

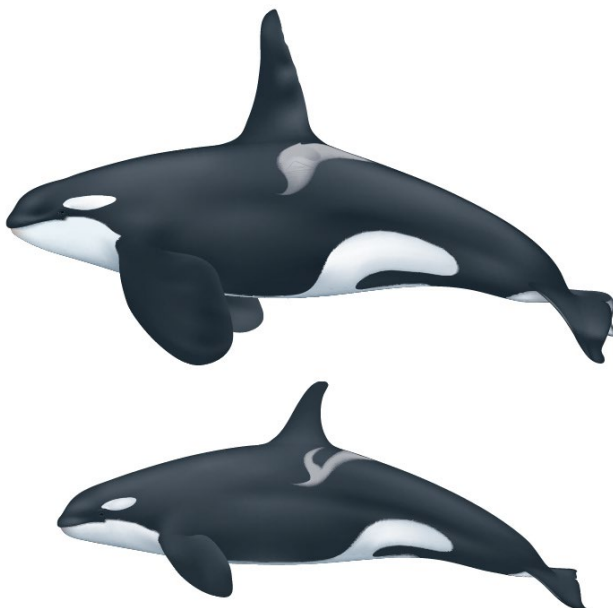
# COSEWIC Assessment and Status Report

on the

## Killer Whale *Orcinus orca*

Northeast Pacific Southern Resident population  
Northeast Pacific Northern Resident population  
Northeast Pacific Transient Killer Whale population  
Northeast Pacific Offshore population  
Northwest Atlantic / Eastern Arctic population

in Canada



Northeast Pacific Southern Resident population - **ENDANGERED**  
Northeast Pacific Northern Resident population - **THREATENED**  
Northeast Pacific Transient Killer Whale population - **THREATENED**  
Northeast Pacific Offshore population - **THREATENED**  
Northwest Atlantic / Eastern Arctic population - **SPECIAL CONCERN**  
2023

**COSEWIC**  
Committee on the Status  
of Endangered Wildlife  
in Canada



**COSEPAC**  
Comité sur la situation  
des espèces en péril  
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2023. COSEWIC assessment and status report on the Killer Whale *Orcinus orca*, Northeast Pacific Southern Resident population, Northeast Pacific Northern Resident population, Northeast Pacific Transient Killer Whale population, Northeast Pacific Offshore population, and Northwest Atlantic / Eastern Arctic population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxxi + 114 pp. (<https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html>).

Previous report(s):

COSEWIC. 2008. COSEWIC assessment and update status report on the Killer Whale *Orcinus orca*, Southern Resident population, Northern Resident population, West Coast Transient population, Offshore population and Northwest Atlantic / Eastern Arctic population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 65 pp. (<https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html>).

COSEWIC. 2001. COSEWIC assessment and update status report on the Killer Whale *Orcinus orca* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 47 pp. (<https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html>)

Baird, R. 1999. COSEWIC assessment and update status report on the Killer Whale *Orcinus orca* in Canada. Committee on the Status of Endangered Wildlife In Canada. Ottawa. ix + 47 pp.

Production note:

COSEWIC would like to acknowledge Randall Reeves (Okapi Wildlife Associates) for writing the status report on Killer Whale, *Orcinus orca*, (Northeast Pacific Southern Resident population, Northeast Pacific Northern Resident population, Northeast Pacific Transient Killer Whale population, Northeast Pacific Offshore population, Northwest Atlantic / Eastern Arctic population) in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by John K. B. Ford, Co-chair of the COSEWIC Marine Mammals Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur L'épaulard (*Orcinus orca*), population résidente du sud, population résidente du nord, population migratrice de la côte Ouest, population océanique et populations de l'Atlantique Nord-Ouest et de l'est de l'Arctique, au Canada

Cover illustration/photo:

Illustration of male (top) and female (bottom) Resident Killer Whales, courtesy Uko Gorter.

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## COSEWIC Assessment Summary

### Assessment Summary – December 2023

**Common name**

Killer Whale - Northeast Pacific Southern Resident population

**Scientific name**

*Orcinus orca*

**Status**

Endangered

**Reason for designation**

The population of this long-lived fish-eating apex marine predator is very small (46 mature individuals) and continues to decline. No immigration occurs and the population shows signs of inbreeding depression. The population is limited and dependent on the availability and abundance of its principal prey, Chinook Salmon, whose current low abundance is expected to continue. The whales are also threatened by increasing vessel traffic and associated acoustic disturbance, contaminants, vessel strikes, and, potentially, oil spills.

**Occurrence**

British Columbia, Pacific Ocean

**Status history**

The “North Pacific resident populations” were given a single designation of Threatened in April 1999. Split into three populations in November 2001. The Northeast Pacific southern resident population was designated Endangered in November 2001. Status re-examined and confirmed in November 2008 and December 2023.

### Assessment Summary – December 2023

**Common name**

Killer Whale - Northeast Pacific Northern Resident population

**Scientific name**

*Orcinus orca*

**Status**

Threatened

**Reason for designation**

The population of this long-lived fish-eating apex marine predator is small (~176 mature individuals) and dependent on the availability of its principal prey, Chinook Salmon, whose current low abundance is expected to continue. This whale is at risk from physical and acoustical disturbance, vessel strikes, contaminants, and, potentially, oil spills. Although this population meets criteria for Endangered, it has been increasing slowly (average of 2%/yr) since monitoring began in 1974, likely recovering from past human-caused mortality and live-capture for public display.

**Occurrence**

British Columbia, Pacific Ocean

**Status history**

The “North Pacific resident populations” were given a single designation of Threatened in April 1999. Split into three populations in November 2001. The Northeast Pacific northern resident population was designated Threatened in November 2001. Status re-examined and confirmed in November 2008 and December 2023.

### **Assessment Summary – December 2023**

**Common name**

Killer Whale - Northeast Pacific Transient Killer Whale population

**Scientific name**

*Orcinus orca*

**Status**

Threatened

**Reason for designation**

The population of this long-lived, apex marine mammal-eating predator is small (~192 mature individuals). Threats include acoustical and physical disturbance, potential future reduction in prey abundance, vessel strikes, and, potentially, oil spills. However, the population appears to have been slowly increasing since the mid-1970s when monitoring began, and its prey base of pinnipeds and small cetaceans is currently stable or increasing.

**Occurrence**

British Columbia, Pacific Ocean

**Status history**

Designated Special Concern in April 1999. Status re-examined and designated Threatened in November 2001 and in November 2008. Status re-examined and confirmed in December 2023.

### **Assessment Summary – December 2023**

**Common name**

Killer Whale - Northeast Pacific Offshore population

**Scientific name**

*Orcinus orca*

**Status**

Threatened

**Reason for designation**

The population of this long-lived apex marine predator is small (~160 mature individuals) and specializes in a diet of sharks and rays. Threats include contaminants, acoustical and physical disturbance, vessel strikes, potential future declines in prey availability, and possibly oil spills. However, the population does not appear to be declining.

**Occurrence**

British Columbia, Pacific Ocean

**Status history**

The “North Pacific resident populations” were given a single designation of Threatened in April 1999. Split into three populations in November 2001. The Northeast Pacific offshore population was designated Special Concern in November 2001. Status re-examined and designated Threatened in November 2008. Status re-examined and confirmed in December 2023.

## **Assessment Summary – December 2023**

### **Common name**

Killer Whale - Northwest Atlantic / Eastern Arctic population

### **Scientific name**

*Orcinus orca*

### **Status**

Special Concern

### **Reason for designation**

The range of this long-lived apex marine predator has recently expanded in the Eastern Arctic and the frequency of sightings has increased, likely due to the availability of new hunting areas because of declining summer sea ice. Occurrence and abundance of these whales elsewhere in their range is poorly known. Threats include hunting, contaminants, and acoustical and physical disturbance as shipping traffic increases. The population's small size (likely fewer than 1,000 mature individuals and perhaps even fewer than 250), known and potential threats, life history, and cultural attributes justify designation as Special Concern.

### **Occurrence**

Quebec, Newfoundland and Labrador, New Brunswick, Nova Scotia, Prince Edward Island, Manitoba, Nunavut, Atlantic Ocean, Arctic Ocean

### **Status history**

Species considered in April 1999 and in November 2001, and placed in the Data Deficient category. Re-examined in November 2008 and designated Special Concern. Status re-examined and confirmed in December 2023.



## **COSEWIC Executive Summary**

### **Killer Whale** *Orcinus orca*

#### **Wildlife Species Description and Significance**

Killer Whales, or Orcas (*Orcinus orca*), are easily identified by their tall, triangular dorsal fin and their distinctive black and white coloration. Only one species is recognized, but the taxonomy of *Orcinus* is a subject of ongoing debate.

#### **Indigenous Knowledge**

All species are significant and are interconnected and interrelated. Aboriginal Traditional Knowledge (ATK) has been included under relevant headings of the report.

#### **Distribution**

Killer Whales occur in all the world's oceans. In Canada, five designatable units (DUs) are recognized. The Northeast Pacific Southern Resident population (DU-1) is generally found around southern Vancouver Island in summer and fall, although the animals may range widely at other times of year and the Northern Resident population (DU-2) occurs from southwestern Vancouver Island north to southeastern Alaska. The Northeast Pacific Transient population (better known in British Columbia [BC] as Bigg's Killer Whale) (DU-3) occurs throughout the coastal waters of BC. The Northeast Pacific Offshore Killer Whales (DU-4) are seen less frequently but are known to travel widely in BC outer coastal waters. Killer Whales are generally less common in the Northwest Atlantic / Eastern Arctic (DU-5), but they are widely distributed there.

#### **Habitat**

Killer Whales can tolerate wide ranges of salinity, temperature, and turbidity, and their distribution appears to be determined mainly by the distribution and accessibility of their prey. The declining extent and duration of sea ice due to ocean warming is making new habitat (and prey resources) available to Killer Whales in Hudson Bay and the High Arctic.

## **Biology**

Killer Whales are long-lived upper trophic-level predators. Individuals can be distinguished by scars and variations in pigmentation and dorsal fin shape. Life history parameters for the Resident populations in BC have been estimated based on nearly 50 years of photo-identification studies. It is not known how well these estimates apply to other populations. Longevity is at least 80 years for females and 40–50 years for males. Females give birth to their first calf at 12–17 years of age and they produce a single calf every 5 years. The generation time is 26–29 years. Females more than 40 years old have an extended period of reproductive senescence. Resident Killer Whales are exceptional among marine mammals in that there is no dispersal of individuals of either sex from the natal group. This does not appear to be true for Transient Killer Whales.

Although they are known to feed on a large number of prey species, the Resident and Transient populations in BC have remarkably different diets. Resident Killer Whales feed on fish, particularly Chinook and Chum Salmon, whereas Transient Killer Whales feed on marine mammals. The diet of Offshore Killer Whales is dominated by sharks and upper trophic-level fish. Killer Whales in the Northwest Atlantic and the Eastern Arctic have been observed feeding on marine mammals and fish.

## **Population Sizes and Trends**

There were 70 Southern Residents in 1974 and 73 in 2021, 132 Northern Residents in 1975 and 332 in 2021. The population of Northern Residents has continued to increase fairly steadily since monitoring began in the mid-1970s. In contrast, although Southern Residents increased fairly steadily through the mid-1990s, they have been mostly declining since then. Both populations have shown annual increases or declines of up to ~3% for several years in a row. The Transient (Bigg's) population has been increasing in recent decades and consisted of at least 349 individuals in 2018. Offshore Killer Whales in BC number around 300 individuals and there is little information on trends for this population. Based on very limited data, at least 160 Killer Whales are thought to visit the eastern Canadian Arctic in summer, and as of 2013, 67 individuals had been photo-identified between Labrador and Nova Scotia.

## **Threats and Limiting Factors**

The carcasses of Killer Whales are rarely recovered, and much of what is known about the threats they face is inferred using a weight-of-evidence approach. West Coast Killer Whales live in small, discrete populations that are inherently vulnerable to increases in mortality or decreases in reproduction. Exchange and interbreeding among these populations appear to be extremely rare, and this limits or prevents any genetic or demographic rescue effect. As a result of their fixed dietary specializations, Residents, Transients, and, most likely, Offshores, are vulnerable to decreases in the quantity or quality of their prey. It is not known whether the Northwest Atlantic / Eastern Arctic population specializes in similar ways.

The main anthropogenic threats to Northeast Pacific populations of Killer Whales are prey depletion, disturbance (physical and acoustic), and contaminants. These threats may act synergistically. Interactions with commercial fisheries (including bycatch), vessel strikes, and oil spills are also of concern. Less is known about threats to Killer Whales in the northwestern Atlantic and the Arctic. Some of the whales that are part of the Northwest Atlantic / Eastern Arctic population may be hunted in Greenland. Climate change likely affects Killer Whales indirectly by influencing their prey and the activities of humans.

### **Protection, Status and Ranks**

In Canada, Killer Whales are protected under the *Marine Mammal Regulations* of the *Fisheries Act* and under the *Canada National Parks Act* and the *Canada National Marine Conservation Areas Act*. The conservation status of the five Killer Whale populations in Canada was evaluated by COSEWIC in 2008 and all but one are now listed under the *Species At Risk Act* (SARA): the Northeast Pacific Southern Resident population as Endangered and the Northeast Pacific Northern Resident, Transient, and Offshore populations as Threatened. The Northwest Atlantic / Eastern Arctic population was assessed as Special Concern by COSEWIC but has yet to be listed under SARA. In December 2023, COSEWIC reassessed the Northeast Pacific Southern Resident population as Endangered; the Northern Resident, Offshore, and Transient populations as Threatened; and the Northwest Atlantic / Eastern Arctic population as Special Concern. A number of measures have been implemented in BC since 2008 to provide special protection to Pacific Killer Whales, especially the Southern Resident population. These include seasonal area closures to fishing and vessel traffic as well as limits on vessel speeds and approach distances, and SARA orders protecting critical habitat.

## TECHNICAL SUMMARY - Northeast Pacific Southern Resident population (DU-1)

*Orcinus orca*

Killer Whale (Northeast Pacific Southern Resident population) (DU-1)

Épaulard (Population résidente du sud du Pacifique Nord-Est)

Other English Common Name: Orca

Other French Common Name: Orque

Indigenous Names: (*note: names do not refer to specific DUs*): Maz7inuxw (Kwakwa'ala); Max'inuxw (Kwakwaka'wakw); Ska-ana (Haida); KELĽOLEMEĽEN (SENĽOTEN); kakawin, kaka7w'in (Nuu-cha-nulth); Kakawad (Ditidaht); qwunus (Lekwungen); Qaiqal xic (Puget Salish); Q'ul-lhanamutsum (Hul'qumi'inum); qəllələməcən (Halkomelem)

Range of occurrence in Canada (province/territory/ocean): British Columbia, Pacific Ocean

### Demographic Information

Generation time	26–29 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, observed and projected
Observed percent of continuing decline in total number of mature individuals within [3 years or 1 generation, whichever is longer, up to a maximum of 100 years]  One generation is 26–29 yr; observed numbers of total population were 91 in 1992, 98 in 1995, and 73 in 2021. Assuming 63% mature (as observed in 2021), number of mature individuals was 57 in 1992, 62 in 1998, and 46 in 2021.	20–26%
Estimated percent reduction in total number of mature individuals within last 2 generations  Two generations is 52–58 years, so 2 generations ago is 1963–1969. Earliest abundance estimate available is for 1967 which was 96 (all ages); in 2021 it was 73. Assuming 63% mature (as in 2021), there were 60 mature individuals in 1967 and 46 in 2021.	~23%
Estimated percent reduction in total number of mature individuals over the last 3 generations.  Three generations is 78–87 years, so 3 generations ago is 1934–1943. No abundance estimate is available prior to 1967, but Killer Whales were often subjected to directed shooting before the 1960s, so reduction is likely greater than 23% (decline over last 2 generations).	At least 23%, likely higher.

Projected percent reduction in total number of mature individuals over the next 3 generations:  In all, 46 mature individuals in 2021. Three generations from 2021 is 2099–2108. From Fig. 4 in Murray <i>et al.</i> (2021), abundance is projected to be about 25 individuals in 2099 and 20 in 2108, or 13–16 mature individuals (assuming 63% mature as observed in 2021).	56–72%
Observed and projected percent reduction in total number of mature individuals over 3 generations, including both the past and the future. Observed reduction in past generation (1992–1995 to 2021) and predicted reduction over next 2 generations (2021 to 2073–2079; from Murray <i>et al.</i> (2021) (Fig. 4) is decline from 91–98 mature individuals to about 25–32 mature individuals	65–75%
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No b. No c. No
Are there extreme fluctuations in number of mature individuals?	No

### Extent and Occupancy Information

Estimated extent of occurrence (EOO)	Exceeds thresholds
Index of area of occupancy (IAO) (Always report 2x2 grid value).	Exceeds thresholds
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of “locations” (use plausible range to reflect uncertainty if appropriate)	Unknown but could be <10
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”?	Unknown
Is there an inferred or projected decline in quality of habitat?	Yes
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	Unknown

Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

#### Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges) No subpopulations	N Mature Individuals
Total (73 all ages, 46 mature) (2021 census)	46, not including post-reproductive females

#### Quantitative Analysis

Is the probability of extinction in the wild at least 20% within 5 generations?	Yes
Population viability analysis using cumulative effects of multiple threats projects continued decline of 56–72% over next 90 years (roughly 3 generations) Murray <i>et al.</i> (2021)	

#### Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes
Overall threat impact: Very High - High
Key threats were identified as: <ul style="list-style-type: none"> <li>I. Pollution (IUCN 9) – high-medium impact</li> <li>II. Natural System Modifications (IUCN 7) – high-medium impact</li> <li>III. Transportation &amp; Service Corridors (IUCN 4) – medium impact</li> <li>IV. Biological Resource Use (IUCN 5) – low impact</li> <li>V. Human Intrusions &amp; Disturbance (IUCN 6) – low impact</li> <li>VI. Climate Change &amp; Severe Weather (IUCN 11) – unknown impact</li> </ul>
What additional limiting factors are relevant? <ul style="list-style-type: none"> <li>I. Fixed cultural attributes</li> <li>II. Mating behaviour and social dynamics</li> <li>III. Low reproduction rate</li> <li>IV. Small population size</li> </ul>

#### Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Not applicable
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	Not applicable
Is there sufficient habitat for immigrants in Canada?	Not applicable
Are conditions deteriorating in Canada?	Yes, abundance of primary prey is projected to continue declining
Are conditions for the source (i.e., outside) population deteriorating?	Not applicable

Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	No

### Data Sensitive Species

Is this a data sensitive species?	No
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### Status History

COSEWIC: The “North Pacific resident populations” were given a single designation of Threatened in April 1999. Split into three populations in November 2001. The Northeast Pacific southern resident population was designated Endangered in November 2001. Status re-examined and confirmed in November 2008 and December 2023.

### Status and Reasons for Designation:

Status: Endangered	Alpha-numeric codes: A3bce+4ace; C1+2a(i,ii); D1; E
Reasons for designation: The population of this long-lived fish-eating apex marine predator is very small (46 mature individuals) and continues to decline. No immigration occurs and the population shows signs of inbreeding depression. The population is limited and dependent on the availability and abundance of its principal prey, Chinook Salmon, whose current low abundance is expected to continue. The whales are also threatened by increasing vessel traffic and associated acoustic disturbance, contaminants, vessel strikes, and, potentially, oil spills.	

### Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A3bce+4ace; A3bce because the decline over the next 3 generations is projected to be >50%, and A4ace because the decline in number of mature individuals observed (a) over the past and projected into the future is >50%. Causes of decline are not known with certainty but believed to be primarily due to reduced prey abundance (c) as well as contaminants (e).
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Extent of occurrence and index of area of occupancy are above thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C1+2a(i,ii). The number of mature individuals is well below the threshold of 2,500 (there are only 46), and there was an observed decline of 20–26% over the last generation that is projected to continue. There is only one subpopulation that contains fewer than 250 mature individuals.
Criterion D (Very Small or Restricted Population): Meets Endangered, D1. Total number of mature individuals is 46, well below the threshold of 250.
Criterion E (Quantitative Analysis): Meets Endangered, E, because a population viability analysis using a cumulative threats model projects a continued decline of mature individuals >50% over next 3 generations.

## TECHNICAL SUMMARY - Northeast Pacific Northern Resident population (DU-2)

*Orcinus orca*

Killer Whale (Northeast Pacific Northern Resident population) (DU-2)

Épaulard (Population résidente du nord du Pacifique Nord-Est)

Other English Common Name: Orca

Other French Common Name: Orque

Indigenous Names: (*note: names do not refer to specific DU*): Maz7inuxw (Kwakwa'ala); Max'inuxw (Kwakwaka'wakw); Ska-ana (Haida);

KELŁOLEMEĆEN (SENĆOŦEN); Kakawad (Ditidaht); kakawin, kaka7w'in (Nuu-cha-nulth); qwunus (Lekwungen); Qaiqal xic (Puget Salish); Q'ul-Ihanamutsum (Hul'qumi'inum); qəłłaləməcən (Halkomelem)

Range of occurrence in Canada (province/territory/ocean): British Columbia, Pacific Ocean

### Demographic Information

Generation time	26—29 yrs
Is there a continuing decline in number of mature individuals?	No
Estimated percent of continuing decline in total number of mature individuals within the last two generations.	Not applicable
Observed percent increase in total number of mature individuals over the last 3 generations Total population (all ages) increased at 2.2%/yr from 1973–2021 (DFO 2022a).	Unknown, but increased by 2.6x over past 1.75 generations (since 1973)
Projected percent increase in total number of mature individuals over the next 3 generations  Population viability analysis using demographic population structure and cumulative effects of multiple threats (Murray <i>et al.</i> 2021) projects increase to about 450 individuals (all ages) or 238 mature individuals (assuming 53% mature as observed in 2021) over next 25 years, then stable over following 50–60 years (about 3 generations)	a. 35%
Estimated percent increase in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.  Observed increase over past 1 generation (1992–1995 to 2021) and predicted increase over next 2 generations (2021 to 2073–2079; from Murray <i>et al.</i> 's (2021) Fig. 4) is increase from 108–110 mature individuals to roughly 238 mature individuals	220% increase over 78–87 years (3 generations)
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	Not applicable as no decline a. b. c.

Are there extreme fluctuations in number of mature individuals?	No
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### Extent and Occupancy Information

Estimated extent of occurrence (EOO)	Exceeds thresholds
Index of area of occupancy (IAO) (Always report 2x2 grid value).	Exceeds thresholds
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of “locations” (use plausible range to reflect uncertainty if appropriate)	Unknown
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”?	Unknown
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Possibly
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	Unknown
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

### Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Total 332 (all ages) in 2021 (DFO 2022a Fig. 3, as interpreted by Brianna Wright, PBS/DFO, pers. comm.)	176, not including post-reproductive females

### Quantitative Analysis

Is the probability of extinction in the wild at least 20% within 5 generations?	No
Population viability analysis using demographic population structure and cumulative effects of multiple threats (Murray <i>et al.</i> 2021) projects increase over next 25 yr then stable for next 50–60 yrs	

### Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes
Overall threat impact: High – Medium
Key threats were identified as: <ol style="list-style-type: none"> <li>I. Natural System Modifications (IUCN 7) – medium impact</li> <li>II. Pollution (IUCN 9) – high-medium impact</li> <li>III. Transportation &amp; Service Corridors (IUCN 4) – low impact</li> <li>IV. Biological Resource Use (IUCN 5) – low impact</li> <li>V. Human Intrusions &amp; Disturbance (IUCN 6) – low impact</li> <li>VI. Climate Change &amp; Severe Weather (IUCN 11) – unknown impact</li> </ol>
What additional limiting factors are relevant? <ol style="list-style-type: none"> <li>I. Fixed cultural attributes</li> <li>II. Mating behaviour and social dynamics</li> <li>III. Low reproduction rate</li> </ol>

### Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada. Muto <i>et al.</i> (2021, p. 133): “Members of the [Northeast Pacific] Northern Resident population have been documented in southeastern Alaska; however, they have not been seen to intermix with Alaska Residents.... Alaska Resident whales are found from southeastern Alaska to the Aleutian Islands and Bering Sea. Intermixing of Alaska Residents have been documented among the three areas, at least as far west as the eastern Aleutian Islands.”	“Eastern North Pacific Alaska Resident Stock” thought to number > 2,000 individuals and increasing (Muto <i>et al.</i> 2021). However, this population almost certainly comprises multiple DUs.
Is immigration known or possible?	No – no immigration observed over past 50 yr
Would immigrants be adapted to survive in Canada?	Presumably
Is there sufficient habitat for immigrants in Canada?	Not known
Are conditions deteriorating in Canada?	Yes, abundance of primary prey forecast to continue declining
Are conditions for the source (i.e., outside) population deteriorating?	Not applicable
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	No

### Data Sensitive Species

Is this a data sensitive species?	No
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### Status History

#### COSEWIC:

The “North Pacific resident populations” were given a single designation of Threatened in April 1999. Split into three populations in November 2001. The Northeast Pacific northern resident population was designated Threatened in November 2001. Status re-examined and confirmed in November 2008 and December 2023.

### Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: Met criterion for Endangered, D1, but designated Threatened, D1, because of the recent and projected continued increase in mature individuals.
Reasons for designation: The population of this long-lived fish-eating apex marine predator is small (~176 mature individuals) and dependent on the availability of its principal prey, Chinook Salmon, whose current low abundance is expected to continue. This whale is at risk from physical and acoustical disturbance, vessel strikes, contaminants, and, potentially, oil spills. Although this population meets criteria for Endangered, it has been increasing slowly (average of 2%/yr) since monitoring began in 1974, likely recovering from past human-caused mortality and live-capture for public display.	

### Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. The population has been increasing at an average of 2% per year since the early 1970s when monitoring began.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Extent of occurrence and index of area of occupancy are greater than 20,000 km <sup>2</sup> .
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Although the population is small (176 mature individuals) and well below the threshold of 2,500, there is no continuing decline.
Criterion D (Very Small or Restricted Population): Meets Endangered, D1, because total number of mature individuals is only 176 which is below the threshold of 250.
Criterion E (Quantitative Analysis): Not applicable. Quantitative analysis projects continued increase in abundance, assuming no further decline in prey availability.

