. The PBDEs: an emerging environmental challenges and another reason for breast-milk monitoring programs. Environ. Health Perspect. 108: 387-392.

Jepson P.D., M. Arbelo, R. Deaville, I.A. Patterson, P. Castro, J.R. Baker, E. Degollada, H.M. Ross, P. Herraez, A.M. Pocknell, F. Rodriguez, F. Howiell, A. Espinosa, R.J. Reid, R. Jaber, V. Martin, A. Cunningham and A. Fernandez. 2003. Gas-bubble lesions in stranded cetaceans: was sonar responsible for a spate of whale deaths after an Atlantic military exercise? Nature. 425: 575.

Jones I.M. 2006. A Northeast Pacific offshore killer whale (*Orcinus orca*) feeding on a Pacific halibut (*Hippoglossus stenolepis*). Mar. Mamm. Sci. 22(1): 198-200.

Kannan, K., J. Koistinen, K. Beckmen, T. Evans, J.F. Gorzelany, K.J. Hansen, P.D. Jones, E. Helle, M. Nyman and J.P. Giesy. 2001. Accumulation of perfluorooctane sulfonate in marine mammals. Environ. Sci. Technol. 35: 1593-1598.

Krahn M.M., D.P. Herman, C.O. Matkin, J.W. Durban, L. Barrett-Lennard, D.G. Burrows, M.E. Dahlheim, N. Black, R.G. LeDuc and P.R. Wade. 2007. Use of chemical tracers in assessing the diet and foraging regions of eastern North Pacific killer whales. Mar. Env. Res. 63(2): 91-114.

Lawson J. and I. McQuinn 2004. Review of the potential hydrophysical-related issues in Canada, risks to marine mammals, and monitoring and mitigation strategies for seismic activities. DFO Can. Sci. Adv. Sec. Res. Doc. 2004/121.

Lindstrom, G., H. Wingfors, M.Dam, and B. von Bavel. 1999. Identification of 19 polybrominated diphenyl ethers (PBDEs) in long-finned pilot whale (*Globicephala melas*) from the Atlantic. Archives of Environ. Contam. Toxicol. 36: 355-363.

Macdonald R.W., T. Harner and J. Fyfe. 2005. Recent climate change in the Arctic and its impact on contaminant pathways and interpretation of temporal trend data. Sci. Total Env. 342: 5-86.

Matkin C.O., E. L. Saulitis, G. M. Ellis, P. Olesiuk and S.D. Rice. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. Mar. Ecol. Prog. Ser. 356: 269-281.

Matkin C.O., L.G. Barrett-Lennard, H. Yurk, D. Ellifrit and A.W. Trites 2007. Ecotypic variation and predatory behaviour among killer whales (*Orcinus orca*) off the eastern Aleutian Islands, Alaska. Fish. Bull. 105(1):74–87.

Matkin, C.O., G. M. Ellis, E. L. Saulitis, L. G. Barrett-Lennard, and D. R. Matkin. 1999. Killer whales of southern Alaska. North Gulf Oceanic Society: Homer, AK.

Morton, A.B. and H.K. Symonds. 2002. Displacement of *Orcinus orca (L.)* by high amplitude sound in British Columbia, Canada. ICES J. Mar. Sci. 59: 71-80.

Nieukirk S.L., K.M. Stafford, D.K. Mellinger, R.P. Dziak and C.G. Fox. 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. J. Acous. Soc. Am. 115(4): 1833-1843.

O'Hara P.D. and K.H. Morgan. 2006. Do low rates of oiled carcass recovery in beached bird surveys indicate low rates of ship-source oil spills? Mar. Ornithol. 34:133-140.

Olesiuk P.F., M.A. Bigg and G.M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Comm. Special Issue 12: 209-243.

Pitman R.L. and P. Ensor. 2003. Three forms of killer whales (*Orcinus orca*) in Antarctic waters. J. Cetacean. Res. Man. 5(2): 131-139.

