***SPECIES AT RISK ACT***
RECOVERY STRATEGY SERIES

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

## Transient Killer Whale

December 2007

Fisheries and Oceans Canada
Pêches et Océans Canada

Canada

# About the *Species at Risk Act* Recovery Strategy 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 provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

## What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

## What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency, and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (http://www.sararegistry.gc.ca/the_act/) outline both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

## What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

## The series

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

## To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/) and the Web site of the Recovery Secretariat (http://www.speciesatrisk.gc.ca/recovery/).

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**December 2007**

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

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# DECLARATION

Fisheries and Oceans Canada has developed its recovery strategy for the transient killer whale as required by the *Species at Risk Act*. This recovery strategy has been prepared in cooperation with jurisdictions responsible for the species, as described in the Preface.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. In the spirit of the Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all Canadians to join Fisheries and Oceans Canada in supporting and implementing this strategy for the benefit of the transient killer whale and Canadian society as a whole. Fisheries and Oceans Canada will support implementation of this strategy to the extent possible, given available resources and its overall responsibility for species at risk conservation. Implementation of the strategy by other participating jurisdictions and organizations is subject to their respective policies, appropriations, priorities, and budgetary constraints.

The goals, objectives and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new information. The Minister of Fisheries and Oceans will report on progress within five years.

This strategy will be complemented by one or more action plans that will provide details on specific recovery measures to be taken to support conservation of the species. The Minister will take steps to ensure that, to the extent possible, Canadians directly affected by these measures will be consulted.

# RESPONSIBLE JURISDICTIONS

The responsible jurisdiction for the transient killer whale is Fisheries and Oceans Canada. The population occurs off the coast of the province of British Columbia and the within areas of that Parks Canada, Environment Canada, the Department of National Defence, Natural Resource Canada and Transport Canada and the province of British Columbia have jurisdiction for activities or a role in supporting transient killer whale recovery. These agencies have all cooperated in the development of this recovery strategy.

# AUTHORS

Kathy Heise was contracted to research and draft the background section of this strategy. The DFO Technical team (see Appendix D) developed the Recovery section, with the contributions of those acknowledged below who participated in a technical workshop.

# ACKNOWLEDGMENTS

Fisheries and Oceans Canada is grateful for the generous contributions of Lance Barrett-Lennard, Volker Deecke, John Durban, Dave Ellifrit, Kathy Heise, Peter Olesiuk, Steven

Raverty, Janice Straley, and Andrew Trites for their contributions through participating in a technical workshop to review this document, consider research needs and evaluate threats.

# STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

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.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats.

This recovery strategy will clearly benefit the environment by promoting the recovery of the transient killer whales. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. Refer to the following sections of the document in particular: Habitat and Biological Requirements, Ecological Role and Limiting Factors.

# RESIDENCE

SARA defines residence as: "*a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*" **[SARA S2(1)]**.

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the SARA public registry: http://www.sararegistry.gc.ca/plans/residence_e.cfm

# PREFACE

The transient population of killer whales are marine mammals and are under the jurisdiction of the federal government. The *Species at Risk Act* (SARA, Section 37) requires the competent minister to prepare recovery strategies for listed extirpated, endangered or threatened species. The transient population of killer whales was listed as threatened under SARA at proclamation on June 5, 2003. Fisheries and Oceans Canada – Pacific Region led the development of this recovery strategy. The strategy meets SARA requirements in terms of content and process (Sections 39-41).

The following includes individuals on the technical team, and others whose feedback was officially sought in the Technical Workshop, but does not include participants in the Stakeholder Recovery Forum or feedback provided at consultations or meetings. The following individuals participated in the Technical Workshop held in January 2007 in Vancouver, B.C.: M. Joyce, A. Greene, J. Ford, P. Ross, P. Olesiuk, K. West, T. Lee, J. Durban, S. Raverty, L. Barrett-Lennard, K. Heise, J. Straley, V. Deecke, D. Ellifrit, A. Trites, and R. Galbraith.

# EXECUTIVE SUMMARY

The 'West Coast transient' population of killer whales (*Orcinus orca*) is acoustically, genetically and culturally distinct from other killer whale populations known to occupy waters off the west coast of British Columbia. This population was designated as 'threatened' by COSEWIC in 2001, and currently numbers approximately 250 animals. Transient killer whales are long-lived upper trophic level predators that are considered to be at risk because of their small population size, their very low reproductive rate (one calf every five years) and their extremely high levels of chemical contaminants that are persistent, bioaccumulative and toxic. Their high contaminant burdens, which have resulted from bioaccumulation in their prey, combined with other anthropogenic threats such as physical and acoustic disturbance, warrant their protection under the *Species at Risk Act*, and they are currently listed as Threatened.

There are significant gaps in our knowledge of transient killer whales, and they are not as well understood as resident killer whales. In part, this is because transients can be very difficult to detect, both visually and acoustically, because of their reliance on stealth when foraging on their acoustically sensitive mammalian prey. In inshore waters they are typically seen in small groups of two to six animals, where they most commonly forage for pinnipeds and small cetaceans. Once prey are alerted to the presence of transients in the area, they generally leave the water or become highly evasive. This may explain why transients travel widely across their range.

The population and social dynamics of transient killer whales are not as well understood as those of residents because transients may disperse from their natal group, and individuals may not be seen for extended periods of time. Their year-round distribution and habitat requirements are also not well understood. These gaps must be addressed before a meaningful numerical target for recovery can be established and before critical habitat can be identified. As such, the long-term goal of this recovery strategy is:

> *To attain long-term viability of the West Coast transient killer whale population by providing the conditions necessary to preserve the population's reproductive potential, genetic variation, and cultural continuity.*

To achieve this goal, interim population and distribution objectives have been established until quantitative objectives can be determined. In addition, recovery objectives to understand and address threats are presented herein. These objectives, established for the next five years and coinciding with the duration of this recovery strategy, will direct the research and recovery activities necessary to achieve the recovery of this population.

*Population Objectives*

- The population size, averaged over the next five years, will remain at or above the current level.
- The number of breeding females in the population, averaged over the next five years, will remain at levels that will provide a neutral or positive growth rate.
- Studies will be undertaken to determine numerical and demographic population objectives that represent long-term viability for this population.

*Distribution Objectives*

- Transient killer whales will continue to utilize their known range.
- Prey will be available, in quantities adequate to support recovery, throughout the currently known range of transient killer whales.
- Studies will be undertaken to determine how the range is utilized at a population and sub-population level.

*Recovery Objectives*

Numerous anthropogenic threats have been identified for transient killer whales. The most pressing threats are: 1) chemical contaminants (both legacy and emerging), and 2) physical and acoustical disturbance (both chronic and acute). However, they are also vulnerable to biological pollutants, trace metals, toxic spills, collision with vessels and the effects of culls on their prey. The first four recovery objectives provide direction for the strategies and approaches that can be used to mitigate and/or eliminate each of the threats facing transient killer whales. The remaining four objectives focus on obtaining information needed to develop a more comprehensive understanding of these threats, which will allow for the refinement of mitigation measures.

- Minimize the exposure to transient killer whales to legacy and emergent pollutants.
- Minimize the risk of prey population reductions from anthropogenic activities, until precise prey needs can be determined.
- Current measures to protect transient killer whales from vessel disturbance will be maintained or modified, if determined necessary from further studies.
- Minimize the exposure of transient killer whales to acute or chronic sound levels in excess of those considered to cause behavioural or physical harm in cetaceans.
- The quantity, quality and distribution of transient killer whale prey necessary to sustain or increase the current population level will be determined.
- A greater understanding of the impacts of contaminants and other biological and non-biological pollutants on transient killer whales will be developed.
- The effects of vessel disturbance on transient killer whales will be evaluated.
- A more comprehensive understanding of the impacts of chronic and acute noise on transient killer whales will be developed.

Strategies are outlined within this recovery strategy to achieve these objectives, many of which are attainable within the next five years. These strategies will also serve to reduce knowledge gaps about transient killer whales and to help identify their critical habitat. Although the transient killer whale population is not expected to achieve high abundances because transients are upper trophic-level predators with a low birth rate, the measures outlined herein will serve to reduce the population's vulnerability to anthropogenic threats and help ensure that it does not decline to an endangered status.

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# 1. BACKGROUND

## 1.1 Species Assessment Information from COSEWIC

| | |
|---|---|
| **Date of Assessment:** | November 2001 |
| **Common Name (population):** | Transient Killer Whale, Orca, West Coast Transient |
| **Scientific Name:** | *Orcinus orca* |
| **COSEWIC Status:** | Threatened |
| **Reason for designation:** | A small population that eats marine mammals. Individuals have high levels of toxic pollutants. |
| **Canadian Occurrence:** | Pacific Ocean |
| **COSEWIC Status History:** | Designated Special Concern in April 1999. Status re-examined and designated Threatened in November 2001. Last assessment based on an existing status report with an addendum. Met criterion for Endangered, D1, but not the definition of Endangered (i.e. not in imminent danger of extinction), therefore designated Threatened. |

## 1.2 Description

Killer whales are the largest members of the dolphin family (Family Delphinidae, Sub-Order Odontoceti, Order Cetacea). Their size, distinctive black and white colouring and tall dorsal fin make them easy to distinguish from other cetaceans. Killer whales are sexually dimorphic. Males are larger and heavier than females, and the dorsal fin of adult males is taller, (averaging 1.8 m in height) than that of females and juveniles of either sex (usually less than 1 m) (Dahlheim and Heyning 1999). Killer whales are relatively easy to recognize individually due to differences in the shape, size and position of the white eye patch and the saddle patch (behind the dorsal fin), as well as variations in the size, shape, and angle of the dorsal fin, and (in many cases) naturally-acquired nicks and scars.

Only a single species is recognized at present, *Orcinus orca*, but variation in the diet, size, colouration, vocalizations and genetic characteristics of different populations of killer whales may lead to a revision of the taxonomy in future years (Dahlheim and Heyning 1999, Ford et al. 2000, Barrett-Lennard and Ellis 2001, Hoelzel et al. 2002, Pitman and Ensor 2003, Reeves et al. 2004). Along the continental shelf and in inshore waters from California to western Alaska, three forms, or ecotypes, are recognized: residents, transients and offshores. These forms rarely, if ever, associate, and differ in their diet and foraging behaviour, vocal behaviour, social structure, genetics and dorsal fin shape (Ford et al. 1998, 2000, Barrett-Lennard and Ellis 2001).

Resident killer whales feed exclusively on fish and cephalopods and travel in acoustically active groups of 10 to 25 or more whales (Ford et al. 2000). Unlike transient killer whales, resident killer whales have an usually stable social structure, with no dispersal of either males or females from their natal matriline (Bigg et al. 1990; Ford et al. 2000).