## TECHNICAL SUMMARY - Northeast Pacific Transient population (DU-3)

*Orcinus orca*

Killer Whale (Northeast Pacific Transient population)  
(DU-3)

Épaulard (Population migratrice du Pacifique Nord-Est)

Other English Common Name: Killer Whale (Bigg's population), Orca

Other French Common Name: Orque

Indigenous Names: (*note: names do not refer to specific DUs*): Maz7inuxw (Kwakwa'ala); Max'inuxw (Kwakwaka'wakw); Ska-ana (Haida);

KELŁOLEMEĆEN (SENĆOŦEN); Kakawad (Ditidaht); kakawin, kaka7w'in (Nuu-cha-nulth); qwunus (Lekwungen); Qaiqal xic (Puget Salish); Q'ul-Ihanamutsum (Hul'qumi'inum); qəłtələməcən (Halkomelem)

Range of occurrence in Canada (province/territory/ocean): British Columbia, Pacific Ocean

### Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	26–29 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years]	Not applicable as there is no decline
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].  Three generations (78–87 yr) prior to 2021 is 1934–1943.	Unknown. Abundance has increased since the mid-1970s (~1.75 generations) but no earlier estimate available.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	Not applicable as there is no decline
Are there extreme fluctuations in number of mature individuals?	No

### Extent and Occupancy Information

Estimated extent of occurrence (EOO)	Exceeds thresholds
Index of area of occupancy (IAO) (Always report 2x2 grid value).	Exceeds thresholds
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of “locations” (use plausible range to reflect uncertainty if appropriate)	Unknown
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”?	Unknown
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	Unknown
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

### Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Total 349 individuals of all ages in 2018, 206 of which were mature (Towers <i>et al.</i> 2019), or 192, assuming 7% of mature individuals are post-reproductive females as in the Northern Resident population	192

### Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	No analysis conducted
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**Threats (direct, from highest impact to least, as per IUCN Threats Calculator)**

Was a threats calculator completed for this species? Yes
Overall threat impact: High – Medium
Key threats were identified as: <ul style="list-style-type: none"> <li>I. Pollution (IUCN 9) –high-medium impact</li> <li>II. Natural System Modifications (IUCN 7) – medium-low impact</li> <li>III. Transportation &amp; Service Corridors (IUCN 4) – low impact</li> <li>IV. Biological Resource Use (IUCN 5) – low impact</li> <li>V. Human Intrusions &amp; Disturbance (IUCN 6) – low impact</li> <li>VI. Climate Change &amp; Severe Weather (IUCN 11) – unknown impact</li> </ul>
What additional limiting factors are relevant? <ul style="list-style-type: none"> <li>I. Fixed cultural attributes</li> <li>II. Mating behaviour and social dynamics</li> <li>III. Low reproduction rate</li> </ul>

**Rescue Effect (immigration from outside Canada)**

Status of outside population(s) most likely to provide immigrants to Canada. Muto <i>et al.</i> (2021, p. 149): "... 14 out of 217 transients on the outer coast of Southeast Alaska and British Columbia were identified as Gulf of Alaska transients and in one encounter they were observed mixing with West Coast transients (Matkin <i>et al.</i> 2012; Ford <i>et al.</i> 2013)."  Two-thirds of 193 Transients identified off California, considered part of this DU, have not yet been observed in Canadian waters (see text)	"Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient Stock" thought to number at least 587 individuals and considered stable (Muto <i>et al.</i> 2021); Transient population off California appears to be stable or growing
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Unknown
Are conditions deteriorating in Canada?	No
Are conditions for the source (i.e., outside) population deteriorating?	No
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Unknown

**Data Sensitive Species**

Is this a data sensitive species?	No
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**Status History**

COSEWIC: Designated Special Concern in April 1999. Status re-examined and designated Threatened in November 2001 and in November 2008. Status re-examined and confirmed in December 2023.
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### Status and Reasons for Designation:

<p>Status: Threatened</p>	<p>Alpha-numeric codes: Met criterion for Endangered, D1, but designated Threatened, D1, because total abundance has increased since the 1970s and the wildlife species is not at imminent risk of extirpation.</p>
<p>Reasons for designation: The population of this long-lived, apex marine mammal-eating predator is small (~192 mature individuals). Threats include acoustical and physical disturbance, potential future reduction in prey abundance, vessel strikes, and, potentially, oil spills. However, the population appears to have been slowly increasing since the mid-1970s when monitoring began, and its prey base of pinnipeds and small cetaceans is currently stable or increasing.</p>	

### Applicability of Criteria

<p>Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No reduction in total number of mature individuals has been observed since monitoring began in 1975.</p>
<p>Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Extent of occurrence is greater than 20,000 km<sup>2</sup> and index of area of occupancy is greater than 2,000 km<sup>2</sup>.</p>
<p>Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Although the population is small enough to qualify for Endangered because the total number of mature individuals is well below the threshold of 2,500 (~192 mature individuals), there is no continuing decline.</p>
<p>Criterion D (Very Small or Restricted Population): Meets Endangered, D1, because total number of mature individuals is ~192, less than threshold of 250.</p>
<p>Criterion E (Quantitative Analysis): Not applicable. No quantitative analyses have been conducted.</p>

## TECHNICAL SUMMARY - Northeast Pacific Offshore population (DU-4)

*Orcinus orca*

Killer Whale (Northeast Pacific Offshore population (DU-4))

Épaulard (Population océanique du Pacifique Nord-Est)

*Other English Common Name: Orca*

*Other French Common Name: Orque*

Indigenous Names: (*note: names do not refer to specific DUs*): Maz7inuxw (Kwakwa'ala); Max'inuxw (Kwakwaka'wakw); Ska-ana (Haida); KELLÖLEMEĆEN (SENĆOTEN); Kakawad (Ditidaht); kakawin, kaka7w'in (Nuu-cha-nulth); qwunus (Lekwungen); Qaiqal xic (Puget Salish); Q'ul-Ihanamutsum (Hul'qumi'inum); qəllaləməcən (Halkomelem)

Range of occurrence in Canada (province/territory/ocean): British Columbia, Pacific Ocean

### Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	26–29 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	No
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years]	Not applicable as there is no decline
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Not applicable
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Not applicable
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	No applicable
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	Not applicable a. b. c.
Are there extreme fluctuations in number of mature individuals?	No

### Extent and Occupancy Information

Estimated extent of occurrence (EOO)	Exceeds thresholds
Index of area of occupancy (IAO) (Always report 2x2 grid value).	Exceeds thresholds
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of “locations” (use plausible range to reflect uncertainty if appropriate)	Unknown
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Not applicable
Is there an [observed, inferred, or projected] decline in number of “locations”?	Unknown
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	Unknown
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

### Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Subpopulations not recognized	Not applicable
Total 53% mature, excluding post-reproductive females (based on Northern Residents), estimated 300 individuals	about 160

### Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	No analysis conducted
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**Threats (direct, from highest impact to least, as per IUCN Threats Calculator)**

Was a threats calculator completed for this species? Yes

Overall threat impact: High – Medium  
 Key threats were identified as:

- I. Pollution (IUCN 9) – high-medium impact
- II. Natural System Modifications (IUCN 7) – medium-low impact
- III. Human intrusions & disturbance (IUCN 6) – low impact
- IV. Biological Resource Use (IUCN 5) – low impact
- V. Transportation & Service Corridors (IUCN 5) – low impact
- VI. Climate Change & Severe Weather (IUCN 11) – unknown impact

What additional limiting factors are relevant?

- I. Fixed cultural attributes
- II. Low reproduction rate

**Rescue Effect (immigration from outside Canada)**

Status of outside population(s) most likely to provide immigrants to Canada. No outside populations are known or recognized	Approximately 30 whales in this population are known only from Alaskan waters and thus could provide rescue effect.
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Likely
Are conditions deteriorating in Canada?	Unknown
Are conditions for the source (i.e., outside) population deteriorating?	Unknown
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Possible, to a very limited extent.

**Data Sensitive Species**

Is this a data sensitive species?	No
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**Status History**

COSEWIC: The “North Pacific resident populations” were given a single designation of Threatened in April 1999. Split into three populations in November 2001. The Northeast Pacific offshore population was designated Special Concern in November 2001. Status re-examined and designated Threatened in November 2008. Status re-examined and confirmed in December 2023.

### Status and Reasons for Designation:

Status: Threatened	Alpha-numeric codes: Met criterion for Endangered, D1, but designated Threatened, D1, because the wildlife species is not at imminent risk of extirpation.
Reasons for designation: The population of this long-lived apex marine predator is small (~160 mature individuals) and specializes in a diet of sharks and rays. Threats include contaminants, acoustical and physical disturbance, vessel strikes, potential future declines in prey availability, and possibly oil spills. However, the population does not appear to be declining.	

### Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No decline in total mature individuals has been observed.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Extent of occurrence is greater than 20,000 km <sup>2</sup> and index of area of occupancy is greater than 2,000 km <sup>2</sup> .
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Although the population is small enough to qualify for Endangered (total number of mature individuals ~160, which is well below the threshold of 2,500), there is no evidence of a continuing decline.
Criterion D (Very Small or Restricted Population): Meets Endangered, D1, with ~160 mature individuals, below threshold of 250.
Criterion E (Quantitative Analysis): Not applicable. No quantitative analysis conducted.

## TECHNICAL SUMMARY - Northwest Atlantic / Eastern Arctic population (DU-5)

*Orcinus orca*

Killer Whale (Northwest Atlantic / Eastern Arctic population (DU-5)

Épaulard (Population de l'Atlantique Nord-Ouest et de l'est de l'Arctique)

Other English Common Name: Orca

Other French Common Name: Orque

Indigenous Names: (*note: names do not refer to specific DUs*): Aarluk, Aarluit (Inuktitut/Inuit); Aarluasiaq (Inuktitut/Nunavik); Arlut / Aarlu (single) / Aarluuk (dual) / Aarluit (plural) (Inuvialuktun)

Range of occurrence in Canada (province/territory/ocean): Quebec, Newfoundland and Labrador, New Brunswick, Nova Scotia, Prince Edward Island, Manitoba, Nunavut, Atlantic Ocean, Arctic Ocean

### Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	26–29 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years]	Not applicable
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Not applicable
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Not applicable
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	Not applicable
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	Not applicable
Are there extreme fluctuations in number of mature individuals?	No

### Extent and Occupancy Information

Estimated extent of occurrence (EOO)	Exceeds thresholds
Index of area of occupancy (IAO) (Always report 2x2 grid value).	Exceeds thresholds

Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of “locations” (use plausible range to reflect uncertainty if appropriate)	Unknown
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	Unknown
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

**Number of Mature Individuals (in each subpopulation)**

Subpopulations (give plausible ranges)	N Mature Individuals
Subpopulations not well defined	Not applicable
	Unknown

**Quantitative Analysis**

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?

Not applicable

**Threats (direct, from highest impact to least, as per IUCN Threats Calculator)**

Was a threats calculator completed for this species? Yes

Overall Threat Impact: High – Low

Key threats were identified as:

- I. Biological Resource Use (IUCN 5) – high-low impact
- II. Energy Production & Mining (IUCN 3) – unknown impact
- III. Transportation & Service Corridors (IUCN 4) – unknown impact
- IV. Natural System Modifications (IUCN 7) – unknown impact
- V. Pollution (IUCN 9) – unknown impact
- VI. Climate Change & Severe Weather (IUCN 11) – unknown impact

What additional limiting factors are relevant?

- I. Low reproduction rate

**Rescue Effect (immigration from outside Canada)**

Status of outside population(s) most likely to provide immigrants to Canada.	Unknown
Is immigration known or possible?	Unknown
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Unknown
Are conditions deteriorating in Canada?	Unknown
Are conditions for the source (i.e., outside) population deteriorating?	Unknown
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Unknown

**Data Sensitive Species**

Is this a data sensitive species?	No
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**Status History**

COSEWIC:

Species considered in April 1999 and in November 2001, and placed in the Data Deficient category. Re-examined in November 2008 and designated Special Concern. Status re-examined and confirmed in December 2023.

**Status and Reasons for Designation:**

Status: Special Concern	Alpha-numeric codes: Not applicable
Reasons for designation: The range of this long-lived apex marine predator has recently expanded in the Eastern Arctic and the frequency of sightings has increased, likely due to the availability of new hunting areas because of declining summer sea ice. Occurrence and abundance of these whales elsewhere in their range is poorly known. Threats include hunting, contaminants, and acoustical and physical disturbance as shipping traffic increases. The population's small size (likely fewer than 1,000 mature individuals and perhaps even fewer than 250), known and potential threats, life history, and cultural attributes justify designation as Special Concern.	

### **Applicability of Criteria**

Criterion A (Decline in Total Number of Mature Individuals):

Not applicable. Although the population is very poorly known, no reduction in total number of mature individuals has been documented.

Criterion B (Small Distribution Range and Decline or Fluctuation):

Not applicable. Extent of occurrence is greater than 20,000 km<sup>2</sup> and index of area of occupancy is greater than 2,000 km<sup>2</sup>.

Criterion C (Small and Declining Number of Mature Individuals):

Not applicable. Although the population may be small enough to qualify for Endangered (total mature individuals is most likely well below the threshold of 2,500), there is no evidence of a continuing decline.

Criterion D (Very Small or Restricted Population):

Not applicable. Possibly meets Threatened, D1, (total number of mature individuals might be <1,000), and perhaps Endangered, D1, because the number of mature individuals could be <250, but actual population size is unknown.

Criterion E (Quantitative Analysis):

Not applicable. No quantitative analysis conducted.

## PREFACE

Since the publication of the previous COSEWIC Status Report on the Killer Whale in 2008, a great deal of new information has become available on Canadian populations of this cosmopolitan species. Much of the impetus for further and expanded data collection and analysis over the last decade and a half has come from the recovery strategies, management plans, action plans and other SARA mandates related to the four Designatable Units (DUs) in Canada's Pacific waters. Much of the new information in this report represents updated coverage of those four West Coast populations. There is still no clear evidence to support a change in DU structure, nor is there any evidence of a major change in distribution, abundance, or conservation status of the four populations. However, the Southern Resident population has continued to be the focus of intensive research efforts and increased protection measures in both Canada and the United States.

Much more is now known about the distribution, movements, and ecology of the Northwest Atlantic / Eastern Arctic population of Killer Whales, which was assessed as Special Concern in 2008. Despite the considerable progress that has been made, there is still no well-justified basis for recognizing more than a single DU in eastern Canada.

The Killer Whales in Canada's Pacific, Atlantic, and Arctic waters move at least occasionally into U.S. waters, and it is likely that some individuals in the Canadian Atlantic and Eastern Arctic also move seasonally into Greenland waters. Perhaps most significantly, members of the highly endangered Northeast Pacific Southern Resident population spend much of the year in both Canada and the U.S., which means that assessing their population status and managing the threats they face (e.g., fishing, vessel traffic, underwater noise, and contaminants) is a joint responsibility. The lead agency in Canada is Fisheries and Oceans Canada (DFO); its counterpart in the U.S. is National Oceanic and Atmospheric Administration (NOAA) Fisheries. Numerous other enforcement and environmental bodies as well as non-governmental organizations and First Nations in both countries are also engaged in conservation efforts, with a special focus on Southern Residents. In Greenland, where Killer Whales are hunted opportunistically and this activity is not regulated, assessment is carried out within the framework of the North Atlantic Marine Mammal Commission<sup>1</sup>.

In terms of the perspectives and attitudes of Indigenous peoples and local communities toward Killer Whales, there are stark differences among regions within Canada. In the West, and specifically British Columbia, the Killer Whale enjoys iconic status. A Ka:'yu:'k't'h'/Che:k'tles7et'h' (Maa-nulth) citizen described Killer Whales as "our relatives and knowledge holders, as beings to be in relationship with and not as something to manage" (L. Johnson pers. comm. 2023). The voices of salmon fishermen there who regard the animals as competitors are largely drowned out by the passionate voices of activists who urge full protection of the animals from any kind of harm. In the Arctic, particularly the eastern Canadian Arctic and Hudson Bay, where Killer Whales are becoming more common, they are regarded with mixed feelings, and attitudes vary within and among communities. At a public hearing convened in 2021 by the Nunavik Marine

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<sup>1</sup> Canadian scientists participate in much of the work of this commission but Canada is not a signatory of the NAMMCO agreement.

Region Wildlife Board and the Eeyou Marine Region Wildlife Board, Inuit participants stated that Killer Whales were being seen more frequently in Hudson Strait and eastern Hudson Bay (including James Bay). They were concerned about the potential impacts on Belugas (*Delphinapterus leucas*) and expressed a strong interest in seeing Killer Whale numbers reduced (Nunavik Marine Region Wildlife Board 2021).



### COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

### COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

### COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

### DEFINITIONS (2023)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species is likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

\* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

\*\* Formerly described as "Not In Any Category", or "No Designation Required."

\*\*\* Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.



Environment and  
Climate Change Canada  
Canadian Wildlife Service

Environnement et  
Changement climatique Canada  
Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

# **COSEWIC Status Report**

on the

## **Killer Whale**

*Orcinus orca*

Northeast Pacific Southern Resident population  
Northeast Pacific Northern Resident population  
Northeast Pacific Transient Killer Whale population  
Northeast Pacific Offshore population  
Northwest Atlantic / Eastern Arctic population

**in Canada**

2023

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# WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

## Name and Classification

Class: Mammalia  
Order: Artiodactyla  
Infraorder: Cetacea (Odontoceti)  
Family: Delphinidae  
Genus: *Orcinus* Species: *O. orca* (Linnaeus, 1758)

Common names (from COSEWIC 2008)

English: Killer Whale, Orca. Historical vernacular – Grampus, Swordfish, Thrasher, Blackfish

French: Orque, Épaulard

Indigenous: Aarluk, Aarluit (Inuktitut/Inuit); Aarluasiaq (Inuktitut/Nunavik); Arlut / Aarlu (single) / Aarluuk (dual) / Aarluit (plural) (Inuvialuktun); mah-e-noh (Kwakiutl – Curtis 1915); Maz7inuxw (Kwakwa'ala – Grubb 1977); Max'inuxw (Kwakwaka'wakw); KELLÖLEMEĆEN (SENĆOFEN); kakawin, kaka7w'in (Nuu-cha-nulth); qwunus (Lekwungen); Qaiqal xic (Puget Salish – Hess 1971); Q'ul-Ihanamutsum (Hul'qumi'inum); qəllaləməcən (Halkomelem)

## Synonyms and notes

Three sympatric but morphologically and genetically distinct assemblages<sup>2</sup> of Killer Whales occur in Canadian Pacific waters. These are known as Resident, Transient (or Bigg's), and Offshore ecotypes, and they differ in their morphology, diet, genetics, and social, acoustic, and foraging behaviour (COSEWIC 2008). Genetic analyses (Morin *et al.* 2010) have led to the Resident and Transient ecotypes being proposed as subspecies and they are currently on the Society for Marine Mammalogy Taxonomy Committee's list of unnamed possible subspecies<sup>3</sup>. Similar distinctions may exist between the Killer Whales off BC and those that are at least seasonally present in northern Alaska, Chukotka, and the western Canadian Arctic (Yukon and Northwest Territories).

In eastern Canadian Arctic (including Hudson Bay) and Canadian Atlantic waters, from the Maritimes northward to the High Arctic, there may be multiple Killer Whale assemblages but knowledge of their delineation and characterization is less advanced than is the case in Canada's Pacific waters.

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<sup>2</sup> A population assemblage is a set of populations belonging to a common genetic lineage.

<sup>3</sup> These proposed subspecies are tentatively called "ENP resident killer whale" (épaulard résident du Pacifique Nord Est) and "ENP transient killer whale or Bigg's killer whale" (épaulard migrateur du Pacifique Nord Est ou épaulard de Bigg), with Krahn *et al.* (2004) cited in support in both cases (see <https://marinemammalscience.org/science-and-publications/list-marine-mammal-species-subspecies/list-of-proposed-un-named-marine-mammal-species-and-subspecies/>).

The Killer Whale is designated as Data Deficient on the IUCN Red List “due to taxonomic uncertainty.” The current Red List assessment notes that besides the two proposed unnamed subspecies in the eastern North Pacific, “Other forms of killer whales in the North Pacific, North Atlantic and Antarctic Ocean may warrant recognition as separate subspecies or even species, but the taxonomy has not yet been fully clarified or agreed” (Morin *et al.* 2010; Foote *et al.* 2009, 2013) (Reeves *et al.* 2017). In addition to the morphological variability and geographical partitioning of Killer Whale populations by land and ice barriers, it has been proposed that “cultural differences in the form of learned behaviours between ecologically divergent killer whale populations have resulted in sufficient reproductive isolation even in sympatry to lead to incipient speciation” (Riesch *et al.* 2012).

## **Description of Wildlife Species**

The body size, striking black and white coloration, and tall dorsal fin make the Killer Whale one of the most recognizable cetaceans. Killer Whales are sexually dimorphic, and the maximum recorded body lengths of males and females are 9.0 m and 7.7 m respectively (Dahlheim and Heyning 1999). The maximum recorded masses are 6,600 kg for a 7.65 m male and 4,700 kg for a 6.58 m female from Japanese waters (Yamada *et al.* 2007). In the eastern North Pacific, the dorsal fin of males can reach a height of approximately 1.8 m, whereas those of females and juveniles reach 0.9 m or less. The flippers and tail flukes are also longer in males than in females (Bigg *et al.* 1987). An elliptical white patch is conspicuously present somewhat above and behind each eye. A grey-white area at the base of the dorsal fin is known as the saddle patch. Each Killer Whale is individually recognizable based on its uniquely shaped dorsal fin and saddle patch, as well as acquired nicks and scars on the dorsal fin and saddle (Ford *et al.* 2000). Photographs of these features are regularly used to distinguish individuals.

There are often slight differences in the morphology of Killer Whales from different populations. In the northeastern Pacific, Resident, Transient, and Offshore animals differ slightly in their dorsal fin shape and saddle patch pigmentation (Ford *et al.* 2000). The dorsal fin of Transients tends to be pointed and their saddle patch is large and uniformly grey. In contrast, the dorsal fin of Residents tends to be rounded at the leading edge and its trailing edge has a fairly abrupt angle. Their saddle patch is more variable than that of Transients and may be uniformly grey or contain a black region. The dorsal fin of northeastern Pacific Offshore Killer Whales is similar to that of Residents but is more rounded at the trailing edge of the tip. Offshore Killer Whales also appear to be smaller than Resident and Transient Killer Whales.

## Designatable Units

As indicated above, no subspecies of Killer Whales are currently recognized, but multiple distinct assemblages, or ecotypes, that differ in morphology, diet, genetics, acoustics, social organization, and foraging behaviour inhabit Canadian waters. The ranges of different ecotypes often overlap. It has been confirmed through whole-genome sequencing that “even in sympatry, contemporary gene flow occurs almost exclusively among individuals of the same ecotype, allowing genomic differentiation to build up between ecotypes so that within an ocean basin ecological variation better predict[s] genetic structuring than geography” (Foote *et al.* 2016).

Five Designatable Units (DUs) of Killer Whales were recognized in the previous species assessment based on morphology, genetics, range, distribution, movements, acoustic behaviour, and feeding ecology (COSEWIC 2008), and no changes in this arrangement are proposed in this update report. The five DUs are (1) Northeast Pacific Southern Resident, (2) Northeast Pacific Northern Resident, (3) Northeast Pacific Transient (or Bigg’s), (4) Northeast Pacific Offshore, and (5) Northwest Atlantic / Eastern Arctic populations. Killer Whales observed in the western Canadian Arctic possibly belong to a population centred in the Chukchi and Bering Seas<sup>4</sup>.

### West Coast of Canada (Northeast Pacific)

#### Residents (DU-1 and DU-2)

Although their ranges overlap, the two Canadian Resident populations (Southern and Northern) do not associate. Both populations are shared with the United States. A third Resident population known as Southern Alaska Residents (also called “Eastern North Pacific Alaska Resident stock”; Muto *et al.* 2021) inhabits waters from southeastern Alaska to at least the northern Gulf of Alaska. Individuals from the Northern Resident population have been documented in southeastern Alaska, but “they have not been seen to intermix with [Southern] Alaska Residents” (Muto *et al.* 2021, p. 133). Recent acoustic and visual evidence has confirmed that at least small groups of individuals from the Southern Alaska Resident population visit Canadian waters off southern Haida Gwaii (Ford and Pilkington 2020). The COSEWIC guidelines for determining eligibility for assessment require that the wildlife species occurs naturally, and *regularly*, or as a seasonal migrant, in Canada, or that the population (= wildlife species) is at high risk of extinction (or in this case, extirpation) in its primary range outside Canada. Neither of these conditions is met (see Ford and Pilkington 2020; Muto *et al.* 2021, pp. 137-138). Therefore, based on the very limited available evidence, the Southern Alaska Resident population is not presently considered a DU requiring COSEWIC assessment.

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<sup>4</sup> “Killer whales observed in the northern Bering Sea and north and east to the western Beaufort Sea have characteristics of transient-type whales, but little is known about these whales (Braham and Dahlheim 1982; George and Suydam 1998)” (Muto *et al.* 2021, p. 149).

A similar issue related to how to define the geographical boundaries of the Transient population (DU-3) is discussed below.

It has been well established since the early 2000s that both the mitochondrial DNA (mtDNA) and the microsatellite data indicate a high degree of contemporary reproductive isolation among North Pacific Killer Whale populations (Krahn *et al.* 2004, p. 16; Figures 1 and 2, and see COSEWIC 2008). The three populations of Resident Killer Whales in the Northeast Pacific were initially distinguished on the basis of association data (Bigg *et al.* 1990; Matkin *et al.* 1999), and their discreteness has since been confirmed by acoustic and genetic data as well as other aspects of their behaviour and ecology (Hoelzel *et al.* 1998, 2002; Yurk *et al.* 2002). The Southern and Northern Resident populations are each fixed for single, different haplotypes in the mtDNA control region, both of which are also present in the Southern Alaska Resident population (Barrett-Lennard and Ellis 2001). Barrett-Lennard and Ellis (2001) found no mitochondrial haplotypes shared by Residents and Transients, which is consistent with findings of Stevens *et al.* (1989), Hoelzel *et al.* (1998, 2007), Parsons *et al.* (2013), and Morin *et al.* (2015).