Raverty, S., M. B. Hanson, B. Huggins, J. Calambokidis, A. Hall, D. Lamborn, S. Norman, J. Gaydos, G. Ellis, and J. K. B. Ford. 2007. Multi-species outbreak of Cryptococcosis (*Cryptococcus gatti*) in stranded harbor, Dall's porpoises and a Pacific white sided dolphin in the northeastern Pacific. *in* Society of Marine Mammalogy Biennial Conference. Preconference Workshop:Conservation Medicine on Marine Mammals., Cape Town.

Rayne S., M. G. Ikonomou, P.S. Ross, G.M. Ellis and L. G. Barrett-Lennard. 2004. PBDEs, PBBs, and PCNs in three communities of free-ranging killer whales (*Orcinus orca*) from the northeastern Pacific Ocean. Env. Sci. Tech. 38(16): 4293-4299.

Ross P. S. 2006. Fireproof killer whales (*Orcinus orca*): flame-retardant chemicals and the conservation imperative in the charismatic icon of British Columbia, Canada. Can. J. Fish. Aquat. Sci. 63(10): 224-234.

Ross P.S. 2002. The role of immunotoxic environmental contaminants in facilitating the emergence of infectious diseases in marine mammals. Hum. Ecol. Risk Assess. 8(2): 277-292.

Ross P. S., G.M. Ellis, M.G. Ikonomou, L.G. Barrett-Lennard and R. F. Addison. 2000. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: Effects of age, sex and dietary preference. Mar. Poll. Bull. 40(6): 504-515.

Ross P. S., S.J. Jeffries, M.B. Yunker, R.E. Addison, M.G. Ikonomou and J.C. Calambokidis. 2004. Harbour seals (*Phoca vitulina*) in British Columbia, Canada and Washington State, USA, reveal a combination of local and global polychlorinated biphenyl, dioxin and furan signals. Env. Tox. Chem. 23: 157-165.

Saulitis E., C. Matkin, L.G. Barrett-Lennard, K. Heise and G.M. Ellis. 2000. Foraging strategies of sympatric killer whale (*Orcinus orca*) populations in Prince William Sound, Alaska. Mar. Mamm. Sci. 16:94-109.

Schrope M. 2002. Whale deaths caused by U.S. Navy's sonar. Nature. 415: 106.

Sih A., A.M. Bell and J.L. Kerby. 2004. Two stressors are far deadlier than one. Trends Ecol. Evol. 19: 274-276.

Simila T. and F. Ugarte. 1993. Surface and underwater observations of cooperatively feeding killer whales in northern Norway. Can. J. Zool. 71: 1494-1499.

Song L., A. Seeger and J. Santos-Such. 2005. On membrane motor activity and chloride flux in the outer hair cell: lessons learned from the environmental toxin tributyltin. Biophys. Journal 88 (3): 2350-2362.

Van de Vijver K.I., P.T. Hoff, K. Das, W. Van Dongen, E.L. Esmans, T. Jauniaux, J. Bouquegenau, R. Blust and W. de Coen. 2003. Perfluorinated chemicals infiltrate ocean waters: link between exposure levels and stable isotope ratios in marine mammals. Environ. Sci. Tech. 37: 5545-5550.

Visser I. 1999. Benthic foraging on stingrays by killer whales (*Orcinus orca*) in New Zealand waters. Mar. Mamm. Sci. 15(1): 220-227.

Williams R., D. Lusseau and P.S. Hammond. 2006. Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca).* Biol. Conserv. 133: 301-311.

Williams R., D.E. Bain, J.K.B. Ford and A.W. Trites. 2002a. Behavioural response of male killer whales to a 'leapfrogging' vessel. J. Cetacean Res. Manage. 4(3): 305-310.

Williams R., A.W. Trites and D.E. Bain 2002b. Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: opportunistic observations and experimental approaches. J. Zool. Lond. 256: 255-270.