Transient killer whales feed on marine mammals, particularly harbour seals (*Phoca vitulina*), porpoises and sea lions (Ford et al. 1998). They travel in small, acoustically quiet groups, and generally rely on stealth to find their prey (Morton 1990, Barrett-Lennard et al. 1996, Ford and Ellis 1999). Their dive times are also significantly longer than those for residents (Morton 1990). They are known to attack and kill baleen whales, and although this is observed infrequently in the coastal waters of British Columbia (Ford et al. 2005), groups of transient killer whales may coalesce when attacking and feeding on baleen whales at sea (Barrett-Lennard and Heise 2006). In coastal waters, kills of minke whales by small groups of transients typically involve a strategy of confining the whale in a bay or inlet (Ford et al. 2005).

Offshore killer whales are the least known of the three ecotypes. They were first identified in the late 1980s, and are most often found on the outer part of the continental shelf (Ford et al. 2000) with occasional sightings in inshore waters. They are most often seen in large acoustically active groups of 20 or more animals, and are thought to prey on fish and elasmobranches (Heise et al. 2003, Jones 2006), although they may also take marine mammals (Herman et al. 2005).

## 1.3 Populations and Distribution

### 1.3.1 Global

Killer whales are found in all of the world's major ocean basins, and are estimated to number at least 40,000-60,000 animals (Forney and Wade 2006). The description of resident, transient, and offshore ecotypes can only reliably be applied to killer whale populations in the northeastern Pacific. In other parts of the world, killer whales are not as well studied, and in some areas it is possible that they may prey on both marine mammals and fish.

### 1.3.2 Canadian Pacific

The three distinct ecotypes of killer whales in the northeastern Pacific are further subdivided into at least seven socially, genetically, culturally and acoustically distinct populations. The majority of these populations use both Canadian and US waters, and are recognized by the governments of both countries.

Three putative populations of transient killer whales have been described to date in the northeastern Pacific. These include the so-called *West Coast transients*, distributed from Washington State to southeastern Alaska, the *AT1 transients*, centred in Prince William Sound and Kenai Fjords, Alaska, and the *Gulf of Alaska transients,* usually sighted in waters of the central and western portion of the Gulf of Alaska (Angliss and Outlaw 2005). The AT1 population has declined precipitously in recent years and is believed to comprise only eight individuals, none of which are reproductive females (Saulitis et al. 2005). The Gulf of Alaska transient population numbers at least 314 individuals, and are most reliably seen between southeastern and western Alaska (Angliss and Outlaw 2005). Although the ranges of the AT1 and the Gulf of Alaska populations overlap, they have never been observed interacting.

The West Coast transient population is the only one known to frequent Canadian waters, and is the focus of this recovery strategy. Approximately 250 individuals are known to travel throughout the waters of British Columbia, although they range from Washington to southeastern Alaska (Cetacean Research Program (CRP)-DFO unpublished data). Defining members of the West Coast transient population is not as straightforward as it is for members of resident killer whale populations, largely because transients are not seen as reliably as residents. As well, unlike resident killer whales, transients disperse from their natal group. As a result, a number of criteria are combined in a weight-of-evidence approach to define the West Coast transient population. These criteria include: 1) association (members frequently associate with other members, and rarely if ever associate with the members of other populations), 2) shared acoustic repertoire of distinct vocalizations, 3) genetic relatedness, 4) shared range, and 5) shared diet and suite of foraging behaviours. In future, similar fatty acid and/or contaminant profiles may also help to define membership within this population (see Herman et al. 2005, Krahn et al. 2007).

An assemblage of approximately 100 transient-type killer whales has been documented off the California coast (Ford and Ellis 1999). This group is poorly-studied and has in the past been considered an extension of the West Coast transient population. A group of killer whale experts at a technical workshop convened in Vancouver 16-17 January 2007, for the purpose of advising Fisheries and Oceans Canada on technical issues relevant to this recovery strategy, determined that the available evidence suggests that the California assemblage belongs to one or more distinct, currently undefined populations. Acoustically, the repertoire of calls from these whales is similar, but not identical to that of transients found in British Columbia (Deecke 2003). Approximately 10 of these individuals have been seen in British Columbia and Alaska, and at times they have been observed interacting with members of the West Coast transient population. These interactions, although rare, suggest that there may be limited gene flow between the two groups. Very little is known about the status of the California assemblage, as these animals are encountered relatively infrequently, even in Californian waters.

Most sightings of transient killer whales in British Columbia tend to take place during the summer and fall, when more people are on the water, but transients are observed in all months of the year. However, they are not evenly distributed throughout the area, and are most frequently found where their prey is particularly abundant. Some transient groups travel throughout the range of the population, including one group that traveled 2,660 km from Glacier Bay Alaska to Monterey California, (Goley and Straley 1994). Other whales have only been seen in particular regions, such as the Queen Charlotte Islands. It is possible that they may have ‘home ranges’ or preferred areas where local knowledge gives them a hunting advantage (Ford and Ellis 1999). Unlike resident killer whales that may remain in an area for several weeks or more, particularly during peak salmon runs, transient killer whales usually pass through an area relatively quickly, likely because their mammalian prey leave the water or become highly evasive once alerted to their presence.

## 1.4 Habitat and Biological Requirements, Ecological Role and Limiting Factors for Transient Killer Whales

### 1.4.1 Habitat and Biological Requirements

The habitat requirements of transient killer whales are not well understood. Their specialized hunting techniques for capturing acoustically-sensitive marine mammals suggest that their habitat must be sufficiently quiet enough for them to acoustically detect their prey. These conditions would also help them to maintain other vital functions such as communication.

Transient killer whales rely completely on abundant marine mammal populations in order to survive. In the coastal waters of British Columbia, their principal prey are pinnipeds and small cetaceans (Ford et al. 1998, Ford et al. 2005). Populations of two of their known prey, harbour porpoises (*Phocoena phocoena*), and Steller sea lions (*Eumetopias jubatus*), are designated as Special Concern under COSEWIC (COSEWIC 2003) and if these species decline, there may be an impact on the available food supply of transients. This could have consequences on the ability of the transient population to grow. More detailed information on the prey preferences of transients is provided in Section 1.4.3 Biological Limiting Factors, Diet.

### 1.4.2 Ecological Role

Transient killer whales feed on warm-blooded animals, and are considered to be apex level predators. The specifics of their dietary preferences are discussed in Section 1.4.3. In British Columbia, the role that killer whale predation plays in the population dynamics of their prey populations is not well understood. However, in western Alaska, several prey populations are in serious decline, and there has been considerable debate in the literature as to whether killer whale predation is the cause. These include the western populations of Steller sea lions, sea otters (*Enhydra lutris*) and harbour seals (Barrett-Lennard et al. 1995, Estes et al. 1998, Springer et al. 2003, Williams et al. 2004, Trites et al. 2007, Wade et al. 2007). While the debate is not resolved, it seems plausible that once prey populations are reduced, for whatever reasons, killer whales are capable of maintaining their prey in a ‘predator pit’ where ongoing predation prevents prey populations from recovering.

### 1.4.3 Biological Limiting Factors

Biological limiting factors that can affect the population growth of transient killer whales include: diet, social organization, survival, dispersal, reproductive success, mating behaviours, reproductive senescence, culture, small population size (depensation) and various souces of natural mortality that are described below. Predation is not a factor limiting the population growth of transient killer whales since they have no natural predators.

#### *Diet*

Field observations (Baird and Dill 1996, Barrett-Lennard et al. 1996, Ford et al. 1998, Ford and Ellis 1999) and fatty acid analyses (Herman et al. 2005) clearly show that transients prey on marine mammals and occasionally seabirds, but they do not eat fish. The capture of three transient killer whales in 1970 reinforces the strength of this dietary preference. After 75 days of refusing fish, one whale died, and after 79 days the remaining two whales began to eat fish.

When they were later returned to the wild, the two surviving whales resumed their diet of marine mammals (Ford and Ellis 1999).

In coastal waters of British Columbia, harbour seals are the most frequently documented prey species of transients, followed by harbour porpoises, Dall's porpoises (*Phocoenoides dalli*) and Steller sea lions. They also consume California sea lions (*Zalophus californianus*), Pacific white-sided dolphins (*Lagenorhyncus obliquidens*), grey whales (*Eschrichtius robustus*), minke whales (*Balaenoptera acutorostrata*), and, less commonly, river otters (*Lutra canadensis*) and elephant seals (*Mirounga angustirostris*) (Baird and Dill 1996, Ford et al. 1998, Ford et al. 2005).

The prey of transients is generally available year-round, although there are seasonal peaks associated with calving and pupping. This may be why transients are seen more reliably throughout the year than resident killer whales (Ford and Ellis, 1999), which are found in inshore waters most frequently in the summer and fall when their principal prey, chinook salmon (*Oncorhynchus tshawytscha*), are most readily available as they return to freshwater to spawn.

Hunting warm-blooded, acoustically sensitive prey has shaped the social and acoustic behaviours of transient killer whales. In coastal waters of British Columbia, they typically travel in small, acoustically quiet groups and they hunt with stealth. Their dive times are long relative to residents and they often swim erratically (Morton 1990). They typically do not vocalize when foraging until after they have made a successful kill (Deecke et al. 2005). While harbour seal kills may occur very quickly, attacks on other species, such as sea lions, Dall's porpoises and minke whales, may be prolonged and involve high speed chases over several kilometres (Ford et al. 1998, Heise et al. 2003, Ford et al. 2005).

### *Social Organization*

Transient killer whales are most often seen in groups of two to six, although they occasionally may be found alone or in much larger groups (Ford and Ellis 1999). In their study of transients around southern Vancouver Island, Baird and Dill (1996) found that they were most commonly encountered in groups of three to four, and that mothers frequently traveled with their adult sons. However, unlike resident killer whales, the social groupings of transient killer whales are much more fluid and difficult to interpret. Transients do not necessarily remain in their natal matrilines for life and there can be some dispersal. The dispersers may mix widely within the population (Ford and Ellis 1999) although there can be strong long-term associations (Baird and Whitehead 2000).

The entire transient population is linked through association; all individual members of the transient population have been seen travelling with at least one other known member of the transient population at some time. As well, West Coast transients are all acoustically linked through the sharing of calls (Ford and Ellis 1999, Deecke 2003). These calls differ from those used by AT1 transients and those used by Gulf of Alaska transients (Saulitis et al. 2005). Transient killer whales that are seen more frequently in California share some calls with those that are most often found in British Columbia waters, but produce several unique calls as well (Ford 1984, Deecke et al. 2005, CRP-DFO unpublished data).

### *Survival and Longevity*

It is difficult to estimate mortality rates for transients since they may disappear for extended periods of time (years) and then reappear. Indeed, transients have been known to reappear after not having been seen for as long as 15 years (CRP-DFO, unpublished data). As a result, there are currently insufficient survival data specific to transients that can be used to estimate survival and longevity rates, and the discussion below is based on data for resident killer whales.

Killer whale survival rates vary with age, and mortality is highest for neonates (from birth to six months) at 37-50% (Olesiuk et al. 1990). The average life expectancy is described for animals that survive the first six months of life, based on data collected between 1973 and 1996 for northern resident killer whales and is estimated to be 46 yrs for females and 31 yrs for males. The maximum longevity is 80 yrs for females and 40-50 yrs for males (Olesiuk et al. 2005).