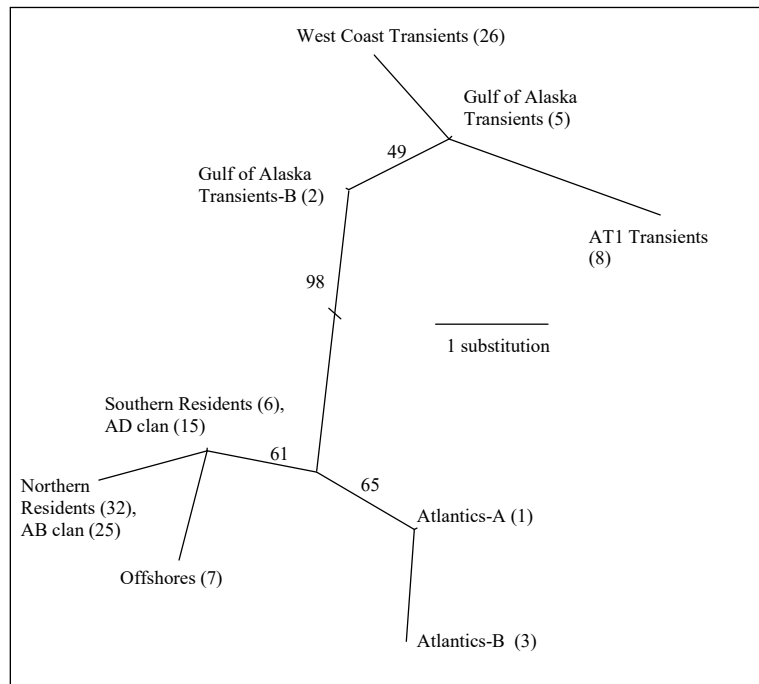


Figure 1. Maximum likelihood phylogram based on seven Pacific and two Atlantic Killer Whale mitochondrial D-loop haplotypes. The numbers on branches indicate percentage bootstrap support. The number of whales sequenced with each haplotype is shown in brackets. AB and AD refer to two acoustic clans of Alaska Residents. The suffixes A and B indicate two different haplotypes from the same subpopulation or, in the case of the Atlantics, the same ocean. The length of the longest branch was reduced by half in this drawing (source: Barrett-Lennard and Ellis 2001).

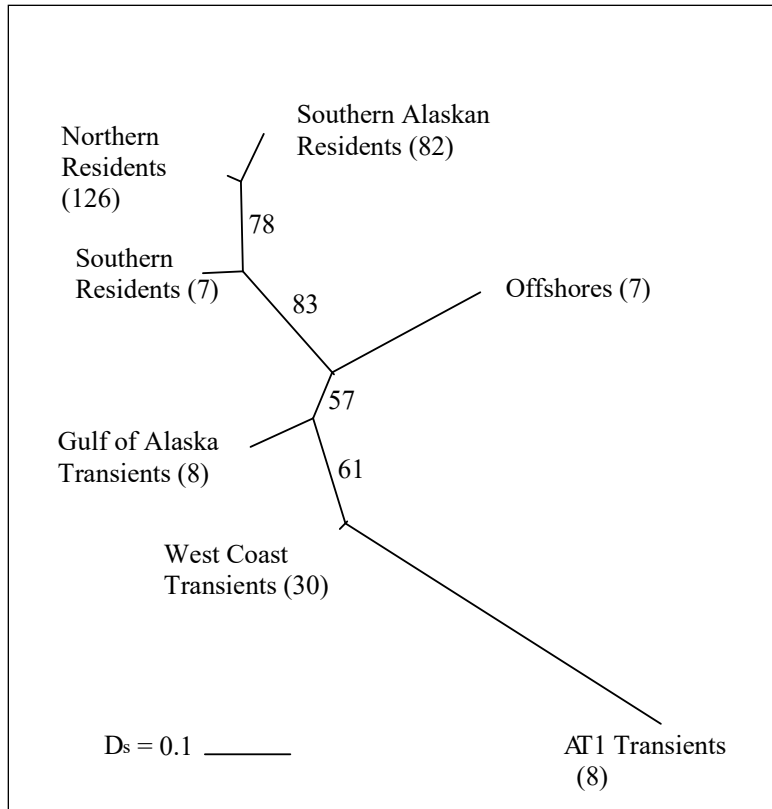


Figure 2. Unrooted neighbour-joining phylogram for Alaska and British Columbia Killer Whales based on 11 microsatellite loci, using Nei's standard genetic distances. The numbers on the branches give percentage bootstrap support. When the Offshore population was removed, support for the Resident / Transient separation was 97% (source: Barrett-Lennard and Ellis 2001). Sample sizes are in parentheses.

## Northeast Pacific Southern Resident Population, DU-1

### Evidence for discreteness

Southern Residents have never been seen to associate with other Resident populations, including the parapatric Northern Resident population, and there is no evidence of mating outside the population from paternity assignments (Ford *et al.* 2018). Southern Residents are acoustically distinct from Northern Residents (DU-2; Ford 1991) and Alaskan Residents (Yurk *et al.* 2002). Also, there is a small but fixed mtDNA haplotype difference between Southern and Northern Residents (Hoelzel *et al.* 1998). COSEWIC (2020a) guideline D1 (evidence of heritable traits or markers that clearly distinguish the putative DU from other DUs) therefore applies.

### Evidence for evolutionary significance

This population is significant because of clear and persistent behavioural patterns that are likely transmitted culturally and thus should be considered heritable in that sense. These include the fact that Northern and Southern Residents do not associate even though their ranges overlap. Both ecotypes persist “in an ecological setting where a selective regime is likely to have given rise to DU-wide local adaptations that could not be reconstituted.” COSEWIC (2020a) guideline S2 (direct evidence or strong inference that can be used to infer that the putative DU possesses adaptive, heritable traits, that cannot be practically reconstituted if lost) therefore applies.

## **Northeast Pacific Northern Resident Population, DU-2**

### Evidence for discreteness

Northern Residents have never been seen to associate with other Resident populations, including the parapatric Southern Resident population. Also, there is a small but fixed mtDNA haplotype difference between Northern and Southern Residents (Hoelzel *et al.* 1998). D1 therefore applies.

### Evidence for evolutionary significance

This population is significant because of clear and persistent behavioural patterns that are likely transmitted culturally and thus should be considered heritable in that sense. These include the fact that Northern and Southern Residents do not associate even though their ranges overlap. Both ecotypes persist “in an ecological setting where a selective regime is likely to have given rise to DU-wide local adaptations that could not be reconstituted.” S2 therefore applies.

## **Northeast Pacific Transient (Bigg’s) Population, DU-3**

In the Northeast Pacific Ocean, three populations of Transient (or Bigg’s) Killer Whales have been described, the “Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient” stock (Muto *et al.* 2021, pp. 148-155), the “AT1 Transient” stock (Muto *et al.* 2021, pp. 156-162), and the “West Coast Transient” population.<sup>5</sup>

Unlike the Resident populations, members of different Transient populations have been seen swimming in close proximity on several occasions. According to the previous COSEWIC status report (2008, p. 6), the three currently recognized populations are distinguished by: (1) patterns of social association (members associate much more frequently with each other than with members of other populations), (2) differences in call repertoires, (3) genetic differences (nuclear and mitochondrial), and (4) inter-population differences in central, or core, range (Ford and Ellis 1999; Barrett-Lennard and Heise 2006).

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<sup>5</sup> Under the U.S. Marine Mammal Protection Act, “stock” is defined as “a group of marine mammals of the same species in a common spatial arrangement, that interbreed when mature.” See <https://www.fisheries.noaa.gov/laws-and-policies/glossary-marine-mammal-protection-act#marine-mammal-stock>

The Transients known from coastal waters of Southeast Alaska south to central California were considered by Ford and Ellis (1999) to be part of the same “West Coast community” based on the widespread movement of some individuals among different coastal regions and based on the fact that these wide-ranging individuals mix with “local” whales when out of their normal range (Black *et al.* 1997). It was also noted that there were similarities in the call repertoires of Transients off California and those in BC and Southeast Alaska (Ford and Ellis 1999). However, a workshop of experts in Vancouver, convened in January 2007 to assist DFO in developing a recovery strategy for Transient Killer Whales, “determined that the available evidence suggests that the California assemblage belongs to one or more distinct, currently undefined populations.” The workshop deemed the acoustic repertoire of the California group to be “similar, but not identical” to that of the BC population. Approximately 10 of the California whales had been seen in BC and Alaska, “at times ... interacting with members of the West Coast transient population,” suggesting “limited gene flow between the two groups” (DFO 2007, p. 3). The workshop noted that the whales in question were “encountered relatively infrequently, even in Californian waters.” Hence, the Transient population found in Canadian waters was considered distinct from Californian Transients in DFO’s Recovery Strategy (DFO 2007) and Recovery Potential Analysis (DFO 2009), as well as in COSEWIC’s previous status assessment (COSEWIC 2008).

Since the last COSEWIC assessment, new evidence has accumulated that supports the inclusion of Californian Transients in the Northeast Pacific Transient DU. Foremost are recent observations that show the interchange of individuals between Canadian waters and coastal Oregon and California to be more frequent and widespread than previously known. Of the 349 Transient whales regularly identified in Canadian Pacific waters and considered to be alive in 2018 (Towers *et al.* 2019), 36 (10.3%) have been observed in Oregon and 23 (6.5%) in California (A. Schulman-Janiger pers. comm. 2022; J. Towers pers. comm. 2022; McInnis *et al.* 2022). Of the 193 Transients regularly encountered in California and considered to be alive in 2021 (A. Schulman-Janiger pers. comm. 2022), 62 individuals have been encountered at least once along the BC coast (J. Towers pers. comm. 2022). Whales from California often associate with BC whales when in this region, and vice versa. Furthermore, underwater calls typically produced by Californian Transients (Deecke 2003) have frequently been recorded on autonomous hydrophone instruments deployed along the outer coast of Washington State and BC, as far north as Haida Gwaii (Riera 2012; Rice *et al.* 2017; Ford and Pilkington 2020; J. Pilkington pers. comm. 2022). These calls are often heard together with calls typical of Transients in BC, indicating mixing of individuals from the two regions.

### Evidence for discreteness

The genetic discreteness (reproductive isolation) of this population from the sympatric Resident populations in the eastern North Pacific was well established by Barrett-Lennard (2000). He found no mitochondrial haplotypes in common between Residents and Transients, and many more fixed mitochondrial differences between the two populations than among their respective subpopulations (or communities or clans) (Figure 1). Further,

there is a high degree of separation in the nuclear DNA, with much higher pairwise  $F_{ST}$  values between Resident and Transient populations than between subpopulations of a common population<sup>6</sup>, and with several loci having population-specific alleles. In addition, much of the cultural evidence for evolutionary significance is relevant to discreteness. The differentiation has in fact been characterized as a case of gene-culture coevolution (Barrett-Lennard 2000) and incipient (Riesch *et al.* 2012) or full speciation (Morin *et al.* 2010). D1 therefore applies.

### Evidence for evolutionary significance

Although Northeast Pacific Resident and Transient Killer Whales are sympatric, their prey preferences and foraging strategies have been described as “strikingly divergent,” the former preying almost exclusively on salmon, the latter on marine mammals (and occasionally seabirds) (Ford *et al.* 1998). This has been characterized as a classic case of ecological niche partitioning (Barrett-Lennard 2000, p. 78). The two ecotypes also differ in their acoustic repertoires and social systems, and exhibit morphological differences consistent with evolutionarily divergent paths (Ford *et al.* 2000). S2 therefore applies.

### **Northeast Pacific Offshore Population, DU-4**

The Northeast Pacific Offshore population ranges across the continental shelf from southern California to the eastern Aleutian Islands, and can occur in Canadian waters in any month of the year (Ford *et al.* 2014). The range of these whales overlaps the ranges of Residents and Transients, but the three lineages do not mix and are reproductively isolated from one another. All evidence indicates that this population constitutes a third northeastern Pacific Killer Whale ecotype (Barrett-Lennard and Ellis 2001; Krahn *et al.* 2007). It has been described as a single network of socially connected individuals (Dahlheim *et al.* 2008; Ford *et al.* 2014).

### Evidence for discreteness

The evidence from genetic analyses (Barrett-Lennard and Ellis 2001; Morin *et al.* 2010, 2015) and feeding ecology (Krahn *et al.* 2007b; Dahlheim *et al.* 2008; Ford *et al.* 2014) indicates that this population represents a separate ecotype and is discrete from other Killer Whale populations in the eastern North Pacific. D1 therefore applies. It has been estimated that the Offshore and Resident lineages diverged from each other over 150,000 years ago (Morin *et al.* 2010). D1 therefore applies.

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<sup>6</sup>  $F_{ST}$  (Fixation Index) is a measure of population differentiation due to genetic structure.

## Evidence for evolutionary significance

The distinctive type and extreme degree of tooth wear, together with direct observations of predation on sharks, including Pacific Sleeper Sharks (*Somniosus pacificus*), distinguishes the Offshore ecotype from other Killer Whales in the eastern North Pacific. The ecological niche occupied by Offshores, despite their overlapping range with Resident and Transient Killer Whales, strongly suggests that they possess adaptive, heritable traits that cannot be practically reconstituted if lost. In addition, there are morphological differences between Offshores and Residents and Transients (Ford *et al.* 2010) suggesting evolutionary divergence. S2 therefore applies.

## **Northwest Atlantic / Eastern Arctic Population, DU-5**

Killer Whales are seasonally present but rare in the western Canadian Arctic (Hartwig 2009; Higdon *et al.* 2013). It is generally assumed that occurrences there represent incursions by individuals or small groups of mammal-eating whales eastward from northern Alaska (see Footnote 4). Higdon *et al.* (2013, p. 312) concluded, “Given the available (but limited) information on [Canadian] Beaufort Sea killer whale group sizes and prey items, it seems likely that the whales occasionally seen in this region are extralimital animals from the Bering Sea transient stock ....” As mentioned in Footnote 4 and above in relation to the Northeast Pacific Transient (Bigg’s) Population, DU-3, there is considerable uncertainty about the population/stock delineation of mammal-eating Killer Whales in the Bering and Chukchi seas. Call dialects of Killer Whales recorded in the southeastern Chukchi Sea (Madrigal *et al.* 2021) are distinct from those typical of West Coast Transient Killer Whales (Deecke *et al.* 2005) as are those recorded from Killer Whales in northern Baffin Island waters (Sportelli *et al.* 2022). No attempt has been made in the current DU structure to account for the Killer Whales occasionally observed in the western Canadian Arctic.

No photographic matches have been made between Killer Whales in the Canadian Arctic and those photo-identified off Labrador and Newfoundland (Lawson and Stevens 2014; Lefort *et al.* 2020a). However, identification catalogues are considered to be in the early stages of development. Satellite telemetry of whales tagged in the High Arctic (off northern Baffin Island in summer) showed that they make long southward migrations, including at least to northern Labrador by early October and in one instance into the open North Atlantic south of Greenland by mid-November (Matthews *et al.* 2011; Lefort *et al.* 2020a). Recently, matches have been made of two individuals photographically identified off northern Baffin Island and in Disko Bay, West Greenland (S. Ferguson pers. comm. 2023).

Killer Whales in the Eastern Arctic and Northwest Atlantic are spatially separate from those in the North Pacific Ocean and therefore they belong to different populations. A whole-genome sequencing study identified two clusters with restricted gene flow between them ( $F_{ST} = 0.23$ ) in eastern Canada, one consisting of Killer Whales sampled in the High Arctic (specifically the Eclipse Sound region,  $n=18$ ) and coastal Newfoundland (2), and the other consisting of animals sampled in the Low Arctic, specifically East Greenland (6), Foxe Basin (1), possibly Arctic Bay (1), and Cumberland Sound (1) (Lefort 2020). Lefort (2020)

concluded that (i) the level of separation found between the two putative populations strongly suggested no recent gene flow, and he argued that (ii) co-occurrence in eastern Canadian Arctic waters of the two populations was due to secondary contact between an ancestral Atlantic population (High Arctic) and a derived sub-Arctic population (Low Arctic) that drifted following a post-Last Glacial Maximum range expansion.

The currently available evidence is not adequate to determine whether, or how, to subdivide the eastern Canadian population into multiple DUs (Jourdain *et al.* 2019; Lefort 2020; Lefort *et al.* 2020a). Therefore, as was the case in 2008 (COSEWIC 2008, p. 9), even though experience as well as the genomic findings of Lefort (2020) continues to suggest that some form of differentiation exists, the data remain insufficient to delineate and characterize more than a single DU in the eastern Canadian Arctic and Canadian Atlantic waters.

### Evidence for discreteness

The Killer Whale populations in the eastern and western Canadian Arctic are spatially separate and therefore discrete from each other. Significant genetic differences were found between two individuals sampled in the eastern Canadian Arctic and Resident, Transient, and Offshore populations in the northeastern Pacific (Morin *et al.* 2015). There are also clear differences in the call dialects of Killer Whales recorded off northern Baffin Island (Sportelli *et al.* 2022) and those recorded in the Chukchi Sea (Madrigal *et al.* 2021), which is the likely source of Killer Whales observed seasonally in the Canadian Beaufort Sea (Higdon *et al.* 2013). No spatial separation has been established between Killer Whales in the Eastern Arctic and those in the Northwest Atlantic. All Killer Whales in the Eastern Arctic and Northwest Atlantic apparently prey on marine mammals. However, there is observational, photo-identification, genetic and other evidence (e.g., biochemical assays) that at least some of them also prey on fish (both teleosts and elasmobranchs), cephalopods, and seabirds, as do Killer Whales in West Greenland (Jourdain *et al.* 2019; Lefort *et al.* 2020a; Remili *et al.* 2023). It has been suggested that “ecotype” differentiation and classification in the Atlantic and Arctic would be better characterized as an “ecological gradient” in feeding behaviour or strategy (Jourdain *et al.* 2019), with the progression toward ecological divergence and niche specialization still at an early stage compared to what is observed in the eastern North Pacific (Tavares *et al.* 2018, p. 11909). Alternatively, given the long history of exploitation of Killer Whales in much of the North Atlantic, whether for predator control, products, or live public display (see Mitchell 1975; Sigurjónsson and Leatherwood 1988), the ecological (and possibly genetic) differentiation that existed in the past may have been lost or obscured, or it has simply become less “sharp” than it once was. Killer whale groups with multiple individuals sampled off northern Baffin Island for whole-genome sequencing were found to be composed of relatives and non-relatives (Lefort 2020), whereas matrilineal groups are what might have been expected (Barrett-Lennard 2000). Given this evidence, social fragmentation may have followed anthropogenic removals (e.g., Øien 1988), with surviving members of pods responding by associating with other pods.

At this point, cultural and ecological divergence with respect to specialized foraging behaviour and diet cannot be used to establish discreteness of Killer Whale populations in eastern Canada as has been done for those in western Canada. Therefore, discreteness of this DU as presently understood is based on spatial separation and/or genetic differentiation from all other Canadian DUs, i.e., those in the Canadian Pacific and the western Canadian Arctic. D2 applies.

### Evidence for evolutionary significance

Although difficult to demonstrate in detail, it can be inferred that Killer Whales in this population possess adaptive, heritable traits that cannot be practically reconstituted if lost. This is typical of other Killer Whale DUs in Canada and of ecologically specialized populations in other regions (e.g., Pitman and Ensor 2003; Reisch *et al.* 2012; Ford and Ellis 2014). There is evidence of deep genetic divergence between two individuals sampled in the eastern Canadian Arctic and those from the northeastern Pacific DUs (Morin *et al.* 2015). S2 therefore applies.

### **Special Significance**

Killer Whales are apex predators with a cosmopolitan distribution. They hold iconic status with many Indigenous Peoples, particularly in BC and Alaska. As charismatic animals, they are exceptionally popular with the general public. Killer Whales have been studied intensively in BC for the last 50 years in one of the world's longest ongoing programs of research on a wild animal population. Within the last 30 years they have also become an important focus of tourism operations, particularly in BC. Scientifically, the Killer Whale is of special significance as it exemplifies the complex interaction among demographic history, culture, ecological adaptation, and evolution at the genomic level (Foote *et al.* 2016). Also, the Killer Whale's ecological role as a fast, powerful, clever predator with high caloric needs gives it the potential to have major effects on the structure of natural communities. For example, hypotheses concerning the impacts of mammal-eating Killer Whales on pinniped and Sea Otter (*Enhydra lutris*) populations have stimulated vigorous scientific debate (T. Williams *et al.* 2004).

## **ABORIGINAL (INDIGENOUS) KNOWLEDGE**

Aboriginal Traditional Knowledge (ATK) is relationship-based. It involves information on ecological relationships between humans and their environment, including characteristics of species, habitats, and locations. Laws and protocols for human relationships with the environment are passed on through teachings and stories, and Indigenous languages, and can be based on long-term observations. Place names provide information about harvesting areas, ecological processes, spiritual significance, or the products of harvest. ATK can identify life history characteristics of a species or distinct differences between similar species.

## Cultural Significance to Indigenous Peoples

This species is culturally significant to Indigenous Peoples who hold detailed knowledge on Killer Whales and their relationships with communities. For the Maa-Nulth on the west coast of Vancouver Island, their identity is founded on a connection to their hahuuli—their lands and seas (L. Johnson pers. comm. 2023). This includes the Killer Whale, who is one of four great spirit chiefs for the Uchuckleshat and a being with whom many people share a name. Similarly, many First Nations on the West Coast have expressed kinship with the Killer Whale (Calliou Group 2014; Port Metro Vancouver 2015). An extensive effort was carried out in 2007–2010 to gather information on attitudes toward and perceptions of Killer Whales from Inuit hunters and elders in two regions of Nunavut, Qikiqtaaluk (Baffin Island and Foxe Basin), and Kivalliq (western Hudson Bay) (Westdal *et al.* 2013). The investigators found that attitudes and perceptions were “not static and var[ie]d] within and across communities’ (Westdal *et al.* 2013, p. 288).

## DISTRIBUTION

### Global Range

Killer Whales are present in all oceans, but are most common in highly productive cold-water areas<sup>7</sup> (Forney and Wade 2006). In the Northern Hemisphere, concentrations have long been known to be present along the west coast of North America, around Iceland and the Faroe Islands, and along the north coast of Norway. In recent decades, relatively large numbers of Killer Whales have been documented in other parts of the North Pacific, such as along the Aleutian Islands (Matkin *et al.* 2007; Zerbini *et al.* 2007), in the Bering Sea (Waite *et al.* 2002), and in the Russian Far East (Filatova *et al.* 2014, 2016; Shabalina *et al.* 2015).

### Canadian Range

Killer Whales are present in all three of the oceans bordering Canada, including in Hudson Bay. Members of a Killer Whale population may be spread over hundreds (and in some cases possibly thousands) of kilometers at any given time. The species’ range in the Canadian Pacific, particularly from spring through fall, is fairly well understood,.

Northeast Pacific Southern Residents (DU-1) range along some 2,300 km of coastline, from Chatham Strait in southeastern Alaska to Monterey Bay in California, with core areas during late spring, summer and fall in the Salish Sea. These include eastern Juan de Fuca Strait, Haro Strait, southern Strait of Georgia (off the Fraser River mouth), Boundary Pass, the passes between the southern Gulf Islands and San Juan Islands, and Puget Sound, all of which have been designated as Critical Habitat for the population in both Canada and the United States (Ford 2014; Ford *et al.* 2017; Carretta *et al.* 2021) (Figures 3 and 4), areas also identified as significant for Killer Whales by the local WSÁNEĆ Nations (Evans

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<sup>7</sup> Because Killer Whales are found in all of the world’s oceans, a global distribution map was not included in this report.

*et al.* 2015). They also visit outer coastal waters off Washington State and Vancouver Island, especially between Grays Harbor and the Columbia River (Ford *et al.* 2000; Hanson *et al.* 2017). Continental shelf waters off southwestern Vancouver Island, including Swiftsure and La Pérouse banks, were noted as important for Killer Whales by the Pacheedaht (Pacheedaht Heritage Project *et al.* 2014), and have recently been identified as Critical Habitat for Southern Residents (Ford *et al.* 2017; DFO 2022c) (Figure 4). Occurrence in the core summer habitat in the Salish Sea appears to be declining; it has been well below average since 2017 (Shields 2023).

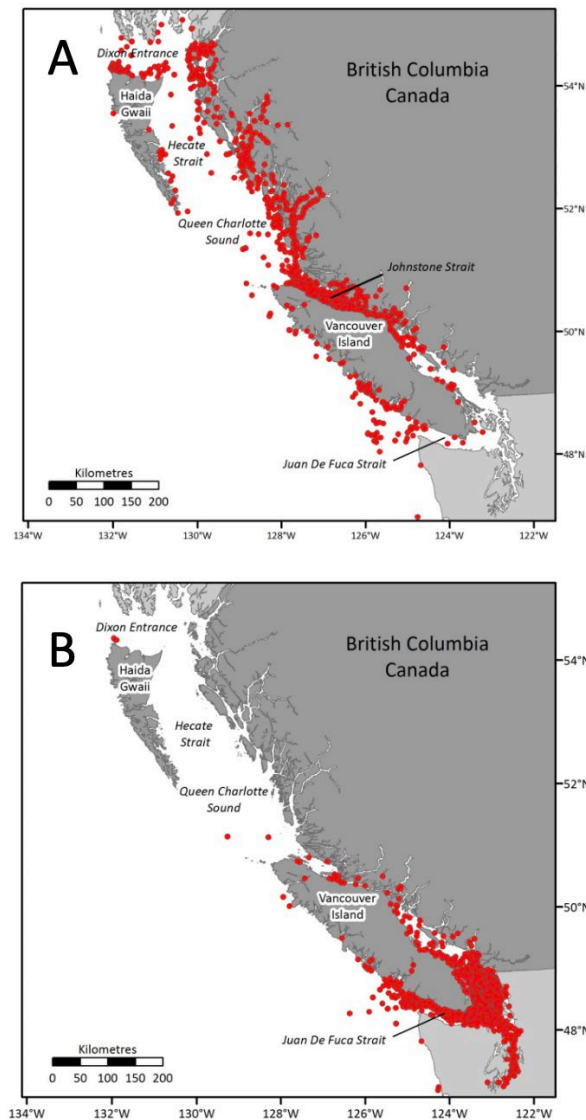


Figure 3. Locations of sightings and encounters with Northern Resident Killer Whales (A) and Southern Resident Killer Whales (B), 1973–2015 (source: Ford *et al.* 2017).