Yamada, T.K., Y. Uni, M. Amano, J. Brownell, R.L., H. Sato, E. Ishikawa, I. Ezaki, K. Sasamori, T. Takahashi, Y. Masuda, T. Yoshida, Y. Tajima, M. Makara, K. Arai, T. Kakuda, A. Hayano, E. Sone, S. Nishida, H. Koike, A. Yatabe, T. Kubodera, Y. Omata, Y. Umeshita, M. Watarai, M. Tachibana, M. Sasaki, K. Murata, Y. Sakai, M. Asakawa, K. Miyoshi, S. Mihara, Y. Anan, T. Ikemoto, N. Kajiwara, T. Kunisue, S. Kamikawa, Y. Ochi, S. Yano and S. Tanabe. 2007. Biological indices obtained from a pod of killer whales entrapped by sea ice off northern Japan. pg. 15. Scientific Committee, International Whaling Commission, Anchorage.

# APPENDIX I. TERMINOLOGY – THREAT ASSESSMENT & PBT CHEMICALS

**Table 5.** Details on terms used for assessment of threats to the northeast Pacific offshore killer whale population. Terms were obtained from the Environment Canada 'Guideline for identifying and mitigating threats to species at risk' (EC 2006).

| TERMS | RATING | DEFINITIONS |
|---|---|---|
| Uncertainty | Low | Effect of threat is *causally linked* with decreased population viability and likely will result in failure to meet management plan objectives |
| | Medium | Effect of threat is *correlated* with decreased population viability and negatively impacts management plan objectives |
| | High | Negative effect of threat on population viability and/or management plan objectives is *assumed* or is plausible |
| Severity | Negligible | Threat has no detectable effects on the population |
| | Low | Effects of threat are sublethal, potentially leading to short-term behavioural changes |
| | Moderate | Effects of the threat result in chronic physiological and/or behavioural changes (e.g. potential for long-term displacement from habitat) |
| | High | Effects of the threat are lethal |
| | Unknown | Available information is insufficient to gauge the degree to which the threat may affect the population viability |
| Mitigation Potential | Low | Implementation of measures to mitigate or prevent impacts on population viability, are not practical, or are likely to be unsuccessful. |
| | Moderate | Implementation of measures to mitigate or prevent impacts on population viability are feasible, and are likely to be somewhat successful |
| | High | Implementation of measures to mitigate or prevent impacts on population viability are currently in place and future measures are likely to be very easy to implement, and are likely to be very successful |
| | Unknown | Available information is insufficient to gauge whether mitigation of effects from the threat is possible |

**Table 6.** Persistent bioaccumulative toxic chemicals (PBTs) that may pose a risk to offshore killer whales. This table was obtained from the final Recovery Strategy for Northern and Southern Resident Killer Whales (DFO 2008).