### *Reproductive Parameters*

As with survival and longevity data, there are few detailed records of reproductive data specific to transient killer whales and much of what is known about killer whale reproduction comes from resident killer whales. Since transients are not reliably sighted yearly, it is possible that females may have given birth to a calf that may or may not have survived. As a result, the discussion below is based on data from resident killer whales.

On average, male and female killer whales reach sexual maturity at 14.2 and 12.8 yrs respectively (Olesiuk et al. 2005). The gestation period is 16-17 months, one of the longest of all whales (Walker et al. 1998, Duffield et al. 1995). Females give birth to their first calf between 12 and 17 yrs of age (ave. = 14.1 yrs), and produce a single calf every five years over a 24 yr reproductive period, although the calving interval is highly variable and can range from two to 11 yrs (Olesiuk et al. 2005). Calving occurs year-round, but peaks in fall through spring. Calves are approximately 2.2-2.5 m in length at birth (Olesiuk et al. 1990).

### *Mating Behaviour*

Mating behaviour between male and female killer whales has rarely been observed in the wild and there is no information about mating behaviour or mate choice in transient killer whales. Genetic and photo-identification studies suggest that the transient, resident and offshore ecotypes are closed to immigration, and that successful mating between these, if it ever occurs, is extremely rare (Barrett-Lennard 2000). Resident killer whales in British Columbia give birth mostly in fall and winter, which implies a peak in mating during spring and summer (16-17 month gestation period; Olesiuk et al. 1990, 2005). There are insufficient data to determine whether transients have a similar seasonality in mating and calving.

### *Reproductive Senescence*

Little is known about reproductive senescence in transient killer whales, but female resident killer whales generally produce their last calf at approximately 40 years, and may live to age 70 or older (Olesiuk et al. 2005). This post-reproductive period is relatively rare in animals, and only occurs in species with maternal care where offspring remain dependent for an extended period.

### *Culture*

Strong cultural traditions that are passed along from generation to generation through learning are evident within the West Coast transient killer whale population. In particular, their preference for mammalian prey is an important feature that helps to define this population. The strength of this tradition is highlighted by the transient killer whale held in captivity that ultimately died because of its refusal to eat fish (discussed in Section 1.4.3.). West Coast transients also have their own unique repertoire of acoustic calls, which is different from those of resident killer whales, as well as with other populations of transients (Ford 1984, Deecke 2003, Deecke et al. 2005, Saulitis et al. 2005).

Transients do not compete with resident killer whales for food, yet they appear to actively avoid residents (Baird 2000), and have even been aggressively attacked by them in one well-documented account (Ford and Ellis 1999). There is much to be learned about the role of culture in transient society, but it likely enhances foraging efficiency as whales pass along hunting techniques and information on important feeding areas to each other.

### *Depensation*

In British Columbia, the West Coast transient killer whale population numbers approximately 250 whales (CRP-DFO unpublished data), and is considered to be at risk because of its low population size. In general, small populations have an increased likelihood of inbreeding and lower reproductive rates, which can lead to low genetic variability, reduced resilience against disease and pollution, reduced population fitness and elevated extinction risks due to catastrophic events. There is evidence of at least one genetic disorder within the West Coast transient population, although it is relatively rare.

In Alaska, the story of the AT1 transient population demonstrates the risks associated with low population size. This population was first encountered in 1984 in Prince William Sound, and numbered 22 whales. These whales were regularly encountered in the area between 1984 and 1989. In the spring of 1989 the Exxon Valdez oil spill occurred in Prince William Sound and in 1990 nine individuals were missing from the group, three of which were seen swimming through oil in the vicinity of the ship shortly after the spill. The following year an additional two whales went missing and all 11 whales are now presumed dead. Since 1990 an additional three whales have disappeared and the population now numbers eight animals (Angliss and Outlaw 2005). As there are no longer any reproductive age females in the group, this will lead to the extirpation of the AT1 population (Saulitis et al. 2002). It is worth noting that the Gulf of Alaska transient population is sympatric with the AT1 population, but there is no interbreeding between these two groups of killer whales (Barrett-Lennard 2000).

### *Natural Mortality*

As discussed above, many transient groups are not encountered on a regular basis, and carcasses are rarely recovered, so there is little known about natural sources of mortality. It can be assumed that they are vulnerable to many of the same risks as resident killer whales, including: entrapment in coastal lagoons or constricted bays, accidental beaching, disease, parasitism, biotoxins and starvation (Baird 2001). Anthropogenic factors may make transients more vulnerable to natural sources of mortality as well. For example, intense high-energy sound may cause animals to strand (Perrin and Gerraci 2002). Death is ultimately due to stranding, but the proximate cause is anthropogenic.

Little is known of the diseases that may affect the survival of killer whales in the wild. Sixteen pathogens have been identified in captive killer whales, and four pathogens have been detected in wild killer whales (Gaydos et al. 2004, Stephen Raverty, BC Ministry of Agriculture, Food and Fisheries, Abbotsford, personal communication Jan 17, 2007). These include marine *Brucella* spp., *Edwardsiella tarda*, *Toxoplasma gondii*, and cetacean poxvirus. As well, twenty-seven additional pathogens have been identified in sympatric species of odontocetes that may be transferable to killer whales. Because transients feed on marine mammals, it is possible that they may be exposed to these pathogens at a higher rate than resident killer whales. These diseases may cause abortions, reduced fecundity and/or increased mortality (Gaydos et al. 2004).

Little is also known of the role of parasites in transient killer whale mortality. There have been no reports of external parasites on West Coast transients (Baird 2000) but they can be infected with internal parasites. These include various species of trematodes, cestodes and nematodes (Dahlheim and Heyning 1999, Raverty and Gaydos 2004), which are likely acquired through infected prey.

Transients may on occasion be vulnerable to accidental beaching or entrapment, although there is only one record of a known transient killer whale accidentally beaching itself. This was a lone male that stranded and subsequently died on a sandbar while foraging near Tofino in 1976 (Ford and Ellis 1999).

Any factor that dramatically alters the abundance of their prey could be a significant source of mortality for transient killer whales. In other areas of the world, there have been massive outbreaks of diseases and biotoxins in pinnipeds and small cetaceans. *Morbillivirus* outbreaks have caused mass mortalities of dolphins and seals (Aguilar and Borrell 1994, Kennedy et al. 2000) and in ocean-living river otters in British Columbia (Mos et al. 2003). There are three ways in which one of the members of the Genus *Morbillivirus* may present a risk to transient killer whales: 1) an outbreak in their community, perhaps most likely due to Dolphin/Cetacean Morbillivirus (DMV), 2) an outbreak of phocine distemper virus (PDV) or canine distemper virus (CDV) among their principal prey – harbour seals – which could dramatically reduce prey abundance for transients, and/or 3) a transfer of PDV or CDV from pinnipeds, river otters or other species to transients, the likelihood of which is unclear.

Harmful algal blooms (HABs) have the potential to put transient killer whales at risk, either through bioaccumulation or through loss of prey. HABs result in the production of biotoxins, such as paralytic shellfish poison, domoic acid, saxitoxin and brevitoxin. Several species of marine mammals have been shown to have a potential susceptibility to their neurotoxic effects (Trainer and Baden 1999). As HABs seem to be increasing in frequency, and have been linked to the deaths of California sea lions (Scholin et al. 2000), transients may be at risk in future.

Changing climatic conditions may also result in a reduction in the food supply of transient killer whales, and ultimately reduce their survival. El Niño events have been linked to large-scale die-offs of pinnipeds in California (Angliss and Lodge 2004). Widespread changes in the circulation and physical properties of the ocean, known as ‘regime shifts’ also have the potential to affect the distribution and abundance of the prey of killer whales (Benson and Trites 2002).

## 1.5 Threats

### 1.5.1 Characterizing Threats Using a Weight-of-Evidence Approach

West Coast transient killer whales are long-lived organisms that sit at the top of the trophic ladder. However, these killer whales appear to have low reproductive rate, which significantly reduces their ability to recover from catastrophic events or population declines. Their small population size (currently estimated at ~250 animals, CRP-DFO unpublished data) places them at additional risk for anthropogenic threats. Since scientific, ethical, logistical and legal challenges preclude direct or causal experimentation with killer whales, a weight-of-evidence approach provides a framework for characterizing and prioritizing the threats that they face. Such an approach is common in the human pharmaceutical sector, where toxicity, safety and efficacy data from controlled laboratory animal experiments are used to extrapolate to humans. In the case of transient killer whales, a weight-of-evidence approach draws upon the collective scientific results from controlled laboratory, captive, and field studies on other marine mammals (such as harbour seals), as well as opportunistic observations and naturally occurring experiments on killer whales and other cetaceans in the wild. This approach is used wherever possible to describe the threats to which killer whales may be vulnerable.

There are numerous anthropogenic threats to the viability of transient killer whales. These include chemical contaminants (both legacy and emerging), biological pollutants, trace metals, physical disturbance, acoustical disturbance (both chronic and acute), toxic spills, disease, collision with vessels, and the effects of culls on their prey (currently prohibited). Of these, the most pressing anthropogenic threats to transient killer whales are: 1) environmental contaminants, and 2) noise and disturbance. As a result of their small population size and their extremely limited reproductive potential, the population is particularly vulnerable to any sources of mortality that may be considered as above ‘background’. However, the extent to which current threats may act synergistically to impact killer whales is unknown, but in other species multiple stressors have been shown to have strong negative and often lethal effects, particularly when animals carry elevated levels of environmental contaminants (Sih et al. 2004).

### 1.5.2 Threat classification

Table 1 Anthropogenic Threat Classification Table.