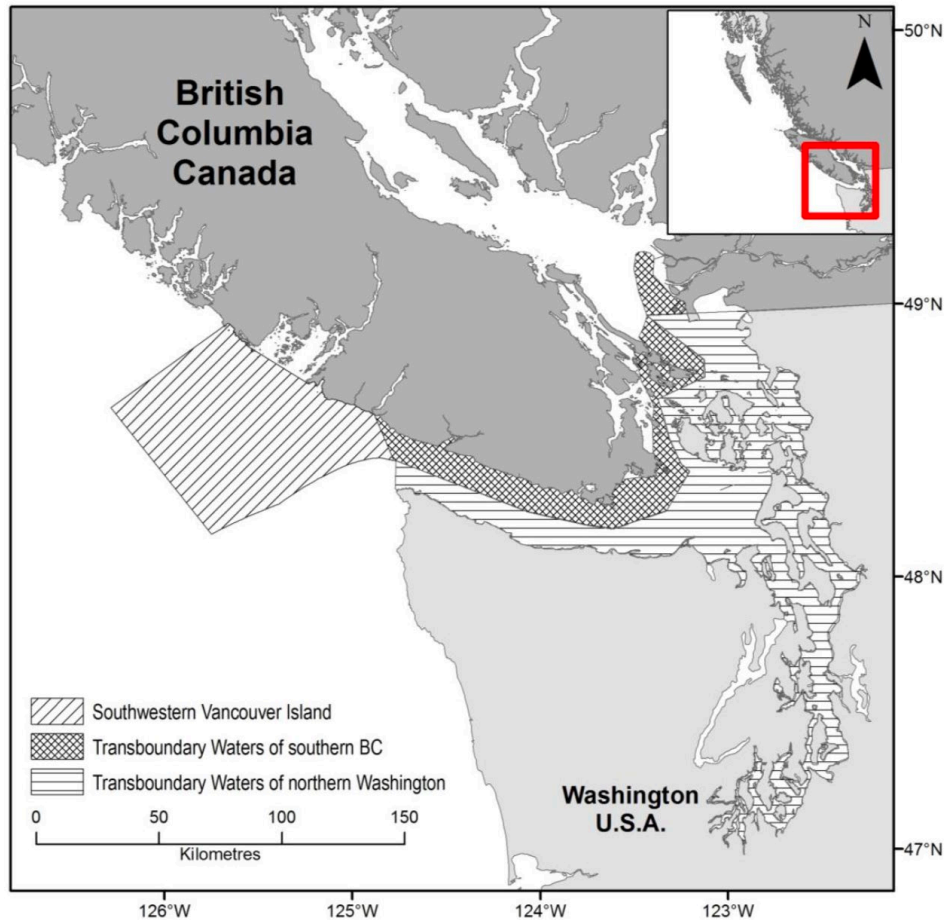


Figure 4. Critical Habitat areas identified for Southern Resident Killer Whales. The hatched areas in the transboundary waters of southern BC and off southwestern Vancouver Island are the Critical Habitat areas in Canadian waters for Southern Resident Killer Whales, as identified under SARA (the area off southwestern Vancouver Island is also identified as Critical Habitat for Northern Residents). The hatched area in the transboundary U.S. waters off northern Washington State was designated as Southern Resident Killer Whale Critical Habitat under the U.S. ESA in 2006. Recent expansion of Critical Habitat off the U.S. mainland outer coast is not shown (source: DFO 2018a).

During winter, both populations of Residents (DU-1 and DU-2) range widely along the outer coast of Vancouver Island, with most groups only occasionally venturing into their main summering areas. Some groups from both populations occur on Swiftsure Bank in winter (Burnham *et al.* 2016; Riera *et al.* 2019). Southern Residents are known to travel as far south as waters off central California and, rarely, as far north as Southeast Alaska (Chatham Strait at 56°N). Pollutant ratios from K and L pod whales suggest that they spend some time foraging in California waters (Krahn *et al.* 2009). Satellite tagging, sightings, and acoustic data indicate that Southern Residents spend nearly all their time on the continental shelf, within 34 km of shore in water less than 200 m deep (Hanson *et al.* 2017). J pod is commonly seen in inshore waters in winter, while K and L pods seem to spend more time offshore (Ford *et al.* 2000).

Northeast Pacific Northern Residents (DU-2) range from Glacier Bay, Alaska, to Grays Harbor, Washington, a linear distance of about 1,500 km (Ford *et al.* 2017). Core areas are in Johnstone Strait, Swiftsure and La Pérouse banks off southwestern Vancouver Island, and western Dixon Entrance (all identified Critical Habitat) (Figures 3 and 5). They are also found frequently in eastern Hecate Strait, Caamaño Sound, and Queen Charlotte Strait (Ford 2014; Ford *et al.* 2017). Northern Residents are not known to move far offshore of the continental shelf in any season.

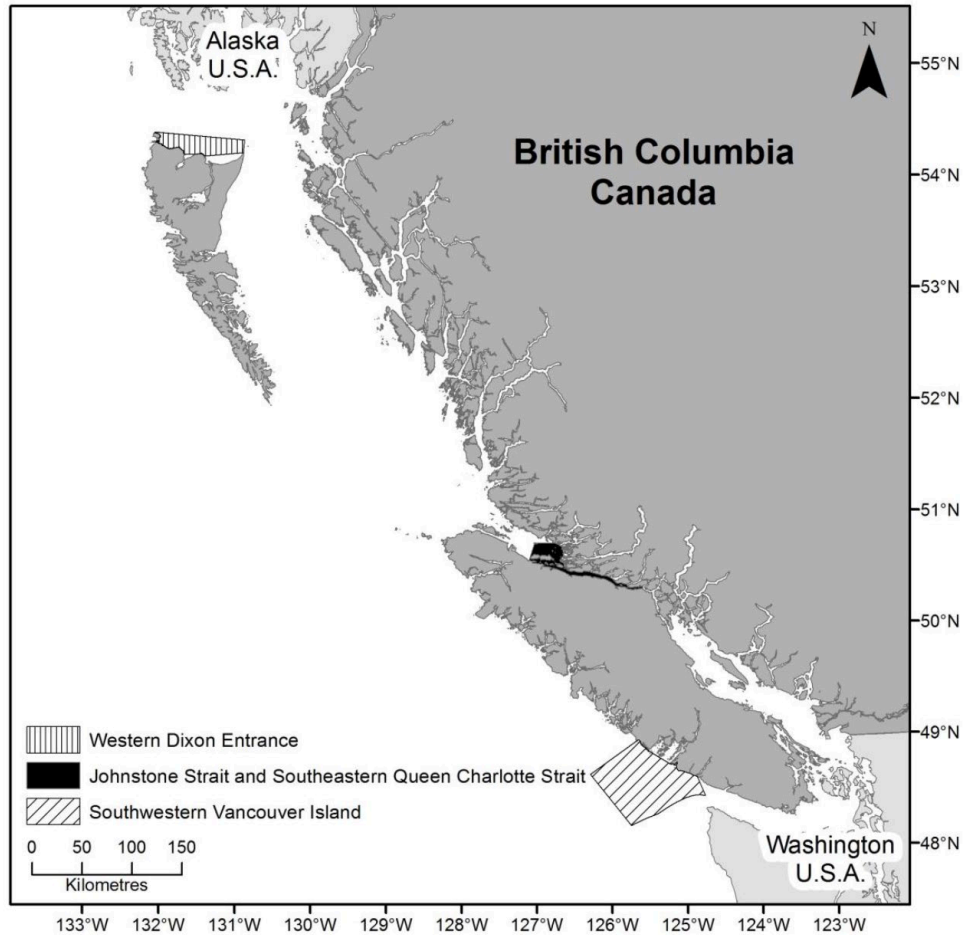


Figure 5. Critical Habitat areas identified for Northern Resident Killer Whales (source: DFO 2018a).

Northeast Pacific Transients (DU-3) occur throughout BC inshore waters year-round, with a peak in occurrence off Vancouver Island in August–September, apparently to take advantage of the local Harbour Seal (*Phoca vitulina*) pupping season (Ford 2014) (Figure 6). The normal range of this DU extends from Glacier Bay to at least central California if not farther south (see **Designatable Units**). The greatest recorded distance between sightings of an individual Transient Killer Whale is more than 2,600 km (Goley and Straley 1994). Mammal-eating Killer Whales from other populations in California and, rarely, southcentral Alaska, also visit BC waters.

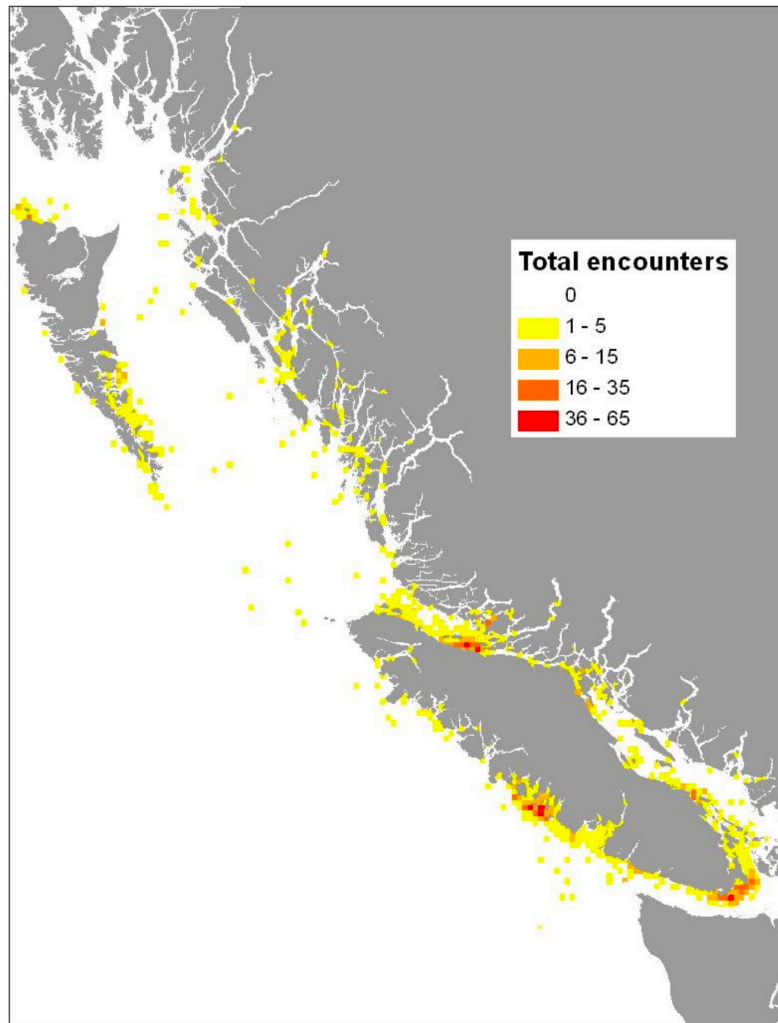


Figure 6. Distribution of encounters with West Coast Transient Killer Whales in Canadian Pacific waters (N = 2,988 encounters during 1990–2011; source: Ford *et al.* 2013).

Northeast Pacific Offshore Killer Whales (DU-4) occur mainly in outer continental shelf waters from the eastern Aleutian Islands to the California Channel Islands (Dahlheim *et al.* 2008; Ford 2014; Ford *et al.* 2014; Schorr *et al.* 2022) (Figure 7). Seven Offshore individuals satellite-tracked along the west coast from southern California to Prince William Sound, Alaska, remained mostly on the continental shelf and slope with only occasional movements beyond the shelf (Schorr *et al.* 2022). In British Columbia, they tend to prefer slope waters off southwestern Vancouver Island and around Haida Gwaii. They do, however, at least occasionally move for short periods into inside waters such as Skincuttle Inlet in Haida Gwaii and Saanich Inlet in southern Vancouver Island (Ford *et al.* 2014, p. 5). Offshores can be encountered in Canadian Pacific waters in any month, but there appears to be a diffuse seasonal shift, with animals moving northward in spring and southward in late summer and fall.

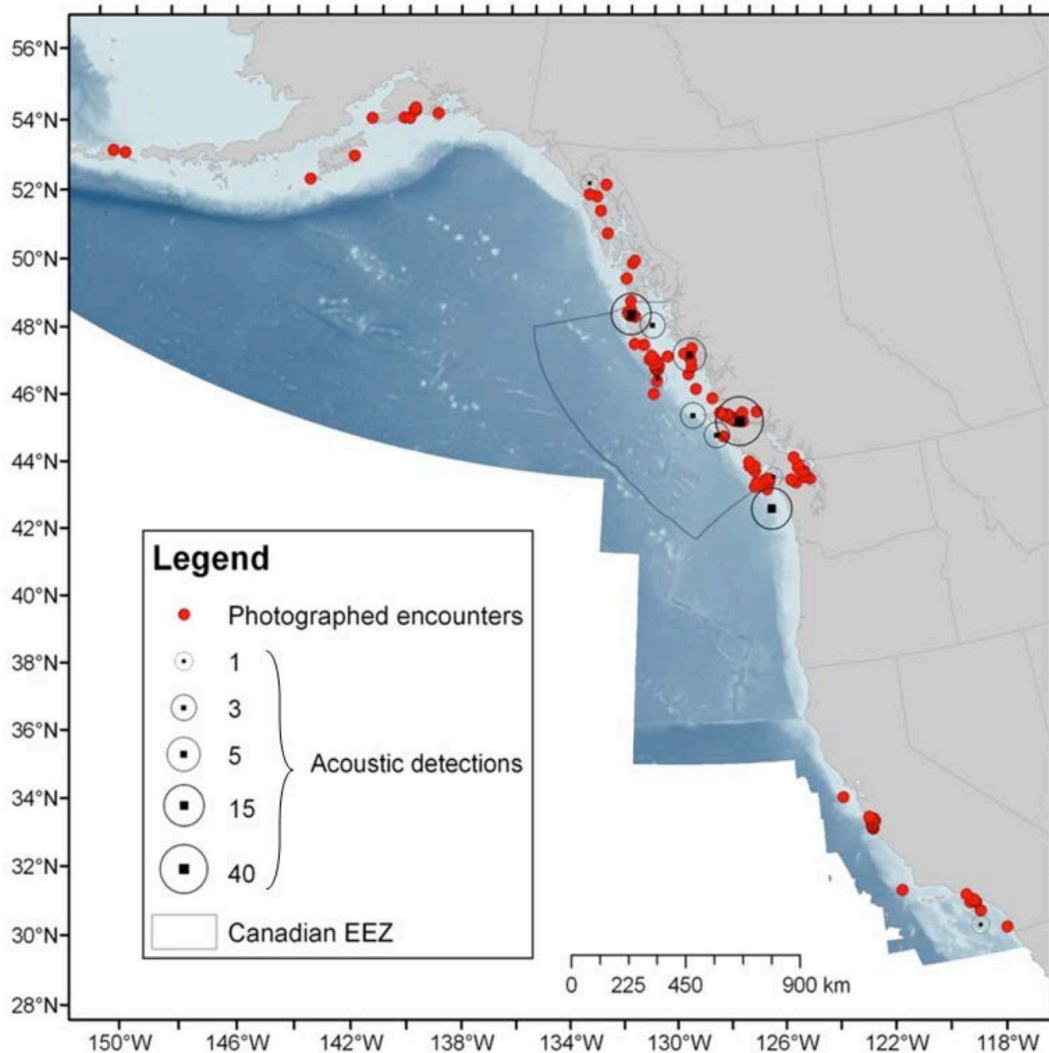


Figure 7. Distribution of encounters with Offshore Killer Whales (red dots; 1988–2012) and numbers of days in which Offshores were detected acoustically at fixed monitoring sites (open circles; 2006–2012). Relative water depths are shown in shades of blue with the continental shelf and sea mounts being the lightest. (N = 157 photographed encounters and 83 acoustic detections; source Ford *et al.* 2014).

Northwest Atlantic / Eastern Arctic Killer Whales (DU-5) range from the High Arctic (Lancaster Sound region) to the northeastern United States and into West Greenland waters (COSEWIC 2008; Higdon *et al.* 2012; Lawson and Stevens 2013; Lefort *et al.* 2020a; S. Ferguson pers. comm. 2023) (Figure 8). Killer Whales were considered common in the Gulf of St. Lawrence and the St. Lawrence estuary in the early to mid-20th century but are now reported there only occasionally (Lesage *et al.* 2007). They are seen in nearshore and offshore waters of Newfoundland and Labrador, particularly in the Strait of Belle Isle (Lawson *et al.* 2007), but also in other so-called “hotspots” such as eastern Newfoundland and around St. Pierre and Miquelon (Lawson and Stevens 2013).

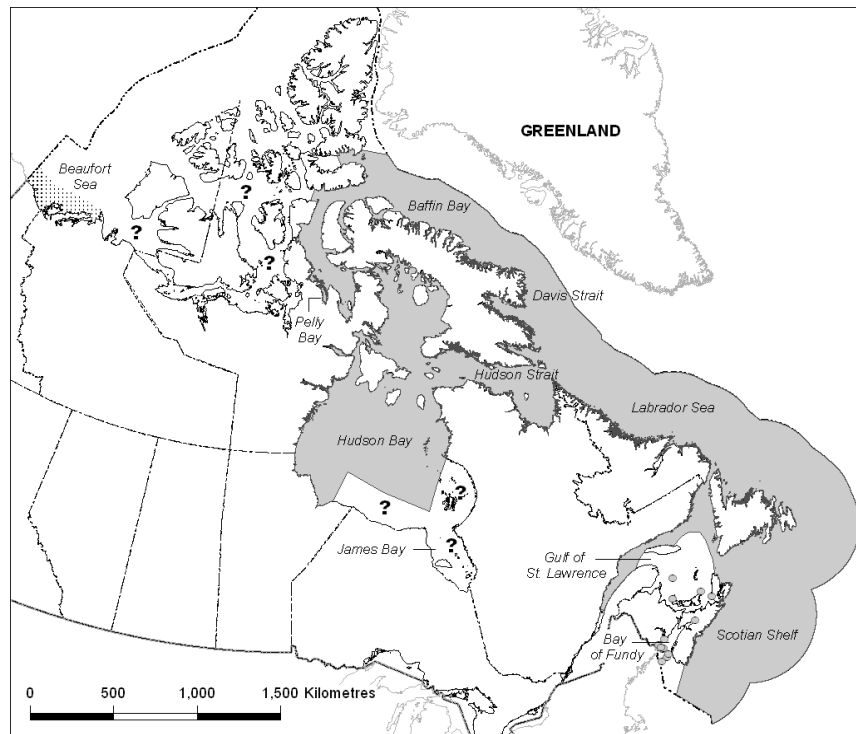


Figure 8. Range of Killer Whales in Canadian waters in the Northwest Atlantic and eastern Canadian Arctic. Killer Whales are rarely sighted in the western Canadian Arctic and are considered extralimital (area of occurrence of these indicated by stippling). Individual sightings in other areas where Killer Whales are rarely encountered (despite substantial survey effort) are indicated by circles (near the Maritime provinces) (source: COSEWIC 2008).

Declining summer sea ice has allowed Killer Whales to expand their range in the Canadian Arctic. They have been observed with increasing frequency in Hudson Bay as well as in the High Arctic north to Jones Sound and west to at least Prince Regent Inlet and the Gulf of Boothia (Higdon and Ferguson 2009; Higdon *et al.* 2014; Matthews *et al.* 2019; Lefort *et al.* 2020a).

Killer Whales are rarely seen in the western Canadian Arctic and are considered uncommon by local Inuvialuit (Hartwig 2009; Higdon *et al.* 2013). It has generally been assumed that the whales seen there are from a mammal-eating population centred in the Chukchi and Bering seas.

## Population Structure

There is significant structure within the Northeast Pacific Resident DUs, reflected mainly in behavioural (including acoustic) and socio-cultural differences. These are summarized below. Structure within the Northeast Pacific Transient and Northeast Pacific Offshore DUs as well as within the Northwest Atlantic / Eastern Arctic DU is much less well defined.

The fundamental social unit of Northeast Pacific Residents is the “matriline,” which consists of up to four generations of whales that are closely related by matrilineal descent. Dispersal of individuals from matrilines is extremely rare, although orphaned calves have been known to join closely related matrilines. Groups of related matrilines that spend most of their time travelling together are known as “pods,” and different pods from the same population frequently travel together. The composition of some pods in the Northern Resident population has been remarkably stable, although other pods have been observed to split between sister matrilines (Ford *et al.* 2000; Ford and Ellis 2002; Stredulinsky *et al.* 2021). Matrilines of the Northern Resident population fall into three distinct acoustic groups, or clans, and the relatively small Southern Resident population has a single acoustic clan consisting of three pods – known as J, K, and L (Ford 1991). Members of the Northern Resident clans frequently associate with one another but remain isolated from the Southern Resident clan.

Social groupings of Northeast Pacific Transients are more fluid or dynamic than those of Residents, and they do not necessarily remain in their natal matrilines for life. Individuals that disperse may mix widely within the population (Ford and Ellis 1999), although strong long-term associations may be formed (Baird and Whitehead 2000). There is evidence of discrete sympatric “genetic clusters” (Parsons *et al.* 2013) as well as acoustically differentiated subpopulations (Sharpe *et al.* 2019) of Transient Killer Whales across the North Pacific between the Gulf of Alaska and the Sea of Okhotsk. These units may reflect either social or ecological specializations or seasonal sympatry of different populations during summer. In BC waters, two possibly discrete subpopulations, an “inner coast” and an “outer coast” group, are recognized (Ford *et al.* 2013). The former is found in significantly shallower water closer to shore and farther from the continental shelf slope (200 m isobath) than the latter. Individuals from both of these putative subpopulations often associate with one another.

The social structure of Offshore Killer Whales is unclear, and it is not known if they disperse from their natal groups. They are frequently encountered in large groups of 50 or even more than 100 individuals, which “may represent aggregations of smaller social units” (Ford *et al.* 2014, pp. 2, 5). However, current thinking is that the social organization of Offshores “lacks the stability seen in Resident and, to a lesser extent, Transient Killer Whales” (Ford *et al.* 2014, p. 12).

In eastern Canadian Arctic and Atlantic waters, it is likely that structure of some type and degree exists but this has not been as well characterized as in Canadian Pacific waters. In the eastern and central North Atlantic (including Iceland), long-term photo-identification and social network analyses have provided support for a high degree of spatial structuring between “communities” of Killer Whales (Foote *et al.* 2010). One or more of these communities apparently specializes in foraging on specific fish stocks (mainly Atlantic Herring [*Clupea harengus*] and Atlantic Mackerel [*Scomber scombrus*], and in one case, Atlantic Bluefin Tuna [*Thunnus thynnus*]), while others are “generalists” that prey on both fish and marine mammals, an example of divergent specialization on different ecological resources. It is quite possible that similar structure exists within what is defined here as the Northwest Atlantic / Eastern Arctic population (DU-5). For example, stable

isotope analysis of tooth dentine indicated that whales from Newfoundland and Nova Scotia (a Western North Atlantic, or WNA, sample) foraged consistently at trophic levels similar to those of whales from various parts of the Canadian Arctic (a CA sample). However, the two groups (WNA and CA) foraged within food webs with distinct baseline isotopic values (Matthews and Ferguson 2013). Whales in the WNA sample had pronounced tooth wear, similar to that associated with the shark-dominated diet of Northeast Pacific Offshore Killer Whales (Matthews and Ferguson 2013). An expanded isotopic study using the same WNA and CA samples (six and five individuals, respectively) but looking at different amino acids and adding samples of dentine from the eastern North Pacific (ENP) Resident and Transient ecotypes (three and four individuals, respectively) for comparisons, led Matthews *et al.* (2021) to conclude that their amino acid-specific isotope results, coupled with differences in tooth wear, were “consistent with ecotype characteristics described in ENP and other killer whale populations.” This conclusion is supported by a quantitative fatty acid signature analysis of blubber samples which showed significant differences within this population: most Killer Whales sampled in the Eastern Arctic showed signatures consistent with predation on seals, Narwhals (*Monodon monoceros*), and Belugas, while those sampled off Newfoundland showed signatures indicating predation on baleen whales (Remili *et al.* 2023).

### **Extent of Occurrence (EOO) and Area of Occupancy (IAO)**

The EOO and IAO calculations for the five Killer Whale DUs presented in the last assessment (COSEWIC 2008) remain largely valid; however, the method of calculating these areas has changed slightly since then. Nonetheless, all values are at least an order of magnitude larger than the thresholds for Threatened under Criterion D (20,000 km<sup>2</sup> for D1 and 2,000 km<sup>2</sup> for D2). Any modification using updated information would clearly have to be very large indeed to make an appreciable difference in the assessment outcome; therefore, no new calculations were made for this report.

### **Fluctuations and Trends in Distribution**

There is no evidence of a significant change in distribution of Killer Whales in Canadian Pacific waters since the previous assessment, although, as mentioned in **Distribution** (above), the occurrence of Southern Residents in their core summer habitat in the Salish Sea appears to be declining and has been well below average since 2017 (Carretta *et al.* 2021, p. 121).