| Pollutant | Use/Source | Persistent | Bio-accumulate | Risk |
|---|---|---|---|---|
| DDT<br>*Dichlorodi-phenyl trichloroethane* | pesticide used in some countries, banned in North America, persists in terrestrial runoff 30 years post-ban, enters atmosphere from areas where still in use | yes | yes | reproductive impairment, immunosuppression, adrenal and thyroid effects |
| PCBs<br>*Polychlorinated Biphenyls* | electrical transformer and capacitor fluid, limited use in North America but enters environment from runoff, spills and incineration | yes | yes | reproductive impairment, skeletal abnormalities, immunotoxicity and endocrine disruption |
| Dioxins and Furans | by-product of chlorine bleaching, wood product processing and incomplete combustion. Mills less of a source now. Current sources include burning of salt-laden wood, municipal incinerators, and residential wood and wood waste combustion, in runoff from sewage sludge, wood treatment | yes | yes | thymus and liver damage, birth defects, reproductive impairment, endocrine disruption, immunotoxicity and cancer |
| PAHs<br>*Persistent Polycyclic aromatic hydrocarbons* | by-product of fuel combustion, aluminum smelting, wood treatment, oil spills, metallurgical and coking plants, pulp and paper mills | yes | no | carcinogenic |
| flame retardants, esp. PBBs and PBDEs<br>*Polybrominated diphenyl ethers* | flame retardants; in electrical components and backings of televisions and computers, in textiles and vehicle seats, ubiquitous in environment. 2/3 product PBDEs banned in Europe. Same two products withdrawn from North American marketplace in 2005, but one (deca) product still used globally | yes | yes | endocrine disruption, impairs liver and thyroid |
| PFOs<br>*Perfluro-octane sulfonate* | stain, water and oil repellent (included in Scotchgard until recently), fire fighting foam, fire retardants, insecticides and refrigerants, ubiquitous in environment | yes | yes but in blood, liver, kidney and muscle | promotes tumour growth |
| TBT, DBT<br>*Tributyltin*<br>*Dibutyltin* | antifoulant pesticide used on vessels | yes | yes | unknown but recently associated with hearing loss |
| PCPs<br>*(Polychlorinated paraffins*) | flame retardants, plasticizers, paints, sealants and additives in lubricating oils | yes | yes | endocrine disruption |
| PCNs<br>*Polychlorinated napthalenes* | ship insulation, electrical wires and capacitors, engine oil additive, municipal waste incineration and chlor-alkali plants, contaminant in PCBs | yes | yes | endocrine disruption |
| APEs<br>Alkyl-phenol ethoxylates | detergents, shampoos, paints, pesticides, plastics, pulp and paper mills, textile industry found in sewage effluent and sediments | moderate | moderate | endocrine disruption |
| PCTs<br>*Polychlorinated terphenyls* | fire retardants, plasticizers, lubricants, inks and sealants, enters environment in runoff | yes | yes | endocrine disruption and reproductive impairment |

*References: Primarily Grant and Ross 2002, but also Lindstrom et al. 1999, Hooper and MacDonald 2000, Kannan et al. 2001, Hall et al. 2003; Van de Vijver et al. 2003, Rayne et al. 2004, Song et al. 2005.*

# APPENDIX II. ORGANIZATIONS CURRENTLY INVOLVED IN RESEARCH ON OFFSHORE KILLER WHALES

Organizations and independent researchers currently involved in research on northeastern Pacific offshore killer whales.

- Fisheries & Oceans Canada - Science Branch, and the Marine Mammal Incident Response Program, Nanaimo, B.C.
- U.S. National Oceanic & Atmospheric Administration, Seattle, WA
- B.C. Ministry of Agriculture, Food & Fisheries, Abbotsford, B.C.
- Cetacean Research Lab, Vancouver Aquarium, Vancouver, B.C.
- B.C. Cetacean Sightings Network, Vancouver Aquarium, Vancouver, B.C.
- Juan de Fuca Express, Victoria, B.C.
- Cascadia Research Collective, Friday Harbor, WA

# APPENDIX III. RECORD OF COOPERATION & CONSULTATION

Offshore killer whales are listed as a species of 'special concern' on Schedule 1 of the *Species at Risk Act* (SARA). As an aquatic species, offshore killer whales fall under federal jurisdiction, and are managed by Fisheries and Oceans Canada (DFO) 200 - 401 Burrard Street, Vancouver, B.C., V6C 3S4.

There are few people in Canada, or elsewhere, with the scientific, technical, traditional or local knowledge of offshore killer whales. As a result, DFO brought together a small internal working group of technical experts in science and management to develop an initial draft of this management plan.

A Cetacean Management Planning Technical Workshop was hosted in November of 2007 to provide a forum for the sharing of knowledge and expertise on a number of 'special concern' cetaceans for which management plans were developed. A group of scientific and technical experts including independent researchers, environmental non-governmental organizations, and other governmental (federal and provincial) staff from both Canada and the United States were contacted to attend this workshop. An invitation letter was sent to all coastal First Nations soliciting their participation in the workshop. This workshop was invaluable in assisting the DFO internal working group in drafting the Management Plan for Offshore Killer Whales in Canada. Given that the population of killer whales considered in this management plan frequent both Canadian and United States (U.S.) waters, bilateral government and non-government input and collaboration was sought.