See Appendix B for clarification of the terms used in categorizing the threats and note that Persistent Organic Pollutants are divided into legacy and emerging contaminants because different strategies are required to address them.)

| **1** | **Stress: Persistent Bioaccumulating Toxins (PBTs): Legacy Contaminants** | **Stressor Information** | | |
|---|---|---|---|---|
| **Stressor Category** | Pollution and Changes in natural processes (Food supply) | **Extent** | Widespread and locally concentrated | |
| | | | **Local** | **Range-wide** |
| **General Stressor** | Persistent Bioaccumulating Toxins (PBTs) | **Occurrence** | Current | Current |
| | | **Frequency** | Continuous | Continuous |
| **Specific Stress** | Direct toxic effects and transfer (and bioaccumulation) of contaminants to killer whales through prey | **Causal Certainty** | Expected | Expected |
| | | **Severity** | High | High |
| **Effect** | Reproductive impairment, endocrine disruption, skeletal abnormalities, cancer, etc. | **Level of Concern** | High | |

| **2** | **Stress: Persistent Bioaccumulating Toxins (PBTs): Emerging Contaminants** | **Stressor Information** | | |
|---|---|---|---|---|
| **Stressor Category** | Pollution and Changes in natural processes (Food supply) | **Extent** | Widespread and locally concentrated | |
| | | | **Local** | **Range-wide** |
| **General Stressor** | Persistent Bioaccumulating Toxins (PBTs) | **Occurrence** | Current | Current |
| | | **Frequency** | Continuous | Continuous |
| **Specific Stress** | Direct toxic effects and transfer (and bioaccumulation) of contaminants to killer whales through prey | **Causal Certainty** | Expected | Expected |
| | | **Severity** | High | High |
| **Effect** | Reproductive impairment, endocrine disruption, skeletal abnormalities, cancer, etc. | **Level of Concern** | High | |

| **3** | **Stress: Chronic Noise** | **Stressor Information** | | |
|---|---|---|---|---|
| **Stressor Category** | Habitat Degradation | **Extent** | Widespread | |
| | | | **Local** | **Range-wide** |
| **General** | Vessel Noise | **Occurrence** | Current | Current |

| | | | | |
|---|---|---|---|---|
| **Stressor** | | **Frequency** | Continuous, with some seasonal variability | Continuous, with some seasonal variability |
| **Specific Stress** | Masking of communication signals, inability to forage successfully | **Causal Certainty** | Plausible but requires further study | Plausible but requires further study |
| | | **Severity** | Unknown | Unknown |
| **Effect** | Physiological and physical harm | **Level of Concern** | Moderate | |
| **4** | **Stress: Acute Noise** | **Stressor Information** | | |
| **Stressor Category** | Disturbance | **Extent** | Local point sources throughout range | |
| | | | **Local** | **Range-wide** |
| **General Stressor** | Intense impulsive sound | **Occurrence** | Current | Current |
| | | **Frequency** | Recurrent | Recurrent |
| **Specific Stress** | Seismic surveys<br>Military sonar<br>Underwater explosions | **Causal Certainty** | Expected | Expected |
| | | **Severity** | Low at current frequency | Low at current frequency |
| **Effect** | Physiological impairment and possible physical harm (from military sonar & underwater explosions only)<br>Behavioural effects | **Level of Concern** | High because of potential to expand | |
| **5** | **Stress: Physical Disturbance** | **Stressor Information** | | |
| **Stressor Category** | Disturbance | **Extent** | Localized but widespread | |
| | | | **Local** | **Range-wide** |
| **General Stressor** | Recreational activities<br>Whale-watching operations | **Occurrence** | Current | |
| | | **Frequency** | Continuous, with some seasonal variability | |
| **Specific Stress** | Interruption of foraging and social behaviours | **Causal Certainty** | Expected but requires further study | |
| | | **Severity** | Unknown | |
| **Effect** | Possible displacement | **Level of Concern** | High | |
| **6** | **Stress: Biological Pollutants** | **Stressor Information** | | |
| **Stressor Category** | Pollution and Changes in natural processes (Food supply) | **Extent** | Localized | |
| | | | **Local** | **Range-wide** |
| **General Stressor** | Prey reduction and toxic effects | **Occurrence** | Anticipated | |
| | | **Frequency** | Recurrent | |
| **Specific** | Prey species are | **Causal Certainty** | Plausible | |

| | | | | |
|---|---|---|---|---|
| **Stress** | vulnerable to pollutants that can spread quickly throughout the marine environment. May also impact killer whales directly. | **Severity** | Low-Medium | |
| **Effect** | Physiological changes, disease, reduced prey availability | **Level of Concern** | Unknown | |

| **7** **Stress: Toxic Spills** | | **Stressor Information** | | |
|---|---|---|---|---|
| **Stressor Category** | Habitat Degradation and Pollution | **Extent** | Localized | |
| | | | **Local** | **Range-wide** |
| **General Stressor** | Toxic spills, including hydrocarbons | **Occurrence** | Anticipated | |
| | | **Frequency** | Recurrent | |
| **Specific Stress** | Ingestion/ exposure to noxious materials | **Causal Certainty** | Demonstrated | |
| | | **Severity** | Low-Medium | |
| **Effect** | Physiological impacts/ death | **Level of Concern** | High | |

| **8** **Stress: Collision with Vessels** | | **Stressor Information** | | |
|---|---|---|---|---|
| **Stressor Category** | Accidental Mortality | **Extent** | Localized | |
| | | | **Local** | **Range-wide** |
| **General Stressor** | High speed vessel traffic | **Occurrence** | Current | |
| | | **Frequency** | Recurrent | |
| **Specific Stress** | Blunt force trauma and/ or lacerations | **Causal Certainty** | Demonstrated | |
| | | **Severity** | Low | |
| **Effect** | Direct or indirect mortality (via infection) | **Level of Concern** | Low | |

| **9** **Stress: Decline in Prey Availability and/or Quality** | | **Stressor Information** | | |
|---|---|---|---|---|
| **Stressor Category** | Consumptive use or culling | **Extent** | Widespread | |
| | | | **Local** | **Range-wide** |
| **General Stressor** | Culling | **Occurrence** | Current | Historical |
| | | **Frequency** | Unknown | Continuous until early 1970s |
| **Specific Stress** | Prey reduction | **Causal Certainty** | Plausible | Plausible |
| | | **Severity** | Low | High |
| **Effect** | Lack of food | **Level of Concern** | Low (based on current seal management and cetacean protections) | |

### 1.5.3 Description of threats

#### *Contaminants*

Transient killer whales are the most polychlorinated biphenyl (PCB)-contaminated marine mammals in the world described to date (Ross et al. 2000), underscoring concerns that they may be at elevated risk for adverse health effects. Within the generic class of contaminants known as Persistent Bioaccumulating Toxins (PBTs), or alternatively Persistent Organic Pollutants (POPs), PCBs, are the greatest toxicological concern in high trophic level organisms in the northern hemisphere. PBTs are persistent, toxic, and bioaccumulate, all features that render transient killer whales vulnerable to heavy contamination and to health risks. PBTs are not typically acutely toxic, but rather are considered as ‘hormone mimics’, or ‘endocrine disruptors’ because of their chronic, slow-acting and insidious effects on normal growth and development of organ systems. As such, affected populations have been shown to suffer from diminished reproductive health, decreased immune function (and increased incidence of disease), skeletal abnormalities, and neurological impairment.

Transient killer whales are at particular risk to PBT contamination because they are long-lived animals that feed high in the food web, with their diet comprising other animals that are already contaminated with PBTs (Ross et al. 2004, Mos et al. 2006). Adult females of both the resident and transient killer whales are less PBT-contaminated than their male counterparts, due to the reproductive transfer of PBTs to their offspring during gestation and lactation (Ross et al. 2000, 2002, Rayne et al. 2004, Ross 2006). Harbour seals, one of the principal prey species of transients, are known to be relatively contaminated with PBT chemicals, particularly near urban areas (Ross et al. 2004). Levels of PCBs in Puget Sound harbour seals have been associated with immunosuppression and endocrine disruption (Mos et al. 2006, Tabuchi et al 2006.)

<u>Legacy Contaminants</u>

PBTs include ‘legacy’ contaminants, such as PCBs and dichloro-diphenyl trichloroethane (DDT), which are no longer widely used in industrialized countries but continue to persist in the environment. Dioxins and furans have declined in the environment and are found at relatively low levels in killer whales, reflecting the metabolic removal of the compounds at increasing trophic levels in the food web (Ross et al. 2000). Transient killer whales contain PCB levels that are two to four times higher than those of the threatened St. Lawrence beluga whales (*Delphinapterus leucas*) (Martineau et al. 1987, Béland et al. 1993, Ross et al. 2000). While unequivocal evidence is a near-impossibility in the real world of complex contaminant mixtures, these belugas are suspected of having contaminant-associated reproductive impairment and immunosuppression, which may explain the failure of the population to recover since they were afforded protection from hunting in 1979 (De Guise et al. 1995). These levels are considerably higher than those known to cause PCB-associated reproductive impairment, skeletal abnormalities, endocrine disruption and immunotoxicity in pinnipeds (Ross 2000, Ross et al. 2004). Although PCB levels are declining in the environment, recent models suggest that it will take decades before the PCB levels in killer whales decline below the thresholds for adverse effects (Hickie et al 2007). Because transient killer whales feed on contaminated prey, their contaminant levels will not decline as quickly as they will for resident killer whales, even if the contaminant is no longer used.

## Emerging Contaminants

While legacy PBTs have been largely regulated in the industrialized world, a number of contaminants with similar properties remain on the market, or represent by-products of current practices. These include the polybrominated diphenyl ethers (PBDEs), which are used as flame retardants in applications ranging from textiles to televisions and computers. Two of the three commercial formulations (penta and octa) have been banned in Europe or withdrawn from the marketplace in North America, but decaBDE remains in use. Since decaBDE breaks down into penta- and octa-like forms in the environment, the exposure of killer whales to increasing levels of endocrine-disrupting PBDEs remains a significant concern. PBDE levels in humans and in pinnipeds have been doubling approximately every four to five years (Hites 2004, Ross 2006). While many questions remain unanswered about the nature of its toxicity, growing evidence of endocrine disruption and immunotoxicity (Darnerud 2003, Hall et al. 2003) highlight the emerging concern associated with this currently-used flame retardant. Analyses suggest that transient killer whales carry even higher levels of PBDEs than members of the Endangered southern resident killer whale population (Ross 2006).

A number of other PBTs may also affect transient killer whales, including persistent aromatic hydrocarbons, di- and tri-butyltin, perfluoro-octane, alkylphenol ethoxylates, and polychlorinated naphthalenes, paraffins and terphenyls. Appendix C lists PBTs and their potential risk to transient killer whales and their prey, as well as a brief summary of their sources.

There is a high level of concern about the potential impacts of PBTs on transient killer whales. A weight-of-evidence approach needs to be incorporated into research, conservation planning and regulatory decision-making, in order to better protect killer whales and their prey from these highly toxic compounds.

## Biological Pollutants

Transient killer whales may be at heightened risk to the impacts of exotic diseases or ‘biological pollution’ as a result of their preference for marine mammals as prey. Viruses, bacteria and macroparasites typically cross species barriers more readily when the two species are more closely related. Transients may be exposed to pathogens that are endemic to their mammalian prey or from spill-over from terrestrial sources, such as domestic pets or livestock. Evidence of sewage- or runoff-related infectious diseases in Puget Sound harbour seals (Lambourn et al. 2001) and in California sea otters (Miller et al. 2002) highlight this route as one of concern for transient killer whales.

A number of high profile mass mortalities in several species have drawn attention to the potential threat that biological pollution poses to marine mammals, and identifies these pollutants as emerging conservation concerns (DeSwart et al. 1995, Miller et al. 2002, Ross 2002, Mos et al. 2003, Mos et al. 2006). Biological pollutants may act via two routes, either by infecting and impacting the prey of transient killer whales, or by infecting transient killer whales themselves. In addition, the immunotoxic nature of the PBTs found at very high levels in transient killer whales may predispose the whales to increased risk or severity of infection by biological pollutants (Jepson et al. 1999, Ross et al. 1996, Mos et al. 2006).