The distribution of Killer Whales in the eastern Canadian Arctic was already changing rapidly by 2008, when it was noted that ice-free areas were becoming larger and lasting longer and Killer Whales were being increasingly sighted in high latitudes. Their distribution in this region has continued to expand, in terms of both the time spent there and the areas visited, apparently owing to the ongoing decline in extent and duration of sea ice, which can function as a behavioural barrier and physical hazard to these whales when present (Higdon and Ferguson 2009; Higdon *et al.* 2013, 2014; Westdal *et al.* 2017; Matthews *et al.* 2019; Lefort *et al.* 2020a). Of 53 knowledge holders interviewed in a study of Killer Whales in Nunavut (Higdon *et al.* 2013), 27 specifically described the population as increasing and

13 noted that sighting rates were increasing. The relative scarcity of sightings in the central and western Canadian Arctic, as reported previously (COSEWIC 2008), has continued (Higdon *et al.* 2012, 2013; Lefort *et al.* 2020a). This may be due partly to low search effort, the shortness of the ice-free season despite ongoing loss of sea ice (Steele *et al.* 2015), the considerable distance from the Atlantic, and/or the comparatively low densities of marine mammal prey species in those regions.

## **BIOLOGY AND HABITAT USE**

### **Life Cycle and Reproduction**

Most of the reproduction and population dynamic (life history) parameters summarized in the previous report (COSEWIC 2008) came from studies of northeast Pacific Residents between the early 1970s and 2004 (Olesiuk *et al.* 1990, 2005). That summary is repeated here, with updates based on new information.

Male Killer Whales reach sexual maturity at 12.8 years (mean). During a period of population growth (1973–1996), Northern Resident females gave birth to their first viable calf at 14.1 years. The age of female sexual maturity increased slightly (but significantly) to 15.4 years during the period of no net growth (1996–2004). The typical age range for first-time mothers was 12–17 years (77%) but some were as young as 9 years and as old as 22 years (Olesiuk *et al.* 2005). The mean age at first conception for both Southern and Northern Residents is 12.1 years in the wild and 9.8 years in captivity according to Robeck *et al.* (2015). Maximum fecundity (probability of becoming pregnant in a single estrous cycle) of Southern Residents reportedly occurs at age 20 to 22, increases quickly during the first four years after sexual maturity, slowly declines from age 22 to 39, and then declines precipitously (Wasser *et al.* 2017). The gestation period is 16–17 months (Walker *et al.* 1998; Duffield *et al.* 1995) or 18 months (Ward *et al.* 2013).

From 1973 to 1996, female Northern Residents produced a single calf every 4.9 years over an average 24-year reproductive period. This changed to one calf every 5.5 years over a 27-year reproductive period, resulting in a slight decline in the reproductive potential of females from 4.7 calves to 4.5 calves. In a study of Southern Alaska Residents from 1984 to 2010, the mean birth interval was 4.9 years and this increased significantly with age of the mother, from 4.3 years at age 20 to about 6.5 years by age 40 (Matkin *et al.* 2014), a pattern also shown in Northern Residents. The calving interval is highly variable and can range from 2 to 11 years or longer. Calving occurs year-round but is diffusely seasonal, peaking from fall through spring (Olesiuk *et al.* 2005). Calves are 2.2–2.5 m long at birth.

Olesiuk *et al.* (1990) measured the annual population growth rate for Northern Residents as 2.9%. In the above-mentioned study of Southern Alaska Residents, the estimated annual rate of increase was 3.5%, which may be close to the maximum for the species (Matkin *et al.* 2014). Overall, no major differences were found in the life history parameters of Northeast Pacific Northern Residents and Southern Alaska Residents. It is worth noting that life history parameters for the Northeast Pacific Southern Resident

population are not considered representative because of that population's exceptionally small size and its extreme exposure to anthropogenic disturbance over the last 40 years (e.g., Krahn *et al.* 2004).

The generation time (average age of parents) for Northern Residents ranged from 26 to 29 years (COSEWIC 2008). This compares to estimates for the species as a whole of 24 years for current conditions (at the calculated  $r$  [population growth rate]) and 25.7 years for pre-disturbance conditions (when  $r = 0$ ) based on a Leslie matrix with a five-parameter model specially designed to produce default values for Red List assessments of cetaceans (Taylor *et al.* 2007). For the purposes of the present assessment, the range given in COSEWIC (2008) is applied to all five DUs.

Females produced their last calf at approximately 40 years but live another 10 years on average and sometimes much longer (Olesiuk *et al.* 2005). It is possible that the presence of older females in a group increases the survival of younger animals even if such individuals no longer contribute directly to population growth (Brent *et al.* 2015). Northeast Pacific Transient (Bigg's) females have a prolonged post-reproductive period similar to that of Residents (Nielsen *et al.* 2021).

Mating behaviour has rarely been observed in the wild. Testosterone levels in captive adult males were highest from March through June (Robeck and Monfort 2006). This, and the fall through spring calving peak, suggests that breeding is most frequent in the spring and early summer.

Survival rates varied with age, with the highest mortality rates in neonates. From birth to 6 months of age, mortality ranged from 37% to 50% (Olesiuk *et al.* 1990); these estimates are crude and may be high. During the period of population growth of Northern Residents (1973–1996), the average life expectancy for animals that survived their first 6 months was 46 years for females and 31 years for males. However, during the period of no net population growth (1996–2004), the estimates fell to 30 years and 19.3 years for females and males, respectively. Longevity was approximately 80 years for females and 40–50 years for males. A female Southern Resident estimated to have been born in 1928–1935 was still living in 2022 (about 87–94 years old) (Center for Whale Research 2023).

For comparison to the survival values for Northern Residents (0.961 for males, 0.989 for adult females; Olesiuk *et al.* 1990), a photographic mark-recapture study of Killer Whales in the southern Indian Ocean from 1964 to 2002 showed that apparent mean adult survival probabilities declined between 1977 and 2002, from 0.935 to 0.895 for males and from 0.942 to 0.901 for females (Poncelet *et al.* 2010). The authors of that study attributed the declines to reduced prey abundance and/or lethal interactions with a demersal longline fishery. A similar study of Killer Whales off Norway associated with a spring-spawning concentration of Atlantic Herring estimated apparent survival probabilities of adult males and adult females as 0.971 and 0.977, respectively (Kuningas *et al.* 2014). Calving intervals in that study ranged from 3 to 14 years.

## Habitat Requirements

Killer Whale movements do not appear to be limited by features of their environment other than sea ice in high latitudes. They inhabit (or at least pass through or visit) a wide range of nearshore and pelagic habitats worldwide and appear capable of tolerating a wide range of temperatures and levels of salinity and turbidity. Their basic requirements include (1) sufficient quantity and quality of prey, (2) an acoustic environment that does not inhibit communication and foraging or result in hearing loss, and (3) safe-passage conditions that allow for seasonal movements, resting, socializing, and foraging.

During summer and fall, the distribution of both Northern and Southern Residents is closely linked to that of Chinook Salmon (*Oncorhynchus tshawytscha*), their preferred prey, and secondarily, Chum Salmon (*Oncorhynchus keta*), especially in autumn (COSEWIC 2008; Hanson *et al.* 2010; Ford *et al.* 2017). Changes in the relative strength of major salmon runs result in corresponding shifts in the areas where Resident Killer Whales are found (Ford and Ellis 2006; Shields *et al.* 2018a). Besides salmon, Residents, possibly mainly Northern Residents, prey on Sablefish (*Anoplopoma fimbria*) if conditions are right, such as at certain points along the shelf break where upwelling brings these fish close enough to the surface for them to be accessible (Ford *et al.* 2017). Resident whales also prey to some extent on bottom fishes such as Pacific Halibut (*Hippoglossus stenolepis*), Lingcod (*Ophiodon elongatus*), and Dover Sole (*Solea solea*) (Ford 2014).

Within the Johnstone Strait area of BC (Figure 5), Northern Residents engage in beach rubbing, and they are sensitive to disturbance while doing so. Whales repeatedly rub on small smooth pebbles on very specific sloped patches of beach in shallow water (Ford *et al.* 2000; Ford 2014). This behaviour has not been observed in other Killer Whale populations in the region and therefore does not seem to be a habitat “requirement” but rather a traditional activity of the Northeast Pacific Northern Resident population.

The main habitat requirement of Northeast Pacific Transients and other mammal-eating populations appears to be the availability and catchability of prey. Because their specialized hunting techniques generally involve stealth, catchability depends on having a quiet enough environment for the Killer Whales to detect and localize prey through listening (Barrett-Lennard *et al.* 1996). This would apply as well to the mammal-eating Killer Whales in the Atlantic and Arctic. The Offshore Killer Whale population generally uses habitat along the outer coast of British Columbia, where high densities of migratory sharks may be found (Ford *et al.* 2014).

## Movements, Migration, and Dispersal

Killer Whales are capable of travelling very long distances in short periods of time, and the different populations exhibit a wide range of degrees to which they are migratory. In the Pacific and probably elsewhere, Killer Whales do not migrate to specific breeding or calving areas that are separate from feeding areas. Rather, they appear to shift their distribution to take advantage of seasonal aggregations of prey, such as salmon returning to rivers to spawn (Residents), newly weaned seal pups making their first forays into nearshore waters (Transients), or Narwhals congregating in deep, narrow fiords in summer (Laidre *et al.* 2006).

The mammal-eating Killer Whales that visit high latitudes in eastern Canada are migratory in the sense that they move as far north in summer as ice conditions allow in order to gain access to concentrations of prey, then depart in September or October moving rapidly southward (i.e., 40 to > 100 km/day) (Ferguson *et al.* 2010, 2012; Matthews *et al.* 2011; Jourdain *et al.* 2019, 2021). A whale (either an adult female or a juvenile male) bearing a satellite-linked tag travelled more than 5,400 km in little over a month, leaving Prince Regent Inlet (northern Baffin Island) in early October and reaching a point in the open Atlantic (near 38°N, 41°W) due east of Virginia by mid-November when the tag stopped transmitting. Mammal-eating Killer Whales overwinter in middle or low latitudes, possibly in open portions of Baffin Bay–Davis Strait (especially off West Greenland), the Labrador Sea and/or elsewhere in the North Atlantic (Lefort *et al.* 2020a, p. 247). To date, no photographic matches of Killer Whales in the Canadian Arctic with Killer Whales in Newfoundland and Labrador have been reported (Young *et al.* 2011; Lawson and Stevens 2014); however, with increased research effort, this may change. Killer Whales are present in the Caribbean Sea in all months of the year (Bolaños-Jiménez *et al.* 2014); the whales sampled at St. Vincent and the Grenadines by Kiszka *et al.* (2021) were killed in April (2), June (3), and August (3), times of year (especially the latter two months) when Killer Whales that migrate to the Arctic would likely be farther north.

Movement patterns may differ markedly among subpopulations (i.e., pods or clans). For example, in the case of the closely monitored Southern Resident population, one pod (J) apparently remains in or near the Salish Sea (including Puget Sound) year-round, whereas the other two pods (K and L) are known to travel south to California in winter and north to northern BC and, on at least one occasion, to southeastern Alaska in spring/early summer (Krahn *et al.* 2004; Carretta *et al.* 2021). These movements arguably constitute migration, although whether they fit the classical definition of being linked to annual seasonal cycles is uncertain.

## **Interspecific Interactions**

### Diet

Killer Whale populations tend to be ecologically specialized and feed only on particular prey types. The diet of Northeast Pacific Resident populations consists almost entirely of teleost fishes, especially salmonids. Chinook Salmon is their primary prey and this species is a limiting factor in the population dynamics of both Southern and Northern Residents (Ford *et al.* 2010; Ward *et al.* 2013; Murray *et al.* 2021). Northeast Pacific Transients, in contrast, prey on marine mammals and occasionally seabirds. Harbour Seals are their predominant prey but Steller Sea Lions (*Eumetopias jubatus*), California Sea Lions (*Zalophus californianus*), Harbour Porpoises (*Phocoena phocoena*), and Dall's Porpoises (*Phocoenoides dalli*) are also important prey species (Ford *et al.* 1998, 2013). Northeast Pacific Offshore Killer Whales prey on sharks, including Pacific Sleeper Shark, Blue Shark (*Prionace glauca*), and Spiny Dogfish (*Squalus suckleyi*) (Ford *et al.* 2011, 2014; Ford 2014), and on upper trophic-level marine fishes such as Pacific Halibut and Opah (*Lampris guttatus*) (Krahn *et al.* 2007b; Ford 2014; Ford *et al.* 2014).

Northwest Atlantic / Eastern Arctic Killer Whales are thought to be primarily mammal eaters, those that occur in the Arctic being especially dependent on cetaceans and pinnipeds (Higdon *et al.* 2011; Jourdain *et al.* 2019; Lefort *et al.* 2020a; Remili *et al.* 2023). Important prey species include Narwhals, Belugas, and Bowhead Whales (*Balaena mysticetus*), as well as Ringed Seals (*Pusa hispida*) (Higdon *et al.* 2012). Lumpsumsuckers (*Cyclopterus lumpus*) reportedly are consumed by Killer Whales in Disko Bay, West Greenland, in mid-winter (February) (Laidre *et al.* 2006). However, Ferguson *et al.* (2010, p. 124) concluded that “the vast majority of killer whales in the Canadian Arctic and the Hudson Bay region preferentially, if not exclusively, consume marine mammals (versus fish).” It is likely, judging from observations of interactions with fishing operations as well as the few stomach contents examined (Lawson *et al.* 2007), that Killer Whales in Newfoundland and Labrador prey at least seasonally on fish as well as on marine mammals. This is similar to situations elsewhere in the North Atlantic (Jourdain *et al.* 2019).

### Predators and competitors

#### *Humans are the only predators of Killer Whales.*

In the Arctic, mammal-eating Killer Whales can be regarded as competitors with humans for marine mammal prey. As stated in a DFO workshop report from 2010, “Many communities in Nunavut are concerned that an increase in Killer Whale[s] will have a negative impact on shared prey stocks [of Bowhead Whales, Narwhals, Belugas, and seals]” (Stephenson and Hartwig 2010, p. 8). This concern was explicitly noted and reinforced by Inuit hunters from 11 eastern Nunavut communities (Kivalliq and Qikiqtaaluk regions) who were interviewed from 2007 to 2010 (Ferguson *et al.* 2012). Initial efforts have been made to quantify Killer Whale energy requirements in relation to cetacean and pinniped abundance in the Hudson Bay region (Ferguson *et al.* 2010, 2011) and the Lancaster Sound region (Lefort *et al.* 2020b).

Observations of fish-eating Killer Whales foraging near and at times “interacting” with fishing vessels (e.g., removing catch from netting or longline hooks), including in Newfoundland and Labrador (Lawson *et al.* 2007), puts them in direct competition with fisheries (Jourdain *et al.* 2019, p. 10).

In Canadian Pacific waters, Resident Killer Whales compete ecologically for salmonids (particularly the highly prized Chinook Salmon) with humans as well as other predators (non-human), including seals and sea lions. Also, the Southern and Northern Resident Killer Whale populations are in ecological competition with each other (Hilborn *et al.* 2012, and see discussion below under **Biological Limiting Factors**).

## Other interactions

As apex predators, Killer Whales can have very large top-down effects on prey species (e.g., T. Williams *et al.* 2004; Barrett-Lennard and Heise 2006). For example, Lefort *et al.* (2020b) estimated that the climate-related range expansion of around 160 Killer Whales in the eastern Canadian Arctic may be allowing them to consume more than 1,000 Narwhals each year during their seasonal residency. Those authors considered this to be an illustration of “the magnitude of ecosystem-level modifications that can occur with climate change-related shifts in predator distributions.”

An analysis of the “non-consumptive” (non-lethal) effects (“landscape of fear”; Laundré *et al.* 2001) concluded that the behavioural effects of Killer Whales on Narwhals and other marine mammals in the Canadian Arctic, even if small, could be having “an appreciable impact at the population level,” an impact that could exceed that of “consumptive mortality” (Breed *et al.* 2017, p. 2632). Further, Breed *et al.* noted the potential for increased densities of Killer Whales “to elicit structural changes to Arctic ecosystems mediated through both consumptive and trait-mediated mesopredator effects” (c.f. Ritchie and Johnson 2009).

## **Physiological, Behavioural, and other Adaptations**

The Killer Whale (as a species) exhibits a mixture of adaptive and maladaptive characteristics. The information and behavioural patterns that are transmitted culturally within and between generations through social learning should help the animals respond to changes in their environment. As discussed in COSEWIC (2008), the rapid spread of behaviour involving the removal of catches from fishing gear (“depredation”) by Killer Whales in the North Pacific is one example of this. However, such behaviour not only invites the ire (and sometimes retaliation) of fishermen, it can also put the animals at greater risk of becoming hooked or entangled (Dahlheim *et al.* 2022). A study of Killer Whales in and near the Strait of Gibraltar off Spain provided evidence that sociality can influence the spread of novel foraging behaviour but also drive population fragmentation, which can have a deleterious effect on an already small community (Esteban *et al.* 2016). The kin-directed food sharing by Northern Resident Killer Whales has been described as “a cooperative behaviour that may ... inhibit dispersal by reducing resource competition among kin” (Wright *et al.* 2016); however, it could also encourage inbreeding (M.J. Ford *et al.* 2018).

The extremely fixed prey preferences and acoustic behaviour of Northeast Pacific Resident populations presumably make them vulnerable to major changes in populations of their preferred prey species and to disturbance caused by noisy human activities. However, both populations have adapted to, or at least managed to tolerate, the increasing vessel traffic, including whale-watching vessels, within their habitat without completely abandoning traditional foraging areas. The short-term effects of vessel presence and vessel noise on foraging behaviour have been studied extensively, particularly in Southern Residents. An acoustic study in the urban coastal waters of Puget Sound near Seattle, “where anthropogenic sounds are ubiquitous, particularly those from motorized vessels,” found that the amplitude of the whales’ calls increased by 1 dB for every 1 dB increase in background

noise levels (Holt *et al.* 2008). As the authors point out, a downside of this “adaptability” is that such vocal compensation has potential costs in terms of energy loss, increased stress, and degraded communication abilities. Also, a tagging study of Southern Residents found that females are more likely than males to respond to close vessel approaches by interrupting their foraging, with an attendant loss of energy needed for fetal growth in pregnancy and for lactation after calving (Holt *et al.* 2021).

Evidence of prey switching in at least one North Atlantic population of Killer Whales that prey mainly on a spring-spawning stock of Atlantic Herring but also “interact” with seals (Vongraven and Bisther 2014; Samarra and Miller 2015) was interpreted as “plasticity” in feeding behaviour and “possible resilience to changing prey availability” in that region (Jourdain *et al.* 2019, p. 10). Barrett-Lennard and Heise (2006, p. 169) proposed that changes in diet or in hunting or foraging behaviour by Killer Whales may occur in two phases: the first a very slow process of “innovation” where one or a few individuals adopt or develop the change, and the second a much quicker process by which the change is “culturally transmitted” to and adopted by the larger group.

## **Limiting Factors**

### Natural mortality

Carcasses of Killer Whales are rarely recovered and relatively little is known about causes of natural mortality. Entrapment in ice, tidal saltwater lakes, or shallow water is well documented (COSEWIC 2008; Westdal *et al.* 2017; Lefort *et al.* 2020a; Jourdain *et al.* 2021). In the Arctic, entrapments or ice-induced strandings usually result in the animals either being killed by hunters or, if not hunted, dying from starvation or suffocation (Matthews *et al.* 2019).

Other sources of mortality likely include infectious disease, accidental beaching (stranding), parasites, biotoxins, and starvation. A number of microbiota with pathogenic potential have been identified in Killer Whales, some of which can cause abortions, reduced fecundity and/or increased mortality (Gaydos *et al.* 2004; Raverty *et al.* 2017). Based on pathology reports on 53 Killer Whales that became stranded in the eastern North Pacific and Hawaii between 2004 and 2013, Raverty *et al.* (2020) found that calves and sub-adults died from infectious disease, malnutrition, congenital malformation, and trauma (in the case of sub-adults); and adults died from bacterial infection (e.g., concurrent sarcocystosis and toxoplasmosis), starvation, and blunt-force trauma. Contributing factors in some deaths included Cookiecutter Shark (*Isistius* sp.) bite wounds and excessive tooth wear.

### **Biological limiting factors**

Biological factors limiting the ability of Killer Whales to persist in a particular region or to recover when depleted are best defined on a population basis rather than for the species as a whole. Although Killer Whales are highly intelligent, long-lived animals with no natural predators, some populations are vulnerable to the biological limiting factors described below.

## Fixed cultural attributes

Fixed cultural attributes can limit the ability of Killer Whales to adapt to rapidly changing environmental conditions. For example, the feeding specializations of Northeast Pacific Resident and Transient Killer Whales are strongly entrenched, and there is no evidence to suggest that individuals switch between marine mammal and fish prey. Three Transients studied in 1970 illustrate the strength of this dietary preference. One died after 75 days in captivity, having refused to eat fish. On the 79th day, the remaining two whales began to eat fish. These whales were later returned to the wild where they resumed their diet of marine mammals (Ford and Ellis 1999). Such strong and consistent foraging specializations mean that the Resident and Transient populations are more vulnerable to depletion of their preferred prey than if they were generalist feeders. It is not known whether other populations in Canada (Northeast Pacific Offshore and Northwest Atlantic / Eastern Arctic) have equally strong prey specializations.

It is generally accepted that the abundance of Resident Killer Whales is limited by the availability of their primary prey, Chinook Salmon (Ford *et al.* 2005b, 2010). Many Chinook stocks are at only a small percentage of their historical abundance levels, and more than 50 stocks within the present-day range of Resident Killer Whales are now extinct (Heard *et al.* 2007; see also COSEWIC 2008). As suggested by Ford *et al.* (2010), Resident Killer Whales are “highly specialized and dependent on this single salmonid species to an extent that it is a limiting factor in their population dynamics.” Recent studies using aerial photogrammetry (Fearnbach *et al.* 2011, 2018; Groskreutz *et al.* 2019; Stewart *et al.* 2021) provided demographic evidence of correlated prey limitation in both Southern and Northern Resident populations, suggesting that the nutritional stress caused by the insufficiency of preferred prey is having long-term negative effects, both lethal and non-lethal. Whitehead and Ford (2018) showed through modelling that ecologically specialized populations may be more successful (adaptive) than generalist populations. at least in the short term; however, they may also be more vulnerable to group extirpation due to poor resilience to environmental change in the long term.

The apparent inability, reluctance, or unwillingness of the whales, particularly Southern Residents, to prey-switch must be regarded as a limiting factor, even though, as the report of an independent panel examining the effects of salmon fisheries noted, correlative studies suggesting a linear causal relationship between Chinook Salmon abundance and the Southern Resident population’s vital rates should be interpreted with “considerable caution” (Hilborn *et al.* 2012).

It is unclear to what extent fixed cultural attributes constrain other Killer Whale populations. However, a study of Killer Whales near the Crozet Islands in the southern Indian Ocean (Busson *et al.* 2019) found that a seven-year “additive mortality event” caused by lethal interactions with illegal longline fisheries led to a sharp decline in local Killer Whale abundance ( 60% decrease in 12 years; Poncet *et al.* 2010). Busson *et al.* (p. 11816) speculated that surviving lone individuals or members of reduced-size groups were unable to “reassociate” in stable groups because (i) doing so would “disrupt an

already-optimal group size and increase costs such as intraspecific competition ... or disease transmission” and/or (ii) the whales’ kin-based, matrilineal social system “prevent[ed] new individuals from permanently joining other groups with which they share[d] low relatedness.”

### Mating behaviour and social dynamics

The propensity of Resident Killer Whales to mate outside their matriline (and clan in the case of Northern Residents) but within their population minimizes the possibility of inbreeding; however, it restricts options for mating when the population becomes very small (Barrett-Lennard 2000; Barrett-Lennard and Ellis 2001), as is the case for Southern Residents. Genotyping and pedigree analysis of Southern Residents showed that the production of offspring by mating within pods is common and there is little evidence of inbreeding avoidance in this small population (M.J. Ford *et al.* 2018). More recently, inbreeding depression in Southern Residents has been judged to be a major factor limiting population growth and is predicted to contribute to future declines (Kardos *et al.* 2023).

Changing conditions can have both positive and negative implications for Southern Residents from the standpoint of the population’s resilience. The grouping pattern that involves high rates of close contact, food sharing, etc. probably enables learning and cultural transmission, but the nearly constant social interactions may also put the group at greater risk of disease outbreaks (Parsons *et al.* 2009) and catastrophic events (such as the impacts experienced by the so-called AT1 population of Transients during the Exxon Valdez oil spill; Matkin *et al.* 2008).

Genetic studies indicate that Northeast Pacific Transient, Resident and Offshore populations are largely closed to immigration, and that successful mating between members of these three different assemblages, if it occurs, is extremely rare (Barrett-Lennard 2000).

### Low reproduction rate

Even if factors that have caused the decline of a Killer Whale population are reduced or eliminated, the time required for recovery will be long because of the species’ life history. Females generally do not give birth to a viable calf (i.e., one that survives its first year) until 12–14 years of age and then produce viable calves at five-year intervals, on average (Ford 2014). Males are unlikely to become effective breeders before reaching their 20s. The maximum potential rate of increase for a Killer Whale population is 3% to 4% annually.

### Small population size

Some Killer Whale populations are at risk by virtue of their small size (i.e., low abundance). In animals with highly matrilineal societies, the social structure may become seriously disrupted if the population becomes too small. The Southern Resident population’s small size (fewer than 100 individuals over the last half-century and possibly longer) in combination with its demographic structure puts it at high risk of extirpation (Hilborn *et al.* 2012). This population has contained, on average, only 22–26 (range 10–53) “effective breeders” in recent decades (M.J. Ford *et al.* 2011, 2018), and some evidence

suggests that this very small effective breeding size has prevailed since at least the mid- to early 1900s (M.J. Ford *et al.* 2018, p. 7). According to Hilborn *et al.* (2012, p. 15), citing M.J. Ford and Parsons (2012), the largest size of the Southern Resident population in the recent past was likely 96 animals in 1967.