A draft version of the management plan was posted to the DFO Pacific Region website for public comment period from April 7 to May 12, 2008. These consultations were web-based, but also included mail-outs to all coastal First Nations. An initial draft (April 2008) of the management plan, a discussion guide and feedback form were made available. In addition, a message announcing the development of the management plan was sent to a marine mammal list serve (MARMAM) with a broad local and international distribution to marine mammal researchers and interested parties, and to a distribution list of whale-related contacts provided to DFO in recent years from environmental groups, non-governmental organizations, government agencies, and the eco-tourism sector.

Comments on the management plan were received from six independent sources and from two government agencies: Environment Canada and the Province of B.C.. Processes for coordination and consultation between the federal and British Columbian governments on management and protection of species at risk are outlined in the *Canada-B.C. Agreement on Species at Risk* (2005). Natural Resources Canada, Department of National Defence, Parks Canada and Transport Canada provided no comments on the draft document. No First Nations responded to consultation letters.

Feedback from the public, government agencies and scientific experts has been carefully considered in the production of the final management plan. Peer review of the document was not considered necessary as applicable experts were in attendance at the Cetacean Management Planning Technical Workshop and were provided an opportunity to provide input through public consultation.

DFO Internal Technical Team for Offshore Killer Whales


Marilyn Joyce — Recovery Lead / Marine Mammal Coordinator
Fisheries & Oceans Canada
Suite 200-401 Burrard Street,
Vancouver, B.C. V6C 3S4.
phone: (604) 666-9965, email: Marilyn.Joyce@dfo-mpo.gc.ca

John Ford — Marine Mammal Scientist
Fisheries & Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd
Nanaimo, B.C. V9T 6N7.
phone: (250) 729-8375, email: John.K.Ford@dfo-mpo.gc.ca

Graeme Ellis — Marine Mammal Scientist
Fisheries & Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd
Nanaimo, B.C. V9T 6N7
phone: (250) 756-7245, email: Graeme.Ellis@dfo-mpo.gc.ca

Peter Olesiuk — Marine Mammal Scientist
Fisheries & Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd
Nanaimo, B.C. V9T 6N7
phone: (250) 756-7254, email: Peter.Olesiuk@dfo-mpo.gc.ca

Jake Schweigert — Section Head, Conservation Biology
Fisheries & Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd
Nanaimo, B.C. V9T 6N7
phone: (250) 756-7203, email: Jake.Schweigert@dfo-mpo.gc.ca

Peter Ross — Research Scientist
Fisheries & Oceans Canada
PO Box 6000, 9860 West Saanich Road
Sidney, B.C. V8L 4B2
phone: (250) 363-6806, email: Peter.S.Ross@dfo-mpo.gc.ca

Larry Paike — Conservation & Protection Supervisor
Fisheries & Oceans Canada
4250 Commerce Circle
Victoria, B.C. V8Z 4M2
phone: (250) 363-3252, email: Larry.Paike@dfo-mpo.gc.ca

Tatiana Lee — Marine Mammal Recovery Planner
Fisheries & Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd
Nanaimo, B.C. V9T 6N7
phone: (250) 756-7050, email: Tatiana.Lee@dfo-mpo.gc.ca

Joy Hillier — Senior Habitat Management Biologist
Fisheries & Oceans Canada
417 - 2nd Avenue West
Prince Rupert, B.C. V8J 1G8
phone: (250) 627-3449, email: Joy.Hillier@dfo-mpo.gc.ca

Jeff Grout — Salmon Coordinator
Fisheries & Oceans Canada
Suite 200-401 Burrard Street,
Vancouver, B.C. V6C 3S4.
phone: (604) 666-9965, email: Jeff.Grout@dfo-mpo.gc.ca

Linda Nichol — Marine Mammal Biologist
Fisheries & Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd
Nanaimo, B.C. V9T 6N7
phone: (250) 729-8374, email: Linda.Nichol@dfo-mpo.gc.ca

Robin Abernethy — Marine Mammal Research Technician
Fisheries & Oceans Canada
Pacific Biological Station
3190 Hammond Bay Rd
Nanaimo, B.C. V9T 6N7
phone: (250) 756-7201, email: Robin.Abernethy@dfo-mpo.gc.ca