Pathogens are capable of spreading quickly in marine mammal populations. For example, *Morbillivirus* epidemics in seals and dolphins spread at a rate of 3000-6000 km per year (McCallum et al. 2003). Certain pathogens, such as *Morbillivirus* spp., occur naturally in the marine environment. Some of the more well-known species of *Morbillivirus* that have been identified include canine distemper virus, phocine (seal) distemper virus, and two forms of cetacean morbillivirus (dolphin and porpoise). Infection can result in pneumonia, reduced lymphocyte production and encephalitis. Cetacean morbilliviruses were responsible for the deaths of more than 50% of the bottlenose dolphin population along the east coast of the US in 1987-1988 (Di Guardo et al. 2005). Cetacean morbilliviruses have been detected in stranded dolphins off California, but there have been no epidemics in the Pacific (Reidarson et al. 1998).

Other pathogens, such as *Brucella* spp. and likely *Toxoplasma gondii*, spill over from terrestrial sources through sewage and agricultural runoff (Lambourn et al. 2001, Miller et al. 2002, Mos et al. 2006). Blood testing of 12 stranded killer whales revealed that nine tested positive for *Brucella* (S. Raverty, BCMAFF, Abbotsford, personal communication Jan. 17, 2007). In cetaceans, *Brucella* is associated with lesions in the reproductive tract as well as encephalitis (González et al. 2002, Steven Raverty, BCMAFF, personal communication Jan. 17, 2007). Harbour seals exposed to runoff from urban and agricultural areas carry a number of bacterial and protozoan pathogens, which they are more vulnerable to due to their increased chemical contaminant burdens (Mos et al. 2006).

There are approximately 100,000 harbour seals in British Columbia (P. Olesiuk, PBS, DFO, unpublished data). If a large pathogenic outbreak caused mass mortalities of harbour seals in British Columbia, such as occurred in northwestern Europe in 1988 (18,000 dead) and again in 2002 (21,000 dead, Di Guardo et al. 2005), there could be potential consequences for transient killer whales due to the loss of one of their principal prey species. As transient killer whales are also heavily chemically contaminated and likely immuno-compromized, they may also be more vulnerable to direct infection with the same pathogens.

Climate change may play a significant, although indirect, role in the development of infectious disease epidemics. For example, changes in the El-Niño Southern Oscillation have resulted in measurable effects on the development of pathogens, survival rates, and disease transmission in the marine environment (Harvell et al. 2002). Exactly how climate change and global warming may affect the vulnerability of killer whales, and in particular, their prey, to pathogens is unknown, but it may become a larger threat in the future as ocean temperatures continue to increase.

### Trace Metals

Little information is available on the levels and effects of trace metals on marine mammals. Trace metals occur naturally in the marine environment, and killer whales have evolved the ability to detoxify some of these substances, such as mercury (Martoja and Berry 1980). However, elevated levels can be found in urban and industrial areas, and may be of concern to both killer whale populations and their prey (Grant and Ross 2002).

### *Acoustic Disturbance*

At the time of writing of the COSEWIC status report on killer whales (Baird 2001), there was relatively little known about the potential impacts of noise on marine mammals. Since then, there has been a growing awareness that noise likely represents a significant threat to marine life that degrades their habitat. It also may affect their ability to detect prey and predators, to communicate and to acquire information about their environment. It can do so by disrupting natural behaviours such as foraging, displacing prey, potentially impairing hearing, either temporarily or permanently, and causing physiological damage (Barrett-Lennard et al. 1996, Erbe 2002, NRC 2003).

It is challenging to describe and measure the effects of disturbance, as responses may be subtle and/or difficult to interpret. As well, animals may show no obvious behavioural response to disturbance, yet still be negatively affected. Todd et al. (1996) found that humpback whales remained in close proximity to underwater explosions and showed no obvious behavioural responses to them. However, there were significantly higher entanglement rates during this time, and subsequent necropsies of two whales that drowned in nets revealed acoustic trauma (Ketten et al. 1993). Although the study of how anthropogenic sources of sound affect marine mammals is relatively new, killer whales rely heavily on the use of sound, and the costs of hearing loss could be severe.

Acoustic disturbance can be of two types: chronic and acute. Potential impacts of these two types of disturbance may differ and require separate mitigation strategies. For this reason, chronic and acute acoustic disturbance are considered separately in this discussion and in Table 1.

#### Chronic Noise

Chronic noise is associated with vessel traffic, particularly shipping, and in some areas of the coast, whale watching. Studies that have measured changes in ambient underwater noise levels over the past 100 years attribute much of the increase in underwater noise to the dramatic increase in commercial shipping. Vessel noise covers a broad band of frequencies, and is now the dominant source of ambient noise in the 0-200 Hz range (NRC 2003). Exactly how this increase in underwater sound may affect killer whales is not well understood. Chronic noise can result in masking, such that animals may find it difficult to communicate. Masking could lead to disruption of social contact or interference with acoustically-coordinated behaviours. This is of particular concern with transient killer whales, as they vocalize much less frequently than resident killer whales (Deecke et al. 2005). Transients also rely heavily on being able to acoustically detect their prey (Barrett-Lennard et al. 1996), so increased underwater noise may reduce their foraging efficiency.

#### Acute Noise

Sources of acute noise in the marine environment include military sonars, seismic surveys, commercial sonars and underwater explosions usually associated with construction. Many of these intense impulsive sounds have the potential to travel large distances underwater (>10-100+ km). Recent evidence suggests that such sounds may have significant impacts on cetaceans, although further research is needed to provide insight into the mechanisms by which these effects occur. In other species of marine mammals, acute noise has been associated with hearing threshold shifts, the production of stress hormones, and tissue damage, which is likely due to the formation of air bubbles or as a result of resonance (Ketten et al. 1993, Crum and Mao 1986, Evans and England 2001, Finneran 2003, Jepson et al. 2003, Fernandez et al. 2004). Marine mammals may be particularly vulnerable to resonance because of the air-filled cavities in their sinuses, middle ear, and lungs, and small gas bubbles in their bowels.

Low-mid frequency sonar has been associated with increased strandings of humpback and beaked whales (IWC 2004), and with unusual behaviours of resident killer whales (K.C. Balcomb, personal communication, in Wiles 2004). Systematic surveys of cetaceans during seismic surveys have been undertaken in UK waters and have shown that killer whales and other cetaceans were generally seen further away during periods when the survey was active (Stone 2003). Although they did not see killer whales at the time, during seismic surveys in southern British Columbia and northern Washington, Bain and Williams (2006) found that harbour porpoises and Steller sea lions showed significant avoidance responses to intense sounds even at relatively low levels, and at distances of up to 70 km or more.

While there is no direct evidence of the effects of high intensity sound on transient killer whales in particular, by inference from other cetacean species, high intensity sound would likely have a detrimental effect. Transients are particularly vulnerable to exposure to these high intensity sounds and because transients are difficult to detect, both visually and acoustically, it is extremely difficult to develop adequate mitigate measures to address exposure to acute sound. They typically travel in small groups, and the likelihood of visually detecting them falls off markedly at distances greater than 1 km (Wade et al. 2003).

### *Physical Disturbance*

Cetaceans are being subjected to increasing amounts of physical disturbance from both vessels and aircraft (IWC 2004). How this may affect transient killer whales is not well understood, but there is concern that it could reduce their foraging success, close vessel approaches may disrupt hunting behaviour. Killer whale attacks on marine mammals are often prolonged and may take place over several kilometres, so the more boat traffic in an area, the greater the possibility that the attack may be interrupted.

Commercial whale watching has increased dramatically in British Columbia in recent years (Baird 2002, Osborne et al. 2003). While the majority of these encounters are with resident killer whales, occasionally whale-watchers encounter transient killer whales. Resident killer whales are likely much more habituated to the ‘behaviour’ of whale watching boats than transients, yet residents show responses to boats following them at a distance of 100 m (Williams et al. 2002). These responses included reduced foraging time, which has the potential to significantly reduce their energy intake due to lost feeding opportunities (Williams et al. 2006). Recognizing that the specialized hunting techniques of transients likely makes them more vulnerable than residents to disturbance, the Whale Watch Operators Association Northwest (WWOANW 2006) suggests that all boaters maintain a distance of 200 m from transients that are actively engaged in a kill. However, simply the close proximity of vessels, and their associated noise, may serve to disrupt an attack.

### *Collision with Vessels*

Until recently there have been relatively few reports of killer whales being struck by boats, but within the last three years there have been four such reports in British Columbia, two of which were fatal for the whales (CRP-DFO, unpublished data). These mortalities suggest that killer whales are at an increasing risk of collision, either as a result of blunt force trauma, and/or through blood loss associated with lacerations received from the boat's propeller. Both commercial shipping and cruise ship traffic have increased dramatically over the last two decades, and are likely to continue to increase, further increasing the risk of collision with killer whales. It is not known whether the often erratic and unpredictable diving behaviour of transient killer whales (Morton 1990) puts them more at risk of collision than resident killer whales.

### *Toxic Spills*

Killer whales do not appear to avoid toxic spills, as indicated by the behaviour of a group of transients in the vicinity of the Exxon Valdez oil spill in 1989 in Prince William Sound, Alaska (and described in Section 1.4.3.8). This spill was associated with unprecedented mortality of both transient and resident killer whales, which likely died from the inhalation of petroleum vapours (Matkin et al. 1999). Spills on a smaller scale have occurred in British Columbia, such as the Nestucca oil spill (875 tonnes in December 1988) in Gray's Harbor, Washington, which drifted into Canadian waters, and the more recent spill of 50 tonnes of bunker fuel into Howe Sound from a ruptured tanker in August 2006. There is currently a considerable amount of tanker traffic in and out of Puget Sound and the Strait of Georgia, which poses a risk for killer whales (Baird 2001, Grant and Ross 2002). If the proposed 30-inch 400,000 barrel/day Gateway Pipeline is built near Kitimat, the risk of an oil spill associated with tanker traffic running from inshore waters to California and Asia will increase significantly.

Spills other than hydrocarbons also pose a risk to killer whales, and a recent spill highlights the fact that these are not merely hypothetical events.

### *Changes in Prey Availability and/or Quality*

In western Alaska, there have been dramatic declines in populations of harbour seals, sea lions and fur seals. These declines are hypothesized to have caused a shift in transient killer whale prey to less desirable species such as sea otters (Estes et al. 1998). There is virtually no information on the abundance or trends of small cetacean and minke whale populations in British Columbia available to determine potential changes in importance or availability of cetaceanscetacean prey for transients.

Much more is known about the historic trends and present abundances of pinnipeds, particularly harbour seals and Steller sea lions. Until the early 1970s, there was an active program to cull both species in British Columbia. By the time these programs were concluded, harbour seal populations were 1/10$^{th}$ of what is assumed to be their historic population size, and their numbers have since rebounded to their pre-cull abundance (Olesiuk 1999). Steller sea lion numbers have also doubled since the culling program ended (DFO 2003). These recovering prey populations have likely had a significant positive effect on the population of transient killer whales (Ford and Ellis 1999), since both seals and sea lions are important in their diet.