## POPULATION SIZES AND TRENDS

### Data Sources, Methodologies, and Uncertainties

Killer Whales from the west coast of Canada have been photo-identified since the early 1970s. The number of Resident Killer Whales is well known because most, if not all, individuals within each population (Northern and Southern) are photographed each year. An annual census of the Southern Resident population is conducted by the Center for Whale Research (CWR), which is based in Friday Harbor, Washington. Estimates of the Northern Resident, Northeast Pacific Transient (Bigg's), and Northeast Pacific Offshore populations are made by Fisheries and Oceans Canada's Cetacean Research Program, (CRP–DFO), Nanaimo. The entire Southern Resident population is photographed annually, and the count is considered accurate. Not all members of the Northern Resident population are seen in some years, so that count is less accurate (see DFO 2022a). As with Northeast Pacific Resident and Offshore populations, a photo-identification catalogue and encounter data for Transient (Bigg's) Killer Whales are maintained at the CRP–DFO in Nanaimo, and are used to estimate the abundance of this population (Towers *et al.* 2019). Abundance estimation for the Offshore Killer Whale population is based on statistical modelling using annual photo-identification histories (see Ford *et al.* 2014).

Most of what is known about Killer Whales in the eastern Canadian Arctic comes from scattered records, although since September 2005, DFO has maintained a GIS sightings database, a community monitoring network, acoustic monitoring, photo-identification, and the opportunistic deployment of satellite transmitters and collection of skin and blubber samples for genetic and other analyses (Higdon *et al.* 2012). *Inuit Quajimajatuqangit* (IQ, Inuit Traditional Ecological Knowledge) is also being compiled as part of this initiative (e.g., see Ferguson *et al.* 2012; Westdal *et al.* 2013; Higdon *et al.* 2014).

In 2006 DFO began large-scale cetacean surveys and a photo-identification cataloguing program in eastern Canada. DFO offices in Quebec, the Maritimes, and in Newfoundland and Labrador maintain regional sightings databases that include all reports of cetaceans in the regions.

As noted in the previous status report (COSEWIC 2008), Killer Whales are rarely sighted in the Bay of Fundy, in the Gulf of St. Lawrence, and on the Scotian Shelf, and survey programs by both DFO and NOAA Fisheries (with a focus on North Atlantic Right Whales, *Eubalaena glacialis*) have not resulted in enough Killer Whale observations to support meaningful abundance estimation in the Maritimes.

## Abundance

The abundance of Killer Whales in Canadian waters overall is relatively small when compared to global, Northern Hemisphere, or basin-wide abundance. Forney and Wade (2006) concluded that there were at least 50,000 Killer Whales worldwide, but they considered it “likely that the total abundance is considerably higher, because estimates are not available for many high-latitude areas of the Northern Hemisphere and for large areas of the South Pacific, South Atlantic, and Indian Oceans” (p. 157). In the North Pacific, if the central estimates for populations in Canada and the United States are combined, the total is around 2,000. In the North Atlantic as a whole, four dedicated sighting surveys conducted between 1987 and 2001 generated a mean overall estimate of 13,615 Killer Whales (Jourdain *et al.* 2019). Those survey results, however, suggested that abundance was “strikingly lower in the North-western Atlantic and mid-Atlantic than in the North-eastern Atlantic” (Jourdain *et al.* 2019, p. 5).

The overall abundance of Killer Whales in Canada (all five DUs combined) likely totals only several thousand, and probably fewer than 5,000 individuals.

### Northeast Pacific Southern Resident population, DU-1

The 2021 census of Southern Residents resulted in a count of 73 individuals (Center for Whale Research 2023), down from 83 whales in 2016. Of this total count, 53 individuals were mature (73%), or 46 (63%) if the seven post-reproductive females in the population are excluded.

### Northeast Pacific Northern Resident population, DU-2

Assuming no births or deaths occurred in the uncensused matriline in 2021, the best estimate of population size in 2021 was 332 individuals (range = 332–336), for an increase of eight animals (or 2.5%) over the previous survey year (DFO 2022a). Of this total, 198 were mature individuals (60%, including adults of unknown sex, reproductive females, post-reproductive females, sexually mature males, and physically mature males; DFO 2022a, Figure 3), or 176 (53%) if post-reproductive females are excluded.

### Northeast Pacific Transient (Bigg’s Killer Whale) population, DU-3

The most recent estimate (2006) of total population size in Canadian waters was 243 individuals (95% probability interval = 180–339) based on a photographic “capture-recapture” approach using Bayesian statistical techniques (Ford *et al.* 2008). Although no similar post-2006 estimate of abundance is available, Towers *et al.* (2019) reported that 206 mature individuals were considered to be alive in 2018. Adding 143 individuals known or thought to be offspring or maternally related kin of those animals gives a total of 349 whales in the 2018 population, or 59% mature. Although the number of post-reproductive females in the population was not tallied by Towers *et al.* (2019), Nielsen *et al.* (2021) indicate that the proportion of post-reproductive females in the Transient Killer Whale population is similar to that in Resident populations. Thus, based on the proportion

of post-reproductive females in the Northern Resident population (7% of mature individuals), the number of mature individuals in the Transient population, excluding post-reproductive females, was about 192 in 2018.

#### Northeast Pacific Offshore population, DU-4

The most recent estimate (2012) of total population size was 300 individuals (95% Highest Posterior Density Interval = 257–373) based on a photographic “capture-recapture” approach using a Bayesian modelling framework (Ford *et al.* 2014). Assuming that the proportion of the population that is mature (excluding post-reproductive females) is similar to that in the Northern Resident population (53%), there were about 160 mature individuals in the Northeast Pacific Offshore population in 2012.

#### Northwest Atlantic / Eastern Arctic population, DU-5

Fifty-three individual Killer Whales were photo-identified from three Arctic regions (Hudson Bay and northern and eastern Baffin Island) between 2004 and 2009 (Young *et al.* 2011), and an additional 45 previously unidentified individuals were photo-identified in the coastal waters of northern Baffin Island between 2010 and 2018 (Lefort *et al.* 2020a). A capture-mark-recapture analysis of 63 individuals photographed between 2009 and 2018 suggested a population size of  $163 \pm 27$  (Lefort *et al.* 2020b). For several reasons, including the fact that (i) sightings of as many as 100 Killer Whales at one time have been reported and that (ii) “photographic effort has been focused in a small area relative to the population’s range” (Lefort *et al.* 2020a, p. 247), it is reasonable to conclude that the number of whales visiting eastern Canadian Arctic waters is more than 163. A recently updated photo-identification catalogue included 94 individuals identified from northern Baffin Island waters and eight individuals between 2009 and 2020 (Kucheravy *et al.* 2023). Applying the 53% mature observed in Northern Resident Killer Whales to the estimated 163 whales in the population, there may be at least 86 mature individuals in the population that visit the eastern Canadian Arctic. Matches of two individuals between northern Baffin Island and West Greenland have recently been documented (S. Ferguson pers. comm. 2023).

Lawson and Stevens (2013) reported that 67 Killer Whales had been photo-identified in Labrador and southward to Nova Scotia but the authors gave no indication of the time period. No matches had been made between the whales photo-identified in the Arctic and those photo-identified in Canadian waters south of Labrador at the time of this writing.

## **Trends**

#### Northeast Pacific Southern Resident population, DU-1

The population size of Southern Residents was likely 96 animals in 1967 (Ford and Parsons 2012 as cited in Hilborn *et al.* 2012, p. 15). At that time, Killer Whales were perceived as a nuisance or a threat by fishermen and other mariners, and this population was likely depleted by decades of directed shooting (Olesiuk *et al.* 1990). The population further declined in the late 1960s and early 1970s because about 47 individuals were live-

captured for public display (Bigg and Wolman 1975; Bigg *et al.* 1990). These captures ended in 1973, at which time there were approximately 70 remaining Southern Residents. By 1980 the population had increased to 84 whales, an increase of 20% (average 2.88%/yr), although the rate of increase varied by pod. The population had increased to 98 whales by 1995 (average 2.3%/yr; Figure 9) as a result of an increase in the number of mature animals and birth rates as well as a decrease in mortality. In 1996 the population entered a period of decline with poor survival and a low birth rate (Krahn *et al.* 2004). By 2001 the population had declined to 78 whales (17.7% overall, or -3.8%/yr). Since 2001 the number of Southern Residents has fluctuated, increasing to 89 by 2006 (Center for Whale Research 2023). Overall, the Southern Resident population declined by four animals between 1997 and 2006, i.e., a decline of 4.4% (-0.4%/yr). However, the number of mature individuals declined by 13 (21%) over this same period.

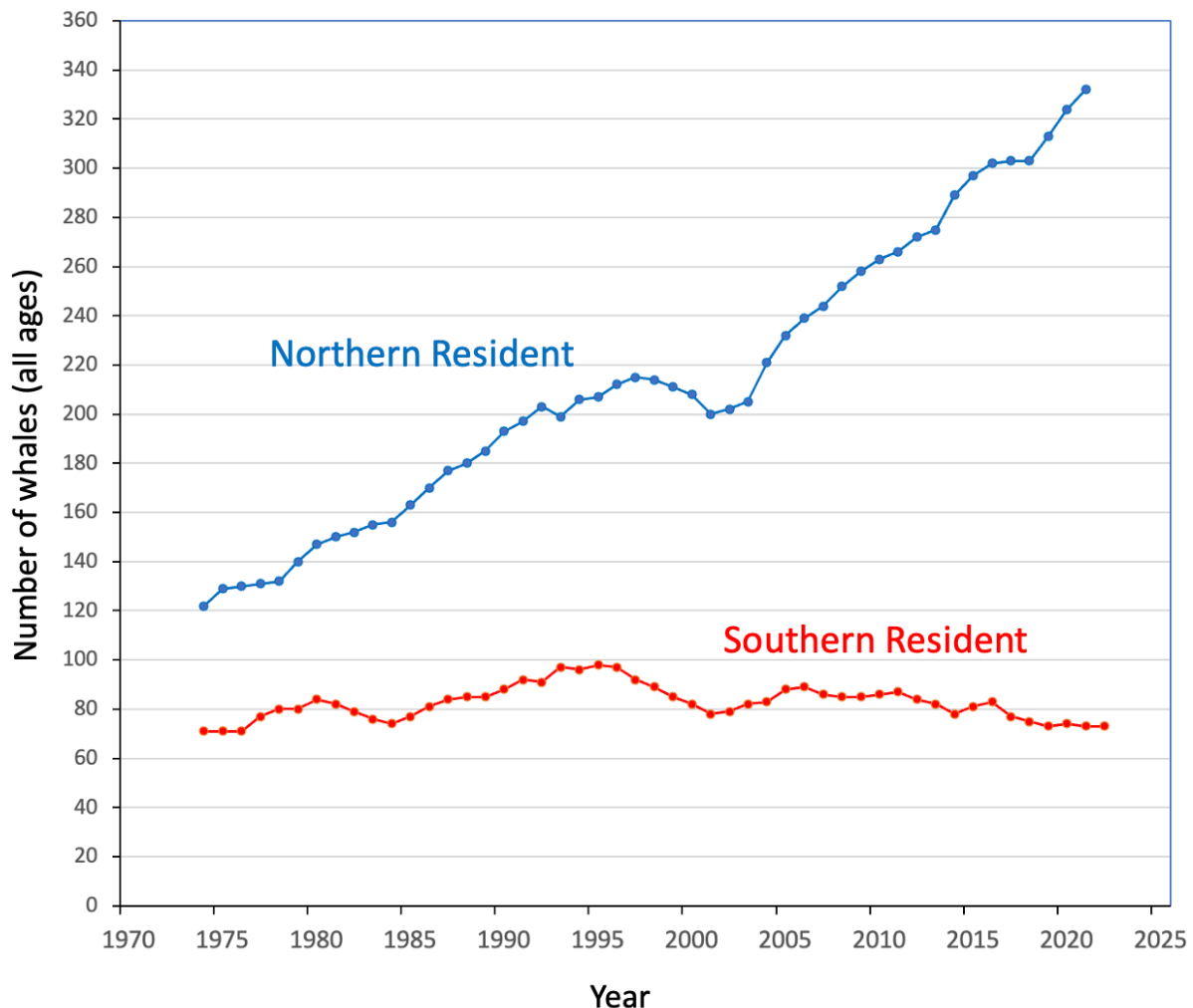


Figure 9. Sizes of the Northern Resident (upper curve, in blue) and Southern Resident (lower curve, in red) Killer Whale populations from 1974 to 2021. Source: Towers *et al.* (2020) and DFO (2022a) for Northern Residents; Center for Whale Research ([www.whaleresearch.com](http://www.whaleresearch.com)) for Southern Residents.

The population fluctuated between 67 and 98 individuals from 1974 to 2011, with intervals of increase alternating with periods of decline (Figure 9); the duration of intervals of positive growth substantially exceeded those when growth was negative (Hilborn *et al.* 2012, p. 7). The realized rate of increase over that period was 0.71% per year. However, since the peak count of 98 individuals in 1995, the population size has been declining at a rate of approximately 1% per year, with a total of 73 individuals counted in 2022 (Center for Whale Research 2023). Long-term demographic data show that this population is food-limited, with declines in survival (Ford *et al.* 2009), fecundity (Ward *et al.* 2009), and social cohesion (Parsons *et al.* 2009) during years with low Chinook Salmon availability (Couture *et al.* 2022; also see **Biological Limiting Factors**).

#### Northeast Pacific Northern Resident population, DU-2

The situation of Northern Residents differs from that of Southern Residents even though the two populations appear to be similarly dependent on Chinook Salmon. Like the Southern Residents, this population was likely depleted by directed shootings prior to the 1960s (Olesiuk *et al.* 1990). Between 1964 and 1973, at least 14 whales, including 12 from one pod, were removed from the Northern Resident population for captivity (Bigg *et al.* 1990). The population contained approximately 132 whales in 1975 and increased to 220 by 1997 (average rate of increase 2.9%/yr) (Figure 9). From 1997 to 2001 the population declined to 201 whales (overall decline of 8.6%, or 2.11%/yr) due primarily to mortality (Olesiuk *et al.* 2005). By 2006 the population had increased to 244 whales. Overall, from 1997 to 2006 the Northern Resident population increased by 24 whales, i.e., by 11% (1.1%/yr; Figure 9). This was due largely to juvenile recruitment, however; the number of mature individuals increased by only 7 animals (6%).

The success of Northern residents relative to Southern Residents between 1974 and the mid-1990s was likely due to their higher initial abundance, which would have buffered the population from changes in birth and death rates. Also, fewer Northern Residents were removed by the live-capture fishery (Olesiuk *et al.* 1990). Finally, Northern Residents are exposed to less disturbance and less environmental contamination than Southern Residents. However, both populations declined significantly during the late 1990s, concurrent with declines in their principal prey, Chinook Salmon (Ford *et al.* 2005b; see **Biological Limiting Factors**).

The Northern Resident population grew at a mean annual rate of 2.2% from 1973 to 2021, numbering at least 332 individuals in 2021 (DFO 2022a). Annual estimated rates of increase from 2011 to 2021 ranged from 0.0 to 5.1 (DFO 2022a, Table 1).

## Extinction risk of Southern and Northern Residents based on quantitative analysis

Quantitative analyses of extinction risk are available for both Northeast Pacific Resident populations (Murray *et al.* 2021). A cumulative effects population viability analysis (PVA) model, incorporating all known and presumed threats, was found to predict demographic rates closest to those observed for both populations. This model built upon an existing PVA model developed for the Southern Resident population (Lacy *et al.* 2017). The recently low abundance of Chinook Salmon in the northeastern Pacific Ocean and the whale population's exposure to vessel disturbance (due to both vessel noise and presence) and chemical pollution (especially tissue concentrations of PCBs) were inferred to play a significant role in the population dynamics of Southern Residents. More recent genetic analyses indicate that their population dynamics are strongly influenced by inbreeding depression, and simulations suggest that the population will decline over the next 100 years (Kardos *et al.* 2023). The mean modelled trajectory for Southern Residents was declining, with a 26% probability of extinction, which was estimated to occur after 86 (+/- 11) years (Murray *et al.* 2021). In contrast, the Northern Resident population (DU-2) was predicted to increase to carrying capacity within 25 years, assuming recent declines in Chinook Salmon abundance do not continue (Murray *et al.* 2021).

## Northeast Pacific Transient (Bigg's) Killer Whale population, DU-3

From the mid-1970s to the mid-1990s, the Northeast Pacific Transient population experienced rapid growth (average 6%/yr) which coincided with dramatic increases in the abundance of Harbour Seals and Steller Sea Lions in BC coastal waters. This rapid apparent growth in Killer Whale abundance (which exceeds the estimated maximum growth rate of 3% to 4% for toothed whales) was interpreted as suggesting that the early increase had been due, at least in part, to movement of adults into nearshore areas (Ford *et al.* 2008). The rate of increase began to slow in the mid-1990s and this slowing continued through 2006 "as the population approach[ed] an equilibrium ... of around 262 whales" (Ford *et al.* 2008). The observed average annual rate of increase of 4.1% since 2012 was "due to relatively low mortality and the birth of over 100 calves during this time period" (Towers *et al.* 2019).

## Northeast Pacific Offshore population, DU-4

Little information is available on trends for this population. Members of the population are observed only infrequently but they are monitored opportunistically. Based on available information, the population appears to be at least stable, with no evidence of a decline from photo-identification records (Ford *et al.* 2014; G. Ellis pers. comm. 2022).

## Northwest Atlantic / Eastern Arctic population, DU-5

Local knowledge indicates that sightings are increasing in the eastern Canadian Arctic and Hudson Bay (Higdon and Ferguson 2009; Jourdain *et al.* 2019; Lefort *et al.* 2020a). To some extent, this may be due to changes in sighting and reporting effort, but there is no doubt that the increased extent and duration of open (ice-free) water has been a major factor. Jourdain *et al.* (2019, p. 11) noted that despite multiple ongoing threats, Killer Whale populations in at least some parts of the North Atlantic, specifically those around Norway, Iceland, and eastern Greenland and in the eastern Canadian Arctic, appear to be increasing. They suggest that this could be a result not only of increasing records due to greater awareness and observer effort but also of “recovery from past removals, increased access to prey due to better management of fisheries, whaling and sealing activities reducing predator competition, [and/or] shifts in prey availability and habitat due to climate change.”

It is possible that there has been an overall increase in the size of the Northwest Atlantic / Eastern Arctic population; however, it is also possible that ongoing removals by unmanaged hunting in Greenland in combination with the other less obvious continuing threats (see **Threats** below) have suppressed (or even reversed) any increase that may have been underway.

### **Rescue Effect**

Rescue effect is unlikely to apply to the two Resident populations (DUs 1 and 2) in the Canadian Pacific. Each of these populations is genetically and culturally unique, with very little evidence of mixing, and no members of these populations are found entirely outside Canadian waters. A rescue effect is possible with the Northeast Pacific Transient (Bigg's) population (DU-3). As described previously, Transient Killer Whales regularly encountered off California can be considered part of this DU due to the frequent occurrence of some of these whales in Canadian waters and their tendency to mix with Canadian members of the DU while in the area. The abundance of California Transient whales was estimated to be at least 193 individuals in 2021 (A. Schulman-Janiger pers. comm. 2022), the majority of which have not yet been identified in Canadian waters (J. Towers pers. comm. 2022). Transients that are found in southeastern Alaska have all been identified at some time along the BC coast and thus are already considered part of the Canadian population (Towers *et al.* 2019). Some degree of rescue effect is also possible with the Northeast Pacific Offshore population (DU-4). The majority of whales in this population have been photo-identified in Canadian waters, but at least 30 individuals have been documented in Alaskan waters but not yet in Canada (although they may occur here; G. Ellis pers. comm. 2022).

In the Atlantic, it is likely that at least some, and possibly all, of the Killer Whales that occur occasionally and “unpredictably” in U.S. Atlantic waters (Waring *et al.* 2015, pp. 71–73) are part of DU-5, and could provide some rescue potential if they do not normally occur in Canadian waters. As mentioned above, two individuals have been photographically matched between northern Baffin Island and West Greenland waters (S. Ferguson pers. comm. 2023). Thus, at least some and perhaps most of the Killer Whales that are observed in West Greenland waters may be part of DU-5 and therefore could have some potential to rescue the Northwest Atlantic / Eastern Arctic population in Canada. However, neither the abundance nor the status of these animals outside Canadian waters is known.

## THREATS

### Historical, Long-term, and Continuing Habitat Trends

Although there has been no documented change in the quantity of Killer Whale habitat, its quality has certainly deteriorated in a variety of ways throughout much of the range of Killer Whales in Canada, the United States, and elsewhere. Among the sources of habitat deterioration that has been documented for decades are (i) physical and acoustic disturbance from commercial, industrial, and recreational human activity (NRC 2003; IWC 2023), and (2) changes in prey availability and quality due to commercial fishing, environmental pollution, and contaminants such as PBDEs (see **Current and Projected Threats**). Modelling approaches have been applied repeatedly to elucidate the likely impacts of multiple long-term and continuing threats to Northeast Pacific Resident Killer Whales, and to evaluate the potential effectiveness of management options (Williams *et al.* 2006, 2016; Lacy *et al.* 2015, 2017; Murray *et al.* 2021).

Reduction of sea ice in the Arctic has created, and will continue to create, dramatically different conditions for Killer Whales and their prey in high latitudes (Overland *et al.* 2019). It is not an exaggeration to say that the Arctic environment has already been transformed by climate change. The effects, both positive and negative, on Killer Whales, on their prey, and on the human activities that in turn affect the whales and their prey (e.g., Reeves *et al.* 2014), are likely to vary both spatially and temporally. In any event, these effects are difficult to predict.

It is important to bear in mind that multiple, co-occurring stressors can have synergistic or cumulative effects (e.g., Sih *et al.* 2004; Williams *et al.* 2016; Wasser *et al.* 2017).

### Current and Projected Future Threats

The nature and severity of some threats differ significantly across the five DUs. However, too little is known about the nature and severity of some threats to make distinctions concerning their likely impacts on the different DUs. Therefore, for some threats discussed in this section, the DUs are treated separately, whereas for other threats, no distinctions are made among the DUs.

The main threats to Killer Whales in Canada are, or have been, deliberate removals, reductions in prey availability, exposure to harmful levels of environmental contaminants, and acoustic or physical disturbance. Other threats that may be significant are interactions with fisheries (especially bycatch but also changes in prey availability caused by overfishing), vessel strikes, and oil spills.

It should be noted that climate change per se is not seen as a direct threat to Killer Whales. Rather, it is likely to affect Killer Whales indirectly by potentiating, or in some instances possibly mitigating, the direct threats identified and described here.

Current and projected future threats are categorized below, following the IUCN-CMP (International Union for the Conservation of Nature–Conservation Measures Partnership) unified threats classification system (based on Salafsky et al. 2008). Some of the threats common to all five DUs are discussed without a breakdown by DU, others are broken down by DU and placed in sequence of decreasing severity of impact (greatest to least), ending with those for which scope or severity is unknown. The assigned cumulative threat impact assessments, by DU, are Very High/High for DU-1, High/Medium for DU-2, High/Medium for DU-3, High/Medium for DU-4, and High/Low for DU-5. These as well as impact values for each threat category are shown in the threats sheets for each DU in **Appendix 1** and in the Technical Summaries (box 24) for each DU.

#### Biological Resource Use (IUCN 5)

##### *Fishing & Harvesting Aquatic Resources (IUCN 5.4)*

Deliberate removals: Eastern North Pacific Killer Whales (DUs 1-4)

Historically, Resident Killer Whales that interfered with commercial and recreational fisheries were likely to be shot at and this may have been a significant cause of mortality (Olesiuk *et al.* 1990). Incidents of depredation on gear by Northern Residents (DU-2) were reportedly increasing off the northern BC coast at the time of the last COSEWIC report (COSEWIC 2008), and may have continued to increase in recent years (Ocean Wise 2019). Such behaviour, once started, is difficult to prevent or mitigate. In Prince William Sound, Alaska, depredation became widespread, and Killer Whales were often shot at until operational changes were made in the fishery (Matkin *et al.* 2008).

As mentioned in **Abundance and Trends**, more than 60 Resident Killer Whales were live-captured in Washington State and BC waters for the public display industry during the 1960s and early 1970s (Bigg and Wolman 1975). No such captures have been authorized in either the United States or Canada since that time.

## Deliberate removals: Eastern Arctic / Northwest Atlantic Killer Whales (DU-5)

Large numbers (thousands) of Killer Whales were taken in the North Atlantic by Norwegian whalers from the 1930s to 1980s, hundreds were killed around Iceland in the 1950s to protect fisheries, and close to 50 were live-captured and exported from Iceland in the 1970s and 1980s (Jourdain *et al.* 2019). They are still hunted, at least opportunistically, in both West and East Greenland and in the Caribbean Sea (particularly St. Vincent and the Grenadines), with no quota or cap on the number that can be killed. Reported catches (presumably meaning landed and thus not including those shot but not secured; “whales struck but lost are usually not reported” according to Heide-Jørgensen 1988) from 1996 to 2021 in West Greenland (possibly including animals that are part of this population, DU-5) totalled 313 whales (NAMMCO 2022). A single whaler in St. Vincent and the Grenadines landed at least 29 Killer Whales between 2007 and 2017 (Fielding and Kiszka 2021). Now that matches have been found between Killer Whales off northern Baffin Island and West Greenland, it is likely that at least some of the whales killed off West Greenland belong to Canada’s Northwest Atlantic / Eastern Arctic population. This may also be the case for at least some of those killed in the Caribbean.

At least 21 (confirmed) plus up to as many as 35 or so (unconfirmed) Killer Whales were killed in the eastern Canadian Arctic between the 1950s and mid-2000s (Higdon 2007). Although Killer Whales have not been deliberately removed (harvested or culled) in the eastern Canadian Arctic on a regular basis, Lefort *et al.* (2020a, p. 250) warned, citing Westdal *et al.* (2013), that increasing Killer Whale occurrence and negative attitudes toward these animals “could result in increased mortality due to management shootings.” In 2022, a single Killer Whale was killed near Pond Inlet, north Baffin Island (Nunatsiaq News, 2022).