Resource Personnel:

Annely Greene — Marine Mammal Program Manager
Fisheries & Oceans Canada
Suite 200-401 Burrard Street,
Vancouver, B.C. V6C 3S4.
phone: (604) 666-0071, email: Annely.Greene@dfo-mpo.gc.ca

Diane Lake — Communications Advisor
Fisheries & Oceans Canada
Suite 200-401 Burrard Street,
Vancouver, B.C. V6C 3S4.
phone: (604) 666-0939, email: Diane.Lake@dfo-mpo.gc.ca

Louvi Nurse — First Nations/SARA Coordinator
Fisheries & Oceans Canada
Suite 200-401 Burrard Street,
Vancouver, B.C. V6C 3S4.
phone: (604) 666-4565, email: Louvi.Nurse@dfo-mpo.gc.ca

Carole Eros SARA Recovery Plan Coordinator
Fisheries & Oceans Canada
Suite 200-401 Burrard Street,
Vancouver, B.C. V6C 3S4.
phone: (604) 666-3610, email: Carole.Eros@dfo-mpo.gc.ca

Cetacean Management Planning Technical Workshop Participants:

| | |
|---|---|
| Alana Phillips | Vancouver Aquarium Marine Science Centre, B.C. Cetacean Sightings Network |
| Anna Hall | University of British Columbia |
| Andy Webster | Ahousaht First Nation |
| Annely Greene | Fisheries & Oceans Canada, Fisheries & Aquaculture Management |
| Brian Gisborne | Independent Researcher |
| Carole Eros | Fisheries & Oceans Canada, Fisheries & Aquaculture Management |
| Charlie Short | Province of B.C. |
| Darrell Campbell | Ahousaht First Nation |
| Diane Lake | Fisheries & Oceans Canada, Communications |
| Edward Trippel | Fisheries & Oceans Canada - Maritime Region, Science |
| Graeme Ellis | Fisheries & Oceans Canada– Pacific Region, Science |
| Heather Holmes | Parks Canada Agency |
| Jake Schweigert | Fisheries & Oceans Canada – Pacific Region, Science |
| Jim Darling | West Coast Whale Foundation |
| Jeff Grout | Fisheries & Oceans Canada, Fisheries & Aquaculture Management |
| John Calambokidis | Cascadia Research Collective |
| John Durban | National Oceanic & Atmospheric Administration |
| John Ford | Fisheries & Oceans Canada– Pacific Region, Science |
| John Scordino | Makah Tribal Council |
| John Titian | Ahousaht First Nation |
| Joy Hillier | Fisheries & Oceans Canada– Pacific Region, Habitat |
| Kathy Heise | University of British Columbia |
| Katie Beach | Nuu-chah-nulth Tribal Council |
| Lance Barrett-Lennard | Vancouver Aquarium Marine Science Centre |
| Larry Paike | Fisheries & Oceans Canada, Conservation & Protection |
| Linda Nichol | Fisheries & Oceans Canada– Pacific Region, Science |
| Louvi Nurse | Fisheries & Oceans Canada, Treaty & Aboriginal Policy |
| Lynne Barre | National Oceanic & Atmospheric Administration |
| Marilyn Joyce | Fisheries & Oceans Canada, Fisheries & Aquaculture Management |
| Pat Gearin | National Oceanic & Atmospheric Administration |
| Peter Olesiuk | Fisheries & Oceans Canada– Pacific Region, Science |
| Peter Ross | Fisheries & Oceans Canada– Pacific Region, Science |
| Rob Williams | Vancouver Aquarium Marine Science Centre |
| Robin Abernethy | Fisheries & Oceans Canada – Pacific Region, Science |
| Steven Raverty | Ministry of Agriculture, Food & Fisheries, Animal Health |
| Tatiana Lee | Fisheries & Oceans Canada, Fisheries & Aquaculture Management |
| Volker Deecke | University of British Columbia |
| Wendy Szaniszlo | Independent Researcher |