In recent years, there have been calls for culls of harbour seals and sea lions because they interfere with commercial and recreational fisheries, by feeding on the targeted species as well as by depredating fishing gear. As seals and sea lions are important prey of transients, any pinniped cull program has the potential to reduce the supply of food available to transients, and potentially negatively affect the total population.

Contaminant loading in small cetacean and pinniped populations can also reduce quality and/or quantity transient killer whale prey. For example, a mass mortality of harbour seals, associated with an infectious disease, could have a significant impact on the available food supply of transient killer whales. Increasing PBT contaminant levels and changing ocean climate associated with global warming may increase the frequency of these epidemics (Walther et al. 2002).

## 1.6 Actions Already Completed or Underway

### 1.6.1 Research

Since the early 1970s, there have been intensive field studies of both resident and transient killer whales in British Columbia undertaken by researchers with DFO, the Vancouver Aquarium, and universities. Annual photo-identification of individual killer whales over this time has provided the foundation upon which studies of killer whale life history, acoustics, genetics and dietary specialization have been built. This, coupled with transboundary collaboration with researchers in Washington, California and Alaska, has been invaluable in providing insight into the life history and ecology of the wide-ranging West Coast transient population. A summary of current research is listed below.

Life history data are collected by photo-documenting individuals on an annual basis whenever possible. The ability to identify and track individuals over time is critical to estimating longevity, birth rates, survivorship, etc., as well as to provide overall abundance estimates for the population. It also forms the basis for analysis for other data, such as acoustic and contaminant analyses. Insight into the foraging behaviour and dietary preferences of killer whales is being provided through direct observations and prey fragment sampling, as well as through the use of acoustic data loggers and time-depth recorders.

Biopsy samples of killer whales are being analyzed for chemical contaminants. These analyses provide information on the contaminant burdens that upper trophic level predators, including humans, are carrying, and to date have revealed that killer whales are among the most contaminated marine mammals in the world. Contaminants in the prey species of killer whales, particularly harbour seals, are also being analyzed. These samples also reflect the contaminant burden of upper trophic level predators, are easier to collect (based on age and sex) than killer whale samples, and provide a means of evaluating the quality of transient killer whale diet (e.g. ‘dietary exposure’ measurement). Environment Canada’s regulatory review of chemicals and non-government programs such as the Green Boater Program and Pesticide Free Lawns, along with the implementation of the Georgia Basin Action Plan (Environment Canada, 2003) are ongoing initiatives that are effective in reducing contaminant inputs to the environment.

Information on the population structure and mating patterns of transient killer whales is being collected through the genetic analyses of biopsy samples. To date these studies have revealed that transient, resident and offshore killer whales are genetically distinct, suggesting a lack of interbreeding. (Barrett-Lennard 2000).

The underwater vocalizations of transient killer whales are being monitored directly during encounters using hydrophones, and also by remotely placed hydrophones. These remote hydrophones can be useful in monitoring habitat use during times of the year when researchers are not able to work in the field.

Killer whales are being monitored for infections, diseases and general health condition through necropsy sampling, and more recently, through assays of exhalations and/or fecal samples obtained from animals in the wild.

Bioenergetic models for killer whales combined with information on the historic abundance of Steller sea lions and harbour seals in British Columbia are being used to estimate the maximum transient killer whale population size that could have been supported by pinnipeds.

DFO is currently undertaking a Recovery Potential Assessment (RPA) to investigate life history parameters for transients, including the ability of the population to grow and recover. This work will inform both the determination of population recovery and assist in the establishment of future population objectives.

The Killer Whale Ecological Survey Team (KWEST), comprised of researchers from California through Alaska who are examining range-wide issues relevant to killer whales, has proposed a broad scale joint Canada/US multi-year killer whale research program across the North Pacific to investigate the ecological role of transient killer whales and their effects on endangered marine mammal species.

### 1.6.3 Management and Stewardship

Stewardship-based whale watching monitoring and education programs continue to promote safe boating behaviour around transient killer whales. At present these programs are based in Johnstone Strait and in the transboundary waters of Georgia Strait, Juan de Fuca Strait, and connecting passes and channels. The ‘Be Whale Wise’ guidelines, which suggest appropriate behaviours for boaters in the vicinity of whales, have recently been revised by DFO.

Sightings and encounters with killer whales by the public are documented in one of two ways. If a sighting or an encounter is made of live animals, this information is forwarded to the BC Cetacean Sightings Network (http://www.wildwhales.org/stewardship/sightings.intro.html). DFO collects information on incidents in which an animal is injured or dead, or interacts with humans in an unusual way or a possible violation has occurred. A 24-hour hotline is available at 1-800-465-4336 for the reporting of all incidents. Necropsies are performed whenever possible, and can provide information on the diet, cause of death, contaminant loads and other aspects of biological interest relevant to killer whales.

Environment Canada is revising their proposed Risk Management Strategy for Polybrominated Diphenyl Ethers, under the *Canadian Environmental Protection Act* (CEPA). This strategy supports the ban of several (but not all) of the forms of PBDEs that are known to bioaccumulate in killer whales.

The Department of National Defence (DND) has established protocols to protect marine mammals from disturbance and/or harm from the use of military active sonar. Maritime Command Order 46-13, for marine mammal mitigation, is to avoid transmission of sonar any time a marine mammal is observed within the defined mitigation avoidance zone, which is established specific to each type of sonar. Ship's personnel receive training in marine mammal identification and detection.

DFO had developed the draft Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment (DFO, 2005a), to address concerns regarding the potential impact of seismic use on marine mammals and other marine life. A process for the revision and further consultation of the draft Statement is underway. In the Pacific Region, each proposed seismic survey is reviewed by DFO marine mammal experts and mitigation measures are developed based on the species of concern in the area of the survey for each project. Further evaluation is necessary to determine the nature and extent of this threat and the effectiveness of these mitigation measures.

A revised COSEWIC status report for killer whales is currently being prepared. This will provide updated information on the population status of transient killer whales, as well as a review of the threats that the population currently faces.

## 1.7 Knowledge Gaps

### 1.7.1 Gaps in Transient Population Data

- There are numerous difficulties associated with accurately estimating the total population of West Coast transients and this is a pressing concern. Achieving consensus among researchers to establish criteria to define and enumerate the population is a priority.
- The life history parameters specific to the transient population are not yet known, primarily because a significant proportion of the population is not reliably sighted each year. Mortality rates are particularly difficult to determine with precision because of long gaps between resightings of many animals in the population. More intensive efforts to encounter transients specifically would help to alleviate this, as well as to acquire acoustic, genetic, distribution and behavioural data that would fill many of the other knowledge gaps for this population. Statistical methods, such as mark-recapture (or sight-resight) techniques, are currently being employed to estimate abundance.
- The historical abundance of transient killer whales is not known. Better estimates of their historical abundance will help to establish meaningful targets for population recovery.
- The population-level consequences of a low population size, and its effects on the sustainability and viability of the transient killer whale population are not well understood.

- The effects of environmental catastrophes on the abundance of transient killer whales and their prey, as well as their habitat, are not well understood. Similarly, the effects of climate or environmental change on transient killer whales, their prey and their habitat are not well understood.

### 1.7.2 Knowledge Gaps Regarding Distribution

- Members of the West Coast transient population range widely, and their spatial and temporal distribution is not well understood. The preferred areas or home ranges of some individuals have been estimated for a small proportion of the population only.
- Critical and important habitat for transient killer whales has not been identified.

### 1.7.3 Dietary Knowledge Gaps

- Although it is well known that transients prey on marine mammals, there are many questions regarding their year-round diet and energetic requirements. The extent to which killer whales rely on specific prey species is not well known. It is also not known how readily, or why, they shift from one prey species to another. The foraging strategies that transients use to detect and successfully hunt their prey are also not well understood.
- Information on the consequences of changes in prey populations is lacking. This is of particular concern given the decline of prey populations in western Alaska and the apparent shifting/switching of key prey species by Gulf of Alaska transients. There is very little known about the distribution and abundance of small cetaceans in British Columbia, thus it is difficult to know their role in the year-round diet of transient killer whales.
- Fatty acid and contaminant profiles that could provide additional information on the full range of prey for West Coast transients have yet to be developed.
- The health indicators for prey populations in the wild are not well developed. Information is generally collected only for stranded small cetaceans and pinnipeds.

### 1.7.4 Knowledge Gaps Regarding Contaminants

- There is a distinct lack of information on the wide range of anthropogenic environmental contaminants to which transient killer whales and their prey are exposed.
- There is a lack of baseline information on contaminant levels in killer whale males, females and young, and trends over time.
- The effects of contaminants on killer whales, both at the individual and the population level, as well as on their prey and their habitat are not well understood. Similarly, the effects of contaminants passed on to offspring from reproducing females are not well known.

- There are very few baseline data on contaminant levels, including hydrocarbons, in the British Columbia coastal environment (West Coast transient killer whale habitat), rendering mitigation of possible sources challenging.
- There are insufficient means available to measure the health of killer whales in the wild (e.g., biomarkers using biopsy samples).
- The virulence of pathogens in killer whales is not well understood.

#### 1.7.5 Knowledge Gaps Regarding Social Behaviour

- The association patterns of West Coast transients are not well understood, nor are the factors that influence their dispersal.
- The extent to which competition exists within or between groups of transients, and whether this is a factor in individuals dispersing (either temporarily or permanently), is not known.
- The breeding system of transients is not well understood. The mechanisms that transients use to avoid inbreeding are unknown, particularly because all members of the West Coast population share acoustic calls.
- The social relationship between residents and transients is not well understood. The relationships between West Coast transients and other transient populations are unknown.

#### 1.7.6 Gaps in Knowledge Regarding Disturbance

- The long- and short-term effects of physical disturbance (e.g. shipping, whale-watching) on transient killer whales are not well understood.
- The long and short-term effects of acoustic disturbance (chronic as well as acute) on transient killer whales and their prey are not well understood.
- There are very few data on ambient noise levels throughout the range of West Coast transients. These data would provide an important frame of reference to use to assess the effects of acoustic disturbance.
- The effects of stress associated with chronic disturbance of transient killer whales are not known.

# 2. RECOVERY

## 2.1 Recovery Feasibility

Transient killer whale populations are not expected to achieve high abundances due to their ecological position as upper trophic-level predators and their apparent propensity to live in relatively small populations. It is presumed that population abundance is limited by prey availability, and whether the current population is below or at carrying capacity is unknown. Regardless, the threat of decline due to the strikingly high contaminant burden that this population carries as a result of bioaccumulation through its prey, along with other potentially significant threats such as disturbance and prey reduction, warrants the protection of *Species at Risk Act* prohibitions and the implementation of recovery actions that will address threats, so that transient killer whales do not decline to an Endangered status. (See section 1.5.2 for the classification of threats and associated risk). As technologies and methodologies currently exist to reduce many of the threats facing killer whales, their prey and their habitat, recovery is considered feasible.