An important consideration with respect to deliberate removals, particularly in all areas of Canada and Greenland (as well as in the Caribbean) where Killer Whales are hunted, is that little or nothing is learned about the demographic aspects or social roles of the individuals that are killed or injured. Given the social complexity and demography of Killer Whales, which individuals are removed matters. Without robust data and analyses, it cannot be assumed that any deliberate removals of Killer Whales (by killing, injuring, or live-capturing) are sustainable.

## Bycatch (all five DUs)

The previous status report indicated, based on anecdotal information and the general absence of net marks or wounds on identification photographs, that Killer Whales in the Pacific (and by implication the Atlantic) “are rarely entangled in commercial fishing gear” (COSEWIC 2008, p 35). However, there is now growing evidence that entanglement in fishing gear takes place more often than once thought. The deaths of two Killer Whales, both Transients, resulting from entanglement in crab pot lines were documented recently: a mature male off California in 2015 (Raverty *et al.* 2020) and a subadult found drifting off the coast of Oregon in 2022 (NOAA 2022). During depredation of a Sablefish fishery (see next section) off the entrance to Juan de Fuca Strait in 2022, a Northern Resident Killer Whale

was apparently temporarily entangled in demersal longline gear (B. Gisborne pers. comm. 2022). In addition to this evidence, an extensive data set of fishery observer records from Alaska for the period 1986 to 2016 revealed that Killer Whale interactions with fisheries, particularly longline and trawl fisheries, in the Gulf of Alaska and the Bering Sea are more frequent than previously believed (Dahlheim *et al.* 2022). In that study, all interactions documented with photographs involved whales assignable to the Resident (i.e., fish-eating) ecotype. It is notable that Transients also die in trawl nets at least occasionally, possibly while attacking Steller Sea Lions attracted to the trawling operations (Dahlheim *et al.* 2022, p. 91). Although the Killer Whale is rarely mentioned as one of the species taken as bycatch in U.S. commercial fisheries, gillnet fisheries (commercial and subsistence/personal use) in Alaska and California as well as trawl fisheries in Alaska, pot fisheries in Alaska, Washington, Oregon, and California, and demersal longline fisheries in Alaska are all known to entangle cetaceans and therefore represent an entanglement risk to all four Pacific DUs (NOAA 2023). Most of those fisheries, like fisheries in Canada, have little or very little observer coverage and therefore the absence (or paucity) of evidence of bycatch cannot be interpreted to mean that there is none.

According to Lawson *et al.* (2007), there were two reports of Killer Whales being entangled in gillnets off Newfoundland and “several” were found floating dead (possibly having died from entanglement). More recently, a large subadult male Killer Whale was entangled and died in a groundfish gillnet in nearshore northern Newfoundland on October 1, 2019. This whale was not matched to any known individuals in the Newfoundland and Labrador catalogue (J. Lawson pers. comm. 2023). It can be assumed that more such cases of incidental mortality occur off all coasts of Canada where entangling gear is deployed and Killer Whales are present. The same point as was made above about the lack of observer coverage applies to fisheries operating off eastern Canada, West Greenland, and elsewhere in the western North Atlantic (including the Caribbean Sea) where DU-5 Killer Whales may occur.

#### Natural System Modifications (IUCN 7)

##### *Other Ecosystem Modifications (IUCN 7.3)*

Reduction in prey availability: Northeast Pacific Southern Resident and Northern Resident populations (DU-1 and DU-2)

As mentioned repeatedly above, the reliance of Resident Killer Whales on healthy populations of Chinook Salmon makes them particularly vulnerable to overfishing or activities that reduce or degrade salmon spawning habitat. Chinook Salmon are their principal prey species from May through September, and they likely rely heavily on Chinook year-round (Ford and Ellis 2006). Fluctuations in Chinook Salmon abundance over the past 40 years appear to have played an important role in Killer Whale population dynamics (Ford *et al.* 2005b, 2010). In the 1980s Chinook abundance was variable across different areas of the coast but was generally higher than the long-term average. Between 1996 and 2000, coastwide Chinook abundance was 24% to 40% below the long-term average (Ford *et al.* 2005b, 2010). During this period, mortality rates of both Northern and Southern

Resident populations were 2–3 times higher than expected based on pre-1996 mortality rates. Mortality was distributed broadly among different pods as well as age and sex classes. From 2000 to 2003, Chinook abundance increased above the long-term average in all areas (except the Strait of Georgia), and mortality rates of Resident Killer Whales declined to levels close to those expected. Overall, there was a striking negative correlation between mortality rates of Resident Killer Whales and abundance of Chinook Salmon from 1979 to 2004 ( $r^2=0.777$ ,  $p < 0.001$ ; Ford *et al.* 2005b, 2010). There was also a significant positive correlation with birth rates during the same period ( $r^2=0.227$ ,  $p < 0.05$ ; Ford *et al.* 2005b, 2010); this correlation of Chinook abundance with Resident Killer Whale birth rates has been further confirmed by Ward *et al.* (2009).

As Hilborn *et al.* (2012) pointed out, the mechanism by which reduced Chinook Salmon abundance could have resulted in increased mortality and fecundity of Resident Killer Whales during the late 1990s is uncertain. Animals may have died from starvation, but it is possible that reduced feeding success led to nutritional stress that in turn increased the animals' susceptibility to disease or parasitism. This effect could have been amplified by the immunosuppressive effects of contaminants such as PCBs, which are found at high levels in these and other Killer Whales (see below). Hormone measures of Southern Residents indicated reduced fecundity (manifested as late pregnancy failure, including unobserved perinatal loss) between 2008 and 2014, a period when Fraser River Chinook and early spring Columbia River Chinook runs were both exceedingly low (Wasser *et al.* 2017).

Most Chinook Salmon stocks in British Columbia and Washington State have declined significantly in recent decades and many have been assessed as Endangered or Threatened in Canada (COSEWIC 2018, 2020b) or in the U.S. (NOAA 2020). These include many stocks that are important in the diet of both Southern (Hanson *et al.* 2010) and Northern (Ford *et al.* 2010) Resident Killer Whale populations. The prospects for survival and recovery of these stocks are uncertain (DFO 2022d), especially considering the potential future impacts of climate change (Crozier *et al.* 2021).

Reduction in prey availability: Northeast Pacific Transient (or Bigg's) Killer Whale population (DU-3)

Changes in prey abundance also are correlated with changes in the abundance (or possibly inshore movements and distribution) of the Northeast Pacific Transient (Bigg's) Killer Whale population (Shields *et al.* 2018b; also see **Trends**). These whales were very rare in inshore BC waters in the 1960s and early 1970s, following decades of harvesting and culling of pinnipeds in BC and neighboring U.S. waters. As the depleted pinniped populations (particularly Harbour Seals) rebounded under federal protective legislation in both countries beginning in the early 1970s, so did the numbers of Transients seen in local waters following a lag of several years (Ford *et al.* 2008, pp. 11-12).

Recently, there have been proposals for renewed predator control of pinnipeds in BC and Washington State to promote the recovery of depleted salmon stocks, which could reduce prey availability for Transient Killer Whales. It has been postulated that Harbour Seal predation on juvenile salmon is a major factor limiting productivity of Chinook Salmon

in the Salish Sea (Chasco *et al.* 2017; Nelson *et al.* 2019), and large scale removals of up to 50% of Harbour Seals have been proposed to enhance Chinook Salmon abundance and thereby promote recovery of Southern Resident Killer Whales (MERS 2019; WSAS 2022; Nelson *et al.* 2023). As previously noted, Harbour Seals are the predominant prey species of Transient Killer Whales.

Reduction in prey availability: Northeast Pacific Offshore Killer Whale population (DU-4)

The food habits of Offshore Killer Whales are less well known than those of Residents and Transients but there is growing evidence that they are shark specialists that occasionally take teleost fishes (Ford *et al.* 2014). This means they are at least potentially vulnerable to reduced prey availability should shark fisheries (including for Spiny Dogfish) expand. Extensive commercial fisheries in BC as well as Alaska, Washington and Oregon, which peaked in the 1940s, seriously depleted dogfish populations throughout the region (Ketchen 1986) and may have, in turn, affected the population of Offshore Killer Whales. Also, if Basking Sharks (*Cetorhinus maximus*) were, as suggested by Ford *et al.* (2014, p. 17), an “important food source” for Offshore Killer Whales, their virtual eradication from Canadian Pacific waters by the 1970s if not earlier (COSEWIC 2007) could help explain why the population of Offshores is so small today.

Reduction in prey availability: Northwest Atlantic / Eastern Arctic population (DU-5)

Not enough is known about Killer Whales around Newfoundland and Labrador to predict how they might be affected by changes in prey populations. It is also not possible to predict with confidence how prey populations in the Arctic, and in turn Killer Whales there, will be affected by reductions in sea ice associated with climate change. Reduced sea ice has been associated with an increased frequency of observations of Killer Whales in the Arctic, where they are able to exploit prey that were previously unavailable (Higdon *et al.* 2006; Higdon and Ferguson 2007). Declines in sea ice extent and coverage are expected to continue for many years (Schiermeier 2007) and the ramifications (positive, negative, or a dynamic mixture) for both Killer Whales and their prey are difficult to predict.

Competition and Depredation

In the Canadian Pacific, Resident Killer Whales may compete with commercial and recreational fisheries for fish (see **Interspecific Interactions**) and in doing so at least occasionally ingest fishing gear. Depredation of demersal longline fisheries for Pacific Halibut and Sablefish is commonly reported in coastal British Columbia waters, especially in spring, and this may be increasing (Ocean Wise 2019). All three clans of Northern Residents have been documented to engage in this activity, but Southern Residents appear to be involved only rarely (J. Ford, unpubl. data). Resident Killer Whales with hooks and fishing lures caught in their mouths are observed occasionally (COSEWIC 2008; Ravery *et al.* 2020). Ford *et al.* (1998) reported that out of eight carcasses of Resident Killer Whales for which stomach contents were obtained, two had hooks or lures designed to catch salmon and two contained hooks used to catch Pacific Halibut. These hooks and lures may be acquired when whales consume fish that escape from fishing gear. Although steel hooks

corrode over time, stainless steel hooks do not and may persist in the digestive system long after they are ingested. A juvenile Resident Killer whale (likely from the Southern Alaska population) necropsied in southeastern Alaska had salmon lures stuck in its mouth, but was likely killed by a halibut hook that had pierced its esophagus (CRP unpublished data cited in COSEWIC 2008; Raverty *et al.* 2020). Also, a Southern Resident necropsied in 1986 had a stainless steel hook in its intestinal tract (COSEWIC 2008). It can be assumed that similar incidents of depredation leading to hook ingestion or snagging occur in longline fisheries in U.S. waters, and probably also in eastern Canadian waters.

## Impacts

The impacts of these interactions with fisheries may appear small, if only well-documented incidents of mortality or serious injury are considered. However, as noted above in regard to deliberate removals, the impacts could be significant given the social complexity and demography of Killer Whale populations.

### Physical Disturbance (IUCN 6.1 – 6.3)

Killer Whales can be disturbed by vessels that approach closely, especially when the whales are feeding or beach rubbing. They are targeted by whale-watching operators and recreational boaters in both BC and Newfoundland. In BC the whale-watching industry grew from a few boats carrying fewer than 1,000 passengers per year in the late 1970s and early 1980s, to 80 boats carrying half a million passengers per year in 1998 (COSEWIC 2008). In addition, people in privately owned vessels often engage in whale watching.

Numerous studies of Resident Killer Whales subject to whale watching have documented short-term behavioural changes linked to nearby boat activity (Williams *et al.* 2006, 2009). Whales may swim faster, travel in less predictable paths, change their dive times, move into more open water, and reduce their foraging time in response to the presence of vessels (Lusseau *et al.* 2009). One recent study (2010–2014) found that females are more likely than males to interrupt their foraging activity, especially deep-dive foraging, when vessels approach closer than 400 m (Holt *et al.* 2021).

### Pollution (IUCN 9)

Domestic & Urban Wastewater (IUCN 9.1), Industrial & Military Effluents (IUCN 9.2), Agricultural & Forestry Effluents (IUCN 9.3), Garbage & Solid Waste (IUCN 9.4), and Air-borne Pollutants (IUCN 9.5)

### Chemically contaminated prey

In the Northern Hemisphere, persistent bioaccumulating toxins (PBTs) present the greatest toxic challenge to long-lived upper trophic-level organisms such as Killer Whales that feed on chemically contaminated prey. Assessing the effects of contaminants is particularly complex, however, because they are widespread in the environment and can interact synergistically to produce toxic effects (Braune *et al.* 2005).

Killer Whales carry the highest concentrations of organochlorine contaminants found in marine mammals (Ross *et al.* 2000). Adult males tend to carry higher levels than reproducing females because PBTs are transferred to offspring during gestation and lactation (Ross *et al.* 2000, 2002; Rayne *et al.* 2004; Ross 2006; Schnitzler *et al.* 2019). Juvenile Southern Residents, like most other individuals in their population, have blubber burdens of PCBs (polychlorinated biphenyls) in excess of health-effects thresholds, presumably owing primarily to maternal transfer, which puts young individuals at greater risk of, for example, immune and endocrine dysfunction (Krahn *et al.* 2009). Northeast Pacific Transient Killer Whales are more contaminated than Resident Killer Whales due to their diet, which includes other mammals already contaminated with PBTs (Ross *et al.* 2000). Similarly, Offshore Killer Whales have higher levels of PCBs than Residents, likely due to their predation on high trophic level sharks (Herman *et al.* 2005; Ford *et al.* 2014).

Although some PBTs, such as highly toxic and carcinogenic PCBs as well as DDT (dichloro-diphenyl trichloroethane), are no longer widely used in industrialized countries, many of these “legacy contaminants” continue to enter the environment from terrestrial runoff and atmospheric transport (Hartwell 2004; Stern *et al.* 2005; Muir *et al.* 2005). Killer Whales in the Eastern Arctic that have been observed feeding on seals, Belugas, and Narwhals (Higdon *et al.* 2011; Westdal *et al.* 2013; Lefort *et al.* 2020a, 2020b) have relatively high PBT tissue levels (Pedro *et al.* 2017). Blubber concentrations of PCBs, along with the next most common groups of PBTs (chlordanes and DDT), found in some North Atlantic Killer Whale populations exceed thresholds that cause physiological, reproductive, and immune impairments (Wolkers *et al.* 2007, Jepson *et al.* 2016, Pedro *et al.* 2017). Desforges *et al.* (2018) predicted that the very high tissue levels of PCBs in Killer Whales globally are likely to precipitate declines in all populations, and particularly in those that feed at high trophic levels and are closest to industrialized areas (also see Schnitzler *et al.* 2018).

Contaminant levels in Killer Whales are considerably higher than those known to cause PCB-associated reproductive impairment, skeletal abnormalities, endocrine disruption, and immunotoxicity in other mammals such as pinnipeds (Ross 2000; Ross *et al.* 2004). Although PCB levels are declining, models suggest that it will take decades before levels in Killer Whales fall below the thresholds for potentially adverse effects (Hickie *et al.* 2007).

“Emerging contaminants” with properties similar to those of legacy PBTs include polybrominated diphenyl ethers (PBDEs), which are used as flame retardants. Levels of PBDEs in the environment have been increasing exponentially (Hooper and McDonald 2000). Although the toxicity of PBDEs is not well understood, these chemicals have been associated with endocrine disruption in laboratory mammals (Darnerud 2003) and immunotoxicity in Grey Seals (*Halichoerus grypus*) (Hall *et al.* 2003). Killer Whales in Norway have been described as being among “the most polluted arctic animals, with levels [e.g., of toxaphenes and PBDEs as well as PCBs and pesticides] exceeding those in polar bears” (Wolkers *et al.* 2007). Northeast Pacific Transient Killer Whales carry higher levels of PBDEs than fish-eating Southern Resident Killer Whales, likely because they feed on

contaminated, high trophic-level marine mammals (Ross 2006). Offshore Killer Whales have higher levels of PBDEs and DDT than Residents, likely due to their predation of higher trophic-level fishes and their occurrence off coastal California, where these contaminants are present in agricultural runoff (Krahn *et al.* 2007b; Ford *et al.* 2014).

#### Industrial & Military Effluents (IUCN 9.2) – mainly oil spills

Oil spills are an ever-present threat in many of the areas inhabited by Killer Whales. The whales show little or no tendency to avoid such spills, as demonstrated by a diesel fuel spill in August 2007 in Johnstone Strait (COSEWIC 2008) and even more graphically by the *Exxon Valdez* crude oil spill in Prince William Sound, Alaska, in 1989 (Matkin *et al.* 2008). During this latter disaster, the Southern Alaska Resident ‘AB’ pod was seen swimming in oil slicks immediately following the spill. This group experienced significant and unprecedented mortality (up to 18 times the expected level) in the months following oil exposure, likely due to the inhalation of petroleum vapours (Matkin *et al.* 2008). Mortality continued in the following year because mothers died, leaving orphaned calves which subsequently died. Mortality in the AT1 Transient population, which inhabits Prince William Sound, did not occur immediately, but 9 of the 22 whales in that group disappeared the following winter. They may have died from the protracted effects of inhaling toxic vapours or from feeding on heavily oiled Harbour Seals. Neither the ‘AB’ pod of Residents nor the AT1 Transient population has recovered since the 1989 spill (Matkin *et al.* 2008).

As of April 2022, 11 oil platforms were active off California (California State Lands Commission 2022). Oregon permanently banned oil drilling in its waters in 2019 (The Register-Guard 2019), and there is no ongoing or planned offshore oil development in Washington State. Most oil development in Alaska takes place on the North Slope and in Cook Inlet. A moratorium on oil exploration and development has been in place off the BC coast since the early 1970s (Hudec and Penick 2003).

Tankers frequently transit the confined BC inshore waters occupied by Resident and Transient Killer Whales. In 2016, opposition fuelled largely by concern about the spectre of oil spills that would have affected Resident Killer Whales led the federal government to place a permanent ban on crude oil tanker traffic along BC’s north coast. However, ship traffic in the Salish Sea, including oil tankers as well as many other vessels with petrochemicals onboard, remains prodigious and is expected to increase greatly in the foreseeable future (Jarvela Rosenberger *et al.* 2017; Heberden 2022). Killer Whales are also at risk of oil spills along the Atlantic coast, given the presence of a large offshore oil and gas industry in Newfoundland (Hebron, Terra Nova, Hibernia, etc.; see CAPP 2018). As both the Northwest Passage and Northern Sea Route continue to open up with the reduction of sea ice, tanker and container traffic has increased and will continue to increase, and with it the risk of Killer Whales in the Arctic and sub-Arctic being exposed to oil spills (Reeves *et al.* 2014).

## Excess Energy (IUCN 9.6)

### *Acoustic disturbance*

The overall level of human-generated (anthropogenic) underwater noise has increased significantly in the North Pacific, North Atlantic, and Arctic over the last few decades, and this is of concern due to its realized and potential impacts on cetaceans, including Killer Whales. Commercial shipping, offshore oil and gas exploration and drilling, military and other uses of sonar, and most recently the rapid expansion of efforts to harness offshore wind energy are most responsible for this increase (Hildebrand 2009; Thompson *et al.* 2010; Erbe *et al.* 2014, 2019; Burnham *et al.* 2022). Noise can interfere with the ability of cetaceans to detect prey, communicate, and acquire information about their environment (NRC 2003, 2005; Weilgart 2007; Nowacek *et al.* 2007; Clark *et al.* 2009). It can also disrupt natural behaviour such as foraging (e.g., by disturbing or displacing the whales or their prey), impair hearing, and even cause physiological damage. Measuring responses to acoustic disturbance is a challenge because reactions may be subtle or difficult to interpret, and animals may not show an obvious behavioural response yet still be affected (Williams *et al.* 2014; Southall *et al.* 2019, 2021).

Vessel traffic is the primary source of chronic noise for Killer Whales. Vessel noise covers a broad band of frequencies, including those used by Killer Whales, and is the dominant source of ambient noise at low frequencies (0–200 Hz; NRC 2003; Veirs *et al.* 2016; Erbe *et al.* 2019). As indicated above (under **Physiological, Behavioural, and other Adaptations**), increasing background noise from vessel traffic has been shown to cause Southern Residents to compensate by increasing the amplitude and duration of their calls, with potential energy costs, more stress, and degraded communication (Foote *et al.* 2004; Holt *et al.* 2009; Wieland *et al.* 2009). Such compensatory behaviour is not unusual in marine mammals (Tyack and Janik 2013).

Efforts made recently to slow vessel traffic in areas frequently occupied by Southern Residents can be expected to mitigate the noise disturbance to some degree as long as vessel operators comply with the guidance (Joy *et al.* 2019; Burnham *et al.* 2021).

Vessel noise may be even more of a concern for Transient Killer Whales because they vocalize less frequently than Residents (Deecke *et al.* 2005), and chronic noise may mask the cryptic calls they use to communicate. Also, mammal-eating Killer Whales primarily hunt by listening for sounds produced by prey animals, and increased noise likely reduces their foraging efficiency by masking such sounds (Barrett-Lennard *et al.* 1996).

High-energy impulsive sounds, such as those produced during seismic surveys, can travel long distances underwater (> 10–100+ km). Such noise may have significant effects on cetaceans, e.g., causing behavioural changes, hearing threshold shifts, elevated stress levels, and tissue damage (COSEWIC 2008). At-sea operating protocols applied to activities that produce high-energy sounds may not adequately protect cetaceans from exposure to harmful levels of sound (NRC 2007; Weir and Dolman 2007). Systematic surveys of cetaceans during seismic surveys in UK waters suggested a degree of

avoidance behaviour by Killer Whales and other cetaceans (Stone and Tasker 2006). Killer Whales have been observed to respond strongly to intense mid-frequency military sonar (Southall and Gentry 2005; Miller *et al.* 2014; Southall *et al.* 2016). On one occasion (described in COSEWIC 2008), Southern Resident Killer Whales exposed to such sonar gathered into a tight group, swam close to shore, changed directions several times, and finally split apart and left the area, travelling quickly in different directions.

High-energy sound from acoustic harassment devices (“seal scarers”) has been associated with the displacement of Northern Resident Killer Whales (Morton and Symonds 2002). Use of these devices is no longer permitted in BC waters (P. Cottrell pers. comm. 2023)

#### Transportation & Service Corridors (IUCN 4)

##### *Shipping Lanes (IUCN 4.3)*

According to COSEWIC (2008), at least eight Killer Whales are known or suspected to have been struck by vessels off the Canadian West Coast, judging by observed incidents, scarring, or recovery of carcasses. Six of these strikes have occurred since 2002. The types of vessels involved ranged from small high-speed skiffs (6–8 m length) to 20 m tugboats. More recently, mortality resulting from vessel strikes was confirmed in an adult female Northeast Pacific Transient and considered likely in an adult male Southern Resident (Raverty *et al.* 2020). Vessel strikes, long believed not to be a significant risk to Killer Whales, is a growing concern. Presumably as vessel traffic increases in areas frequented by Killer Whales, the risk of their being struck and killed or seriously injured also increases.

#### Human Intrusions & Disturbance (IUCN 6)

##### *Recreational Activities (IUCN 6.1)*

As regular objects of intense attention by “eco”-tourism (whale watching), Resident Killer Whales are at high risk of being disturbed by the close approach and physical presence of vessels and by vessel noise. Disturbance is regarded as a significant factor affecting the recovery potential of Southern Residents. The types of effects of whale-focused tourism for which there is empirical evidence include short-term disruption of behaviour (faster swim speeds, changes in course and dive time, compensatory acoustic patterns), reduction in time spent foraging, and displacement away from preferred habitat.

## *War, Civil Unrest & Military Exercises (IUCN 6.2)*

Killer Whales pass through areas where military exercises occur (including live-fire ranges) in both Canadian and U.S. waters. For example, CUTLASS Fury is a biennial NATO exercise that occurs off Nova Scotia and Newfoundland (e.g., NATO 2019). A similar biennial exercise, Trident Fury, takes place off the west coast of Vancouver Island (Pacific Navy News 2020). Military sonar and live-fire exercises at sea can cause serious behavioural disturbance and in some instances physiological damage or even death of cetaceans (Parsons *et al.* 2008). Mitigation may help prevent impacts but does not eliminate the risk.

## Energy Production & Mining (IUCN 3)

### *Offshore Renewable Energy (IUCN 3.3)*

Offshore renewable energy development is expected to expand rapidly along the BC coast and the U.S. west coast, including in areas frequented by Resident and Transient Killer Whales. The planned NaiKun Wind Energy project in Hecate Strait is of particular concern in relation to Northern Residents. Also, tidal, wave, or ocean current (i.e., hydrokinetic) energy development is a concern, perhaps especially in the tidal passes that are heavily used by Resident Killer Whales (e.g., Lavoie 2012).

Offshore wind energy production in eastern Canada is in the early stages of development but is considered to have great potential (e.g., Nicholson 2023). Interest in hydrokinetic energy production in Atlantic Canada is centred in the Bay of Fundy (Stocks 2023), an area rarely visited by Killer Whales (Melville in review).

Some physical and acoustic disturbance of Killer Whales (and their prey) during turbine siting (high-resolution geophysical surveys) and installation (pile driving, explosives) can be expected from all offshore wind projects involving such work. However, the greatest concern may be the associated increase in ship traffic. This brings more noise disturbance and the risks of vessel strikes and fuel spills. Overall, however, the net impacts of commercial-scale development of offshore renewable energy sources are uncertain.

## Garbage & Solid Waste (IUCN 9.4)

Ingestion of microplastic particles is an emergent concern for many marine organisms (Alava 2020; Moore *et al.* 2022). High levels of these pollutants have been documented in Beluga Whales (Moore *et al.* 2020), which are among the prey species of Killer Whales in the Arctic. Recently, microplastics have been found in fecal samples from Southern Resident Killer Whales (K. Parsons pers. comm. 2023).

Entanglement in derelict fishing gear (“ghost” gear) is another concern that is not (yet) regarded as a problem for Killer Whales but may occur at least occasionally.

### 3.2 Mining and Quarrying

Deep-sea mining for polymetallic nodules to obtain nickel, copper, manganese, and especially cobalt for use in producing electric-vehicle batteries does not currently appear to represent a threat to Killer Whales in Canada. However, there is great concern about the ecological effects of seabed disturbance and waste dumping (e.g., Meggs 2023) which could, conceivably, have negative effects on Killer Whales and/or their prey.