Contaminants are considered a high priority threat that must be addressed, and sources of these chemicals are widespread and diffuse. Accordingly, cooperation among federal, provincial and municipal governments, industries that produce or use these chemicals, and action at a citizen level, will be necessary to mitigate the effects of this threat. Effective implementation of initiatives such as Environment Canada's Georgia Basin Action Plan (EC-GBAP 2005), Environment Canada's regulatory review of these chemicals, and non-governmental programs such as the Green Boater Program and Pesticide Free Lawns, will complement the objectives in this recovery strategy to improve the quality of killer whale prey and their habitat, and reduce disturbance to important life processes. The decline of PCBs, DDT, dioxins and furans in the local marine environment since their source control and regulation demonstrates that actions taken can have tangible results and should serve as a model for the management of persistent, bioaccumulative and toxic (PBTs) chemicals, such as the largely unregulated PBDEs.

As prohibitions on the killing of pinnipeds since the early 1970s have resulted in pinniped populations approaching or at historic levels of abundance, there appears to be no immediate threat of prey limitation. However, further research on the dietary needs of the transient population is required.

Finally, measures to address the threat of disturbance have resulted in a reduction in disturbance from some priority activities. The successful implementation of monitoring programs for boaters viewing and operating vessels around all marine mammals, including transient killer whales, indicate a greater awareness and compliance to appropriate boating practices (e.g., 'Be Whale Wise' boating guidelines developed by DFO and the US National Oceanic and Atmospheric Administration). Ecotourism operators in British Columbia have shown leadership and initiative in developing codes of practices, such as the 'Best Practices Guidelines' developed by the industry-based Whale Watch Operators Association- Northwest (WWOANW 2006), which have also evolved to consider new information regarding activities that cause disturbance. Protocols for the mitigation of acute noise from both military active sonar and seismic have similarly reduced the threat of disturbance or injury from these activities (see Section 1.6.3).

## 2.2 Recovery Goal

*To attain long-term viability of the West Coast transient killer whale population by providing the conditions necessary to preserve the population's reproductive potential, genetic variation, and cultural continuity*

## 2.3 Population Objectives

This recovery goal reflects the complex social and behavioural dynamics of transient killer whales and the key threats that may lead to their decline. In the absence of historical data, it does not identify a numerical target for a "viable" population because the current understanding of killer whale population demographics is inadequate for setting a meaningful value at this time. However, because maintaining the demographic conditions that will preserve the population's reproductive potential, genetic variation, and cultural continuity is fundamental to the population's continued existence, population objectives, in the form of demographic indicators, have been expressed herein that will serve as interim measures of recovery success.

There are three population objectives for the five-year time span of this recovery strategy:

P1 The population size, averaged over the next five years, will remain at or above the current level.

P2 The number of breeding females in the population, averaged over the next five years, will remain at levels that will provide a neutral or positive growth rate.

P3 Studies will be undertaken to determine numerical and demographic population objectives that represent long-term viability for this population.

## 2.4 Distribution Objectives

Transient killer whales currently range widely throughout British Columbia, and into southeastern Alaska and Washington state waters. This range likely reflects the whales' hunting strategies and the wide distribution of their prey. At the same time, little is understood about how transient killer whales associate and how groups range and utilize the known habitat. The following distribution objectives are directed at understanding these relationships and ensuring that the population, as a whole, has access to adequate quantities of their known prey species throughout their range.

There are three distribution objectives for the five-year time span of this recovery strategy:

D1 Transient killer whales will continue to utilize their known range.

D2 Prey will be available, in quantities adequate to support recovery, throughout the currently known range of transient killer whales.

D3 Studies will be undertaken to determine how the range is utilized at a population and sub-population level.

## 2.5 Recovery Objectives

To achieve protection (recovery) of this population, studies to understand conservation threats and the development of measures to address the threats are necessary. Given our current knowledge, the primary anthropogenic threats to the long-term survival of transient killer whales appear to be environmental contaminants and disturbance. However, while some of the key prey species of pinniped are currently at historic high levels, the potential for these populations to decline because of human activities dictates the need for objectives to ensure prey remains available at sufficient quantities and of adequate quality so as not to limit transient killer whale population maintenance and/or increases.

Recovery objectives for the next five years of this recovery strategy, which directly address these threats and contribute to achieving the overarching long term recovery goal and the population and distribution objectives, are outlined below. The first four objectives provide direction for the strategies and approaches that can be used to mitigate and/or eliminate each of the threats facing transient killer whales. The remaining four objectives focus on obtaining information needed to develop a more comprehensive understanding of these threats, which will allow for the refinement of mitigation measures.

R1 Minimize the exposure to transient killer whales to legacy and emergent pollutants.

R2 Minimize the risk of prey population reductions from anthropogenic activities, until precise prey needs can be determined.

R3 Current measures to protect transient killer whales from vessel disturbance will be maintained or modified, if determined necessary from further studies.

R4 Minimize the exposure of transient killer whales to acute or chronic sound levels in excess of those considered to cause behavioural or physical harm in cetaceans.

R5 The quantity, quality and distribution of transient killer whale prey necessary to sustain or increase the current population level will be determined.

R6 A greater understanding of the impacts of contaminants and other biological and non-biological pollutants on transient killer whales will be developed.

R7 The effects of vessel disturbance on transient killer whales will be evaluated.

R8 A more comprehensive understanding of the impacts of chronic and acute noise on transient killer whales will be developed.

## 2.6 Approaches Recommended to Meet Recovery Objectives

Approaches recommended to achieve the population, distribution and recovery objectives outlined in Section 2.3, 2.4 and 2.5 are detailed in Table 2 and are meant to serve as guidance to future Action Planning, as required by SARA and to recovery activities that will be undertaken by government and non-government organizations. Although the objectives are focused on a five-year term, the many approaches outlined below will likely extend past the term of this recovery strategy or be ongoing requirements.

In addition to the lead role DFO has for this population's recovery, there are several government agencies who have a key role in supporting transient killer whale protection and recovery including: Parks Canada, Environment Canada, the Department of National Defence, Natural Resource Canada and the Province of British Columbia.

While governments and agencies have legislative and program responsibilities to support transient recovery, the role of non-government organizations and the public in general cannot be underestimated with respect to effecting transient recovery. Stewardship, education and outreach need to be considered in each of the following specific approaches for recovery.

### 2.6.1 Recovery planning

Table 2. Recovery Planning Table

| Priority | Threats addressed | Broad strategy to address threat | Recommended approaches to meet recovery objectives |
|---|---|---|---|
| Objective P1 & P2: *Population size and demographic monitoring* | | | |
| | n/a | Population census | Directed surveys |
| | | | Collaborations with other transient researchers |
| | | | Formal and informal sightings networks including opportunistic photo-identification |
| | | Analytical modelling | Numerical and demographic population modelling |
| *Objective P3: Setting demographic and numerical population objectives* | | | |
| | n/a | Analytical modelling | Numerical and demographic population modelling |
| Objective D1 & D3: *Monitoring of range utilization* | | | |
| | n/a | Population census | Directed surveys |
| | | | Collaborations with other transient researchers |
| | | | Formal and informal sightings networks including opportunistic photo-identification |
| Objective D2: *Monitoring of prey distribution* | | | |
| | n/a | Population monitoring | Pinniped surveys |
| | | | Formal and informal sightings networks for small cetaceans |
| Objective R1: *Reducing contaminants in Transient Killer Whales (TKW) and their prey* | | | |
| | Contamination | Regulations & Prohibitions | Maintain and enforce existing prohibition on regulated PBTs and other non-PBT chemicals |
| | | | Evaluate the need for and efficacy of prohibitions on use of unregulated PBDEs and other non-PBTs that affect TKW or their prey and implement mitigation measures as necessary |
| | | | International cooperation and collaboration to reduce PBTs used outside Canada that contribute to Canadian contaminant levels |
| | | Stewardship & Education | Government and non-government education and stewardship programs for industrial and private use of PBT and non-PBT compounds including currently used pesticides |
| | | Contaminant Monitoring | Dedicated sampling program for transient killer whales |
| | | | Dedicated sampling program for harbour seals |
| | | | Benchmark studies for other important prey species (other pinnipeds and cetaceans) |
| | | | Sediment sampling and monitoring (provides link to model food web bioaccumulation & link to sediment quality guidelines) |
| | | | Necropsy stranded TKW to evaluate possible exposure to contaminants, biological pollutants & pathogens |
| Objective R2: *Protecting Prey Populations* | | | |

| Priority | Threats addressed | Broad strategy to address threat | Recommended approaches to meet recovery objectives |
|---|---|---|---|
| | Prey limitation | Pinniped harvest protection | Maintain current harvest restrictions and ensure research, nuisance seal or other authorized removals do not cause pinniped population level reductions |
| | | Small Cetacean protection | Maintain harvest restrictions and develop and/or maintain programs to protect small cetaceans from anthropomorphic threats |
| Objective R3: *Protecting TKW from vessel disturbance* | | | |
| | Disturbance | Regulations | Implement the proposed Marine Mammal Regulation amendments of the *Fisheries Act* |
| | | Stewardship & Education | Government and non-government education and stewardship programs for stewardship and education programs aimed at reducing vessel disturbance |
| | | Guidelines | Amend as necessary and/or develop species or area specific guidelines for viewing of transient killer whales |
| | | Enforcement & Monitoring | Continue and modify, as necessary, enforcement and monitoring programs directed to compliancy with guidelines and regulations |
| | | | Evaluate the efficacy of enforcement and education programs, and develop as necessary new approaches and protocols for TKW |
| Objective R4: *Protecting TKW from harmful acute and chronic sound exposure* | | | |
| | Disturbance & harm | Seismic survey management | Review, develop and implement mitigation measures for all seismic surveys conducted throughout British Columbia TKW range to prevent disturbance or injury |
| | | Sonar management | Continue development and implementation of adequate National Defence sonar protocols to minimize risk of exposure of transients to intense sound sources |
| Objective R5: *Determining prey needs* | | | |
| | Prey limitation | Studies on foraging | Opportunistic prey sampling during dedicated population census surveys |
| | | | Directed surveys to determine diet of transients in offshore waters<br>Population abundance surveys of cetacean prey species |
| | | | Opportunistic observations through formal and informal sightings networks |
| Objective R6: *Understanding the effects of contaminants and biological pollutants on TKW* | | | |
| | Toxic Contamination | Data collection, analysis & modelling | Develop methods to measure the contaminant effects on health of TKW using biopsy |
| | | | Demographic data exploration to evaluate possible population level impacts |
| | | Studies on surrogate species | Controlled stuides on surrogate species (laboratory animals or other more abundant species auch as harbour seals) to predict effects of contaminants on TKW |
| | Biological Pollutants & Pathogens | Analysis of existing and new necropsy data | Necrospy, sample collection and analysis of samples |
| Objective R7: *Understanding vessel disturbance effects* | | | |
| | Disturbance | Behavioural studies | Dedicated studies of foraging behaviour and predation |

| Priority | Threats addressed | Broad strategy to address threat | Recommended approaches to meet recovery objectives |
|---|---|---|---|
| | | | rates in the presence of vessels |
| Objective R8: *Understanding the effects of acute and chronic sound exposure* | | | |
| | Disturbance & harm | Behavioural studies | Determine effect of high levels of chronic and acute industrial underwater noise on TKW behaviour and foraging success |
| | | Data synthesis | Compile existing data to evaluate the impact of chronic and acute sound exposure |

## 2.7 Performance Measures

The performance measures that will be used to determine whether the objectives established within this recovery strategy are effective are explicitly stated within the objectives themselves. The evaluation of the performance of this recovery strategy will thus be addressed through the achievement of each objective. Given our limited understanding of transient killer whale population dynamics, the role of prey limitation, the mechanisms and effects of anthropogenic threats and potential for synergistic effects between threats, completing the studies identified in this recovery strategy is a crucial first step towards achieving the long term goal of population viability. However, it is uncertain whether these information gaps can be filled within a five-year time period and this will be considered in the overall evaluation at the end of this timeline.

## 2.8 Critical Habitat

"Critical habitat" is defined under SARA as "*the habitat that is necessary for the survival or recovery of a listed wildlife species that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species*" (SARA s.2 (1)). Under SARA, defining critical habitat for transient killer whales to the extent possible is a legal requirement (SARA s.41 (1) (c)). However, there are significant gaps in our knowledge of the habitat requirements of transient killer whales.

Transients do not appear to be limited by specific physical features of the environment, other than features that may help them to successfully capture their prey. They generally range widely over the coast, and although transients may be seen year-round, they rarely remain in any one area for extended periods, likely because their hunting tactics rely on being able to surprise their prey. Once prey becomes alerted to the presence of transient killer whales in an area, they engage in anti-predator behaviours and become more difficult to capture. Ambient noise is potentially an important factor influencing foraging success of transients, as they likely detect prey by passive listening (Barrett-Lennard et al. 1996, Ford and Ellis 1999). Transients could potentially be displaced from foraging habitat if chronic anthropogenic noise interferes with prey detection. Transients often return repeatedly to particular areas to forage (e.g. seal and sea lion haul-outs), but our understanding of which of these areas are important to transients on a population level is still very limited. Consequently, it is necessary to develop a Schedule of Studies to better understand and identify critical habitat. This is included in Section 2.8.1, Schedule of Studies to Identify Critical Habitat.

### 2.8.1 Schedule of Studies to Identify Critical Habitat

Table 3. Schedule of Studies for the Identification of Critical Habitat

| Description of Activity | Outcome/Rationale | Timeline |
|---|---|---|
| Spatial analysis of existing sighting data | To better understand habitat utilization | Within one year of recovery strategy of acceptance |
| Spatial analysis of existing data with respect to the distribution of the prey of transient killer whales | To better understand habitat utilization and whether transient distribution is correlated to prey abundance | Within next five years |
| Spatial analysis of transient kill locations with respect to ambient noise environment | To determine whether transient hunting success is influenced by anthropogenic noise | Within next five years |
| Year-round surveys to determine range and seasonal movements of transients | To better identify areas of occupancy | Within next five years |
| Year-round surveys to determine the spatial and temporal distribution and abundance of small cetaceans | To better understand habitat utilization and whether transient distribution is correlated to prey abundance | Within next five years |
| Formal and informal sightings network for TKW and small cetaceans | Acquire better information on the distribution of transient prey and how it may influence transient distribution | Within next five years |

## 2.9 Effects on Other Species

The collateral effects of protecting the habitat for transient killer whales through addressing contaminants and other sources of pollution are likely to be widespread, and will be beneficial to human health as well as to a wide variety of organisms including transient prey. However, if transient killer whale populations increase, a reduction from the current high levels of abundance of pinniped populations might be anticipated. However, it would not be expected that these populations would be in jeopardy. Not enough is known about the population status of cetacean prey species to predict an effect. The strategies to protect transient killer whales from disturbance are complimentary to those recommended for resident killer whales and will have a positive effect on marine mammals in general.

## 2.10 Recommended Approach for Recovery Implementation

A single species, single population approach is recommended for recovery of transient killer whales that encompasses a variety of strategies that focus on the threats to killer whales, their prey and their habitat. However, because the strategies to address threats and some of the research needs are similar to those for resident killer whales, in practicality, it is likely that some activities will be conducted in a combined or complementary fashion.

## 2.11 Statement on when Action Plans will be Completed

Within two years of posting the final version of this recovery strategy, one or more action plans will be developed. The plan(s) will include descriptions of programs, plus a timeline of programs with estimated budgets and will encompass a timeframe of at least five years. The action plan(s) will complement the action plan(s) that are to be developed for resident killer whales, where appropriate, and may be coordinated for certain aspects if logistically feasible. In the interim, many of the strategies in this document can be acted on and therefore, recovery implementation will be an ongoing activity that can occur in the absence of any formal action plan.

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## APPENDIX A. GLOSSARY OF TERMS

Bioaccumulation - The process by which (toxic) substances from prey and the environment increase in concentration over time in living organisms

Depensation - When a decline in population numbers leads to reduced survival or reduced reproduction

Endocrine disruptor - A substance that interferes with the normal processes of natural hormones in the body (which are responsible for the maintenance of reproduction, development and behaviour)

Immunotoxicity - An adverse effect on an organism's immune system due to exposure from a chemical substance

Immunosuppression - A reduction in the activation or efficacy of the immune system

Lymphocyte - A type of white blood cell involved in immune system functioning

Putative - Commonly thought

Senescence - Aging

Sympatric - Closely related populations or ecotypes that overlap in their range but do not interbreed

# APPENDIX B. ANTHROPOGENIC THREAT CLASSIFICATION TABLE DEFINITIONS

Note that these are taken from the Draft *Species at Risk Act* Implementation Guidance, Guidelines on Identifying and Mitigating Threats to Species at Risk, September 27, 2006 produced by Environment Canada.

## Stressor Categories

Broad definition indicating the type of threat.
Habitat Loss or Degradation, Exotic or Invasive Species, Changes in Ecological Dynamics or Natural Processes, Pollution, Accidental Mortality, Consumptive Use, Disturbance or Persecution, Climate and Natural Disasters, Natural Processes or Activities

## Threat Definitions

General Stressor - Typically the general activity causing the specific threat. To be determined by status report author or recovery team/planner.

Specific Stress - The specific factor or stimulus causing stress to the population.

Effect - Indicated by an impairment of a demographic, physiological or behavioural attribute of a population in response to an identified or unidentified threat that results in a reduction of its viability.

Extent - Indicate whether the threat is widespread, localized or unknown across the species range.

Occurrence - Indicate whether the threat is historic, current, imminent, anticipated or unknown.

Frequency - Indicate whether the threat is a one-time occurrence, seasonal, continuous, recurrent, or unknown.

Causal Certainty - Indicate whether the best level of evidence suggests demonstrated, expected, plausible, or unknown linkage between stressor and effect on population viability.

Severity - Indicate whether the severity of the threat to the population is high, moderate, low or unknown.

# APPENDIX C. POLLUTANTS THAT MAY POSE A RISK TO TRANSIENT KILLER WHALES.

| Pollutant | Use/Source | Persistent | Bio-accumulate | Risk |
|---|---|---|---|---|
| DDT<br>*(Dichloro-diphenyl-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, aluminium 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 sulfonates* | 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 deVijver et al. 2003, Rayne et al. 2004, Song et al. 2005

## APPENDIX D. FISHERIES & OCEANS CANADA TECHNICAL RECOVERY TEAM MEMBERS

| | |
|---|---|
| Marilyn Joyce | Fisheries and Aquaculture Management (Chair) |
| John Ford | Cetacean Research Program |
| Peter Ross | Ocean Science Division |
| Graeme Ellis | Cetacean Research Program |
| Ryan Galbriath | Oceans & Watershed Planning |

## APPENDIX E RECORD OF COOPERATION AND CONSULTATION

Transient killer whales are listed as "threatened" on Schedule 1 of the Species at Risk Act (SARA) and as an aquatic species are under federal jurisdiction, and are managed by Fisheries and Oceans Canada (DFO) 200 - 401 Burrard Street, Vancouver, BC., V6C 3S4.
As there are few people in Canada with scientific, traditional or local knowledge of transient killer whales, DFO brought together a small internal group of technical experts to develop an initial draft of this recovery strategy.

A Technical Workshop was hosted in January 2007 to provide a forum for the sharing of knowledge and expertise on transient killer whales between the Recovery Team and an invited group of researchers, environmental non-governmental organizations, and other governmental (federal and provincial) staff from both Canada and the United States. This workshop was invaluable in assisting the DFO Transient Killer Whale Recovery Team in the drafting of the recovery strategy. Given that the population of killer whales considered in this recovery strategy frequent both Canadian and United States (US) waters, bilateral government and non-government input and collaboration was sought.

On the advice of the Species at Risk First Nations Coordinator, a letter was sent to all coastal First Nations soliciting their participation in the development of the recovery strategy. Bands or groups who responded with a specific interest in this species were contacted directly. Consultations were web, mail and email based and included mail-outs to all coastal First Nations. An initial draft (March 2007) of the recovery strategy and a discussion guide and feedback form were made available. In addition, a message announcing the development of the recovery strategy, was sent to a marine mammal list serve (MARMAM) with a broad local and international distribution to marine mammal researchers and interests, 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. An announcement was put in the DFO internal staff publication "In the Loop".

Comments on the recovery strategy were received from three independent sources and from three government agencies: Parks Canada, the Department of National Defence and the Province of BC. Natural Resources Canada, Environment Canada and Transport Canada had no comments on the strategy. Seven First Nations responded to consultation letters: two requested a copy of the recovery strategy: two requested a meeting to discuss the recovery strategy and two expressed an interest engagement at a later date, one letter of support was received.

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

<u>DFO Recovery Team:</u>

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| Marilyn Joyce | Fisheries & Oceans Canada |
| John Ford | Fisheries & Oceans Canada |
| Graeme Ellis | Fisheries & Oceans Canada |
| Peter Ross | Fisheries & Oceans Canada |
| Peter Olesiuk | Fisheries & Oceans Canada |
| Kim West, | Fisheries & Oceans Canada |
| Tatiana Lee | Fisheries & Oceans Canada |
| Ryan Galbraith | Fisheries & Oceans Canada |

<u>Technical Workshop Participants:</u>

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| John Durban | National Oceanic & Atmospheric Administration |
| Steven Raverty | Ministry of Agriculture and Lands, Animal Health Center |
| Kathy Heise | University of British Columbia |
| Lance Barrett-Lennard | Vancouver Aquarium Marine Science Centre |
| Volker Deecke | University of British Columbia, |
| Janet Straley | University of Alaska |
| Dave Ellifrit | Centre for Whale Research |
| Andrew Trites | University of British Columbia |