#### **Number of Threat Locations**

For Killer Whales in Canada, there are many more than 10 threat-based locations. This is probably also true of three of the five DUs (3, 4, and 5) when considered individually. However, given the relatively small population sizes, population structure, social organization, grouping behaviour, and tendency to congregate in specific areas and at specific times to feed on salmon (or in the case of Northern Residents, to beach rub), the number of threat locations for Northeast Pacific Resident populations (DUs 1 and 2), and particularly Southern Residents, is possibly less than 10.

## **PROTECTION, STATUS, AND RECOVERY ACTIVITIES**

### **Legal Protection and Status**

The Northeast Pacific Southern Resident population was listed as Endangered under SARA in 2003 and as Endangered under the U.S. *Endangered Species Act* in 2005. The Northeast Pacific Northern Resident and Transient populations were listed as Threatened under SARA in 2003. The Northeast Pacific Offshore Killer Whale population was listed as Special Concern in 2003, then uplisted to Threatened in 2011. The Northwest Atlantic / Eastern Arctic population was assessed as Special Concern by COSEWIC in 2008 but has yet to be listed under SARA. In December 2023, COSEWIC reassessed these populations: Northeast Pacific Southern Resident population as Endangered, Northern Resident, Offshore, and Transient populations as Threatened, and Northwest Atlantic / Eastern Arctic population as Special Concern. Killer Whales are also protected under the *Fisheries Act*, the *Canada National Parks Act*, and the *Canada National Marine Conservation Areas Act*.

Critical Habitat, as defined under SARA, was officially identified for both Northeast Pacific Resident Killer Whale populations in 2009 (DFO 2011; Ford *et al.* 2017). This consisted of a 3,390 km<sup>2</sup> area including the Canadian side of Juan de Fuca and Haro straits and Boundary Pass, the waters surrounding the Southern Gulf Islands, and part of southern Georgia Strait off the mouth of the Fraser River for Southern Residents, as well as a 905 km<sup>2</sup> area in Johnstone Strait for Northern Residents (Figure 4 in Ford *et al.* 2017). Two additional areas have since been identified as Critical Habitat, one off southwestern Vancouver Island (for Southern and Northern Residents) and the other in western Dixon Entrance (for Northern Residents) (DFO 2022c). Importantly also, the U.S. government

designated a 6,630 km<sup>2</sup> area of marine habitat on the American side of the Salish Sea, including Puget Sound, as Critical Habitat for Southern Residents under the U.S. *Endangered Species Act* in 2006 (Federal Register 2021). This area was recently expanded to include an additional 41,207 km<sup>2</sup> off the outer coast as far south as Point Sur, California (Federal Register 2021). Critical Habitat has not yet been identified for Transient or Offshore Killer Whales, but Ford *et al.* (2013) provide information to support its identification for Transients.

In 1982, a 1,248-ha area of western Johnstone Strait was designated by the BC Ministry of Environment as the Robson Bight (Michael Bigg) Ecological Reserve in order to protect Northern Resident Killer Whale rubbing beaches from human disturbance (Ford *et al.* 2017).

## Non-Legal Status and Ranks

As explained under *Synonyms and notes* in the **Name and Classification** section, at the global species level, the Killer Whale is assessed as Data Deficient on the IUCN Red List. The NatureServe Global Conservation Status, assessed in 2016, is G4 – Apparently Secure. The NatureServe statuses for the five DUs in Canada are as follows: Southern Resident (DU-1) – Critically Imperiled (S1); Northern Resident (DU-2) – Imperiled (S2); Transient (DU-3) – Imperiled (S2); Offshore (DU-4) – Imperiled (S2); Northwest Atlantic / Eastern Arctic (DU-5) – No Status Rank (SNR) (NatureServe: [https://explorer.natureserve.org/Taxon/ELEMENT\\_GLOBAL.2.105428/Orcinus\\_orca](https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.105428/Orcinus_orca))

## Land Tenure and Ownership

The concept of land tenure and ownership is not obviously relevant to a marine species such as the Killer Whale. However, under this heading it may be relevant to cite the legal designations of Critical Habitat (mentioned above under **Legal Protection and Status**) for Southern and Northern Residents in Canada and for Southern Residents in the United States. Recently implemented “no fishing” and “no entry” zones in specific areas to protect the whales and their foraging habitat (see below) exemplify the kinds of measures that can accompany these designations.

## Recovery Activities

A Recovery Strategy for Resident Killer Whales (both populations) was published in 2008 and amended in 2011 and 2018 (DFO 2018a). An Action Plan for Resident Killer Whales was published in 2017 (DFO 2017). A Recovery Strategy for Transient Killer Whales was published in 2007 (DFO 2007), and a Recovery Strategy for Offshore Killer Whales in 2018 (DFO 2018b). Multi-species action plans for Gulf Islands National Park Reserve, Pacific Rim National Park Reserve, and Gwaii Haanas National Marine Conservation Area Reserve all include recovery actions for the Killer Whale DUs in the Canadian Pacific.

Numerous special measures have been put in place specifically to increase protection and promote recovery of Resident Killer Whales, especially the Southern Resident population (DFO 2022c; Government of Canada 2022). These include temporary area-based fishing closures “to protect salmon and to minimize disturbance from vessels,” seasonal prohibitions on vessel traffic (“Interim Sanctuary Zone”) in parts of the southern Gulf Islands, two new seasonal slowdown areas near Swiftsure Bank, and a required vessel separation distance of 400 m. Vessels are prohibited from approaching Killer Whales to within less than 400 m in southern BC coastal waters between Campbell River and just north of Ucluelet (DFO 2022b). In addition, the Vancouver Fraser Port Authority has an ongoing voluntary program to slow down commercial vessel traffic in Haro Strait and Boundary Pass as well as on Swiftsure Bank (Burnham *et al.* 2021; Vancouver Fraser Port Authority 2022).

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## COLLECTIONS EXAMINED

No collections were examined for the preparation of this report.

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## **BIOGRAPHICAL SUMMARY OF REPORT WRITER**

Randall Reeves was Marine Mammals Specialist Subcommittee Co-chair and a member of COSEWIC for nine years. He has written a number of the marine mammal COSEWIC status reports over the last 40 years. He is also chair of the IUCN Cetacean Specialist Group and chair of the U.S. Marine Mammal Commission's Committee of Scientific Advisers.

## Appendix 1. IUCN Threat Calculator results (one for each DU).

<b>Species or Ecosystem Scientific Name</b>	Orcinus orca Killer Whale Northeast Pacific Southern Resident population DU-1		
<b>Element ID</b>		<b>Elcode</b>	
<b>Date (Ctrl + ";" for today's date):</b>	2023-03-30		
<b>Assessor(s):</b>	Randall Reeves, John Ford, Hal Whitehead, Dwayne Lepitzki, Karen Timm, Greg Wilson, Shannan May-McNally, Andrew Trites, Kim Parsons, Viv Tulloch, Katie Kowarski, Thomas Doniol-Valcroze, Sheila Thornton, Rianna Burnham, Graeme Ellis, Rowshyra Castaneda, Sam Iverson, Jordan Hoffman, Erika Thorleifson, Alana Philips, Bronwyn Harvey, Jennifer Yakimishyn, Larry Johnson, Katarina Duke, Aline Carrier, Brett Freake, Carilia Horning		
<b>References:</b>	Draft COSEWIC report and calculator prepared by R. Reeves.		
<b>Overall Threat Impact Calculation Help:</b>	<b>Level 1 Threat Impact Counts</b>		
	<b>Threat Impact</b>		<b>high range</b>
	A	Very High	0
	B	High	2
	C	Medium	1
	D	Low	2
<b>Calculated Overall Threat Impact:</b>	Very High		High
<b>Assigned Overall Threat Impact:</b>	AB = Very High - High		
<b>Impact Adjustment Reasons:</b>			
<b>Overall Threat Comments</b>	Gen time 26-29 years, therefore timeframe for severity and timing is 78-87 years into the future; eat Chinook Salmon and other salmonids; continuing decline in numbers expected but magnitude uncertain, 15% past decline over 2 gens; habitat quality projected to decline, 46 mature individuals, clear evidence of inbreeding depression; PVA: 20% prob of extinction in 5 gens; EN D1 (2008), CH has been identified; extremely low numbers suggest any mortality would cause population decline.		

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & Commercial Development	Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
1.1	Housing & urban areas					Southern Resident Killer Whales in BC (and Washington State) frequent inshore and nearshore waters. In fact, much of their identified Critical Habitat is close to large urban and residential areas. While it is hard to specify how and to what degree of severity such proximity itself affects the animals, it almost certainly increases the likelihood of exposure to specific threats such as those considered under 1.2, 3.3, 4.3, 5.4, 6.1, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.2	Commercial & industrial areas		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	The same point as made for 1.1 applies here. Also, among other specific things, expansion of Roberts Bank Terminal, Port of Vancouver, could have a significant impact on the Fraser River stock of Chinook salmon and in turn on the nutrition of Southern Residents ( <a href="https://thenarwhal.ca/port-of-vancouver-roberts-bank-scientists/">https://thenarwhal.ca/port-of-vancouver-roberts-bank-scientists/</a> ) (7.3). Ongoing and future construction or expansion of power plants, shipyards (e.g., LNG terminals), and permanent port structures is a concern. Mitigation needed both in design and during construction/operation of approved developments.
1.3	Tourism & recreation areas						Beach resorts as well as campgrounds and recreational docks, areas where people are in kayaks, using paddleboards, etc. have the potential to disturb and at least temporarily displace Killer Whales.
2	Agriculture & Aquaculture						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						A study in BC from 1985 to 2000 showed that noise from acoustic harassment devices intended to deter seals from salmon aquaculture pens displaced Killer Whales away from waters nearby (Morton and Symonds 2002). This displacement effect apparently ended when the devices were no longer used in the area (Broughton Archipelago). Acoustic deterrence devices are no longer being used in BC aquaculture facilities. Aquaculture facilities in BC are not known to represent a significant entanglement problem for this DU at present, but such facilities (mainly for salmon or shellfish) do exist in parts of the whales' range (e.g., Clayoquot Sound), and are often being relocated, so it is important to at least monitor the industry's development and seek to identify and investigate facilities that overlap habitat used by Southern Residents.
3	Energy Production & Mining						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.1	Oil & gas drilling						Oil and gas development including offshore exploration, drilling, and production (scored here) as well as transport (e.g., tankers; 5.4) brings risks of oil spills (9.2). Noise associated with related activities, such as seismic surveys, and vessel traffic can disrupt communication and foraging by fish-eating Killer Whales (9.6). Although there is currently no offshore oil and gas development activity in BC, tankers regularly move through BC waters. Ongoing and future climate change will heighten the risks of oil exposure and disturbing noise in BC and waters outside Canada used by these salmon-eating populations of Killer Whales. The devastating effect of the Exxon Valdez crude oil spill on the Southern Alaska Resident AB pod is a cautionary example of fish-eating Killer Whales' susceptibility (9.2).
3.2	Mining & quarrying						Deep-sea mining for polymetallic nodules is still in a developmental stage but could become a source of disturbance to these Killer Whales and/or their prey.
3.3	Renewable energy						Offshore renewable energy development is expected to expand rapidly along the BC and U.S. west coasts, including in areas frequented by Southern Resident Killer Whales. Some physical and acoustic disturbance of the whales during wind turbine siting (high-resolution geophysical surveys) and installation (pile driving, explosives) is expected, but the greatest concern may be the increase in ship traffic associated with such development. Potential wave and/or tidal energy projects could also potentially affect this DU.
4	Transportation & Service Corridors	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
4.1	Roads & railroads						
4.2	Utility & service lines						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.3	Shipping lanes	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Ship traffic is regarded as a significant (and growing) threat to Southern Residents. Vessel strike is a known cause of serious injury and mortality, with small high-speed skiffs as well as large tugboats and ships involved. There is a trend for vessel speeds to increase (particularly high-speed ferries), which increases the risk of strikes. Though vessel strikes are rarely reported, it is reasonable to assume that some go undetected and therefore are not reported. Mitigation measures (e.g., seasonal closures to vessel traffic in specific areas, voluntary and mandatory vessel speed limits) may help reduce the severity of strike risk but their effectiveness needs to be evaluated regularly and adjustments made as appropriate <a href="https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/regulations-vessel-effects-southern-resident-killer-whales">https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/regulations-vessel-effects-southern-resident-killer-whales</a> ; <a href="https://www.pac.dfo-mpo.gc.ca/fm-gp/mammals-mammiferes/whales-baleines/srkw-measures-mesures-ers-eng.html">https://www.pac.dfo-mpo.gc.ca/fm-gp/mammals-mammiferes/whales-baleines/srkw-measures-mesures-ers-eng.html</a> )
4.4	Flight paths						
5	Biological Resource Use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Northeast Pacific Resident Killer Whales have long been protected from deliberate injury or killing (the live-capture of individuals for display or research ended in the 1970s). Full legal protection is expected to continue. However bycatch (entanglement) in fishing gear is ongoing and, although not frequent or at a high level in absolute terms, entanglement may be a significant threat to Resident Killer Whales in BC and adjacent waters. Most documented cases have involved gillnets but Killer Whales elsewhere also die incidentally in demersal longline and trawl gear. In addition to entanglement per se, the whales are at some risk of ingesting hooks or lures, and also of being harmed (shot at) by fishermen in retaliation for depredation. The latter probably is a more frequent risk for Northern than for Southern Residents.
6	Human Intrusions & Disturbance	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.1	Recreational Activities	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	As regular objects of intense attention by “eco”-tourism (whale-watching), Resident Killer Whales are at high risk of being disturbed by the close approach and physical presence of vessels and by vessel noise (9.6). Disturbance is regarded as a significant factor affecting the recovery potential of Southern Residents. The effects of whale-focused tourism for which there is empirical evidence include short-term disruption of behavior (faster swim speeds, changes in course and dive time, compensatory acoustic patterns), reduction in time spent foraging, and displacement away from preferred habitat. Mitigation measures such as seasonal prohibitions on vessel traffic in parts of the southern Gulf Islands and the required vessel separation distance of 400 m should reduce the severity of this threat to some extent.
6.2	War, civil unrest & military exercises		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Military sonar (9.6) and live-fire exercises at sea can cause serious behavioral disturbance and, in some instances, physiological damage or even death of cetaceans. Southern Residents are known to pass through naval exercise and live-fire ranges (e.g., area WG in the Strait of Georgia, WH in Juan de Fuca Strait). Mitigation may help prevent impacts but does not eliminate the risk. Vessel traffic associated with military activities can cause noise disturbance (9.6) as well as injury or death from ship strike (4.3).
6.3	Work & other activities		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	There is currently no biopsy collection or tagging of Southern Residents but photography from vessels and drones continues to facilitate population monitoring.
7	Natural System Modifications	BC	High – Medium	Pervasive (71-100%)	Serious – Moderate (11-70%)	High (Continuing)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications	BC	High – Medium	Pervasive (71-100%)	Serious – Moderate (11-70%)	High (Continuing)	A major way in which a wide variety of human activities affect Southern Residents is by reducing, or otherwise altering, the availability of Chinook Salmon, their preferred prey. The Roberts Bank Terminal project mentioned under 1.2 is a good example. Historical anthropogenic reduction of the productivity and carrying capacity of freshwater spawning, rearing, and migratory habitat (e.g., by dams and diversions), together with large-scale ocean fishery removals and unfavourable ocean conditions that affect the survival and maturation of juvenile fish (driven at least in part by climate change), likely helps to prevent recovery of the Southern Resident population. Though the mechanism of effect is uncertain, there is a strong inverse correlation between Resident Killer Whale mortality rate and Chinook Salmon abundance and a significant positive correlation between the whales' birth rates and Chinook Salmon abundance. Starvation or poor nutrition due to lack of access to adequate high-quality prey may increase the whales' susceptibility to disease and parasitism. This susceptibility may be amplified by the immunosuppressive effects and reduced fecundity associated with pollutants (such as PCBs).
8	Invasive & Other Problematic Species & Genes						
8.1	Invasive non-native/alien species/diseases						
8.2	Problematic native species/diseases						Although there is evidence that some stranded Killer Whales in the eastern North Pacific have died from (or at least suffered from) bacterial infections such as sarcocystis and toxoplasmosis, there is no reason to think that disease is a current threat to Southern Residents. Domoic acid toxicosis is a major problem for some other marine mammals in the eastern North Pacific, but there is currently no evidence that it is a problem for Killer Whales. It is also worth noting that cryptococcosis is pervasive in the eastern North Pacific and affects porpoises and Harbour Seals in BC (G. Ellis, pers. comm. 2022).
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9	Pollution	BC	High – Medium	Pervasive (71-100%)	Serious – Moderate (11-70%)	High (Continuing)	Killer Whales tend to have very high body burdens of toxic chemicals in their tissues (PCBs, pesticide residues, flame retardant compounds, etc.). These chemicals, some of which are known or suspected to cause reproductive impairment, skeletal abnormalities, endocrine disruption, and immunosuppression, can come from many sources and be airborne, waterborne or acquired through maternal transfer or ingestion of contaminated prey.
9.1	Domestic & urban waste water						
9.2	Industrial & military effluents						Oil spills are an ever-present threat in many areas throughout the population's range. The whales do not appear to avoid such spills, as demonstrated by a diesel fuel spill in Johnstone Strait in 2007 and the infamous Exxon Valdez spill in 1989 (from which the most heavily affected pod of Residents has still not recovered). It is assumed that inhalation of toxic petroleum vapours was responsible for the very high mortality.
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						Ingestion of microplastic particles is an emergent concern for many marine organisms. Entanglement in derelict fishing gear ("ghost" gear) is another concern but it is not (yet) regarded as a problem for these Killer Whales.
9.5	Air-borne pollutants						
9.6	Excess energy	BC	High – Medium	Pervasive (71-100%)	Serious – Moderate (11-70%)	High (Continuing)	Acoustic disturbance by anthropogenic sound (noise) is a major concern for Killer Whales. Sources of greatest concern are geophysical (including seismic) surveys, military sonar, military live-fire exercises at sea, pile driving (a major noise source associated with offshore wind development), and vessel traffic. Noise can impair the whales' ability to detect and capture prey, communicate with one another, and more generally acquire information about their environment. Impacts are mostly sublethal. Efforts have been made in both Canada and the U.S. to mitigate this threat.
10	Geological Events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate Change & Severe Weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	The habitat shifts and disturbances due to climate change are probably affecting and will continue to affect, this Killer Whale population. Some of the effects, such as sea level rise, ocean acidification, and marine heatwaves (e.g., The Blob in 2013 and 2018), on the whales and/or their prey may be positive and others negative.
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						
11.5	Other impacts						

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).

<b>Species or Ecosystem Scientific Name</b>		Orcinus orca Killer Whale Northeast Pacific Northern Resident population DU-2	
<b>Element ID</b>		<b>Elcode</b>	
<b>Date (Ctrl + “;” for today’s date):</b>		2023-03-30	
<b>Assessor(s):</b>		Randall Reeves, John Ford, Hal Whitehead, Dwayne Lepitzki, Karen Timm, Greg Wilson, Shannan May-McNally, Andrew Trites, Kim Parsons, Viv Tulloch, Katie Kowarski, Thomas Doniol-Valcroze, Sheila Thornton, Rianna Burnham, Graeme Ellis, Rowshyra Castaneda, Sam Iverson, Jordan Hoffman, Erika Thorleifson, Alana Philips, Bronwyn Harvey, Jennifer Yakimishyn, Larry Johnson, Katarina Duke, Aline Carrier, Brett Freake, Carilia Horning	
<b>References:</b>		Draft COSEWIC report and calculator prepared by R. Reeves.	
<b>Overall Threat Impact Calculation Help:</b>		<b>Level 1 Threat Impact Counts</b>	
<b>Threat Impact</b>		<b>high range</b>	<b>low range</b>
A	Very High	0	0
B	High	1	0
C	Medium	1	2
D	Low	3	3
<b>Calculated Overall Threat Impact:</b>		High	High
<b>Assigned Overall Threat Impact:</b>		BC = High – Medium	
<b>Impact Adjustment Reasons:</b>		Population is increasing, some threats overlap	
<b>Overall Threat Comments</b>		Generation time 26-29 years therefore timeframe for severity and timing is 78-87 years into the future; eat Chinook and Chum Salmon; increasing pop trend 2.6x over 1.75 gens; possible decline in habitat; 176 (or 183) matures; PVA predicts continued increase over next few decades; TH D1 (2008); CH has been identified; Northern Residents are exposed to less disturbance and less environmental contamination than Southern Residents.	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
1.1	Housing & urban areas						Resident Killer Whales in BC (and Washington State) frequent inshore and nearshore waters. In fact, much of the identified Critical Habitat for both DUs is close to large urban and residential areas. While it is hard to specify how and to what degree of severity such proximity itself affects the animals, it almost certainly increases the likelihood of exposure to specific threats such as those considered under 1.2, 3.3, 4.3, 5.4, 6.1, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6.
1.2	Commercial & industrial areas		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	The same point as made for 1.1 applies here. Also, among other things, liquified natural gas terminals at Kitimat currently under construction are likely to cause temporary and/or permanent displacement and will definitely result in a major increase in large vessel traffic through Douglas Channel, creating more chronic noise (9.6) and increasing the risk of ship strikes (4.3) as well as fuel oil spills (9.2). Ongoing and future construction or expansion of power plants, shipyards, and permanent port structures is a concern. Mitigation needed both in design and during construction/operation of approved developments.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism & recreation areas						Beach resorts as well as campgrounds and recreational docks, areas where people are in kayaks, using paddleboards, etc. have the potential to disturb and at least temporarily displace Killer Whales. Beach-rubbing behaviour of Northern Residents could be affected by such disturbance
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						A study in BC from 1985 to 2000 showed that noise from acoustic harassment devices intended to deter seals away from salmon aquaculture pens displaced Killer Whales away from waters nearby (Morton and Symonds 2002). This displacement effect apparently ended when the devices were no longer used in the area (Broughton Archipelago). Acoustic deterrence devices are no longer being used in BC aquaculture facilities [Is this true?]. Aquaculture facilities in BC are not known to represent a significant entanglement problem for this DU at present, but such facilities (mainly for salmon or shellfish) exist in parts of the whales' range (e.g., Clayoquot Sound?), and are often being relocated, so it is important to at least monitor the industry's development and seek to identify and investigate facilities that overlap habitat used by Northern Residents.
3	Energy production & mining		Negligible	Pervasive (71-100%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
3.1	Oil & gas drilling						Oil and gas development including offshore exploration, drilling, and production (scored here) as well as transport (e.g., tankers; 5.4) brings risks of oil spills (9.2). Noise associated with related activities, such as seismic surveys, and vessel traffic can disrupt communication and foraging by fish-eating Killer Whales (9.6). Although there is currently no offshore oil and gas development activity in BC, tankers regularly move through BC waters. Ongoing and future climate change will heighten the risks of oil exposure and disturbing noise in BC and waters outside Canada used by this salmon-eating population of Killer Whales. The devastating effect of the Exxon Valdez crude oil spill on the Southern Alaska Resident AB pod is a cautionary example of fish-eating Killer Whales' susceptibility (9.2).
3.2	Mining & quarrying						Deep-sea mining for polymetallic nodules is still in a developmental stage but could become a source of disturbance to these Killer Whales and/or their prey.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.3	Renewable energy		Negligible	Pervasive (71-100%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Offshore renewable energy development (mainly wind and hydrokinetic) is expected to expand rapidly along the BC coast, including in areas frequented by Northern Resident Killer Whales. Some physical and acoustic disturbance of the whales during turbine siting (high-resolution geophysical surveys) and installation (pile driving, explosives) is expected, but the greatest concern may be the increase in ship traffic associated with such development.
4	Transportation & Service Corridors	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Ship traffic is regarded as a significant (and growing) threat to Southern Residents. Vessel strike is a known cause of serious injury and mortality, with small high-speed skiffs as well as large tugboats involved. There is a trend for vessel speeds to increase (particularly high-speed ferries). Though vessel strikes are rarely reported, it is reasonable to assume that some go undetected and therefore are not reported. Mitigation measures (e.g., seasonal closures to vessel traffic in specific areas, voluntary and mandatory vessel speed limits) may help reduce the severity of strike risk but their effectiveness needs to be evaluated regularly and adjustments made as appropriate
4.4	Flight paths						
5	Biological Resource Use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Northeast Pacific Resident Killer Whales have long been protected from deliberate injury or killing (the live-capture of individuals for display or research ended in the 1970s). Full legal protection is expected to continue. However, bycatch (entanglement) in fishing gear is ongoing and, although not frequent or at a high level in absolute terms, entanglement may be a significant threat to Resident Killer Whales in BC and adjacent waters. Most documented cases have involved gillnets but Killer Whales in BC and elsewhere also die incidentally in demersal longline and trawl gear. In addition to entanglement per se, the whales are at some risk of ingesting hooks or lures, and also of being harmed (shot at) by fishermen in retaliation for depredation. The latter probably is a more frequent occurrence for Northern than for Southern Residents. Entanglement in derelict ("ghost") gear is not known to be a problem for these Killer Whales but would be scored under 9.4.
6	Human intrusions & disturbance	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.1	Recreational activities	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	As regular objects of intense attention by “eco”-tourism (whale watching), Resident Killer Whales are at high risk of being disturbed by the close approach and physical presence of vessels and by vessel noise (9.6). Among the types of effects of whale-focused tourism for which there is empirical evidence are short-term disruption of behavior (faster swim speeds, changes in course and dive time, compensatory acoustic patterns), reduction in time spent foraging, and displacement away from preferred habitat. Mitigation measures such as seasonal restrictions on vessel traffic and the required vessel separation distance of 400 m should reduce the severity of this threat to some extent. The Robson Bight Ecological Reserve in Johnstone Strait, designated in 1982, is closed to the public specifically to protect Northern Resident Killer Whales attempting to engage in 'beach rubbing' from being disturbed. There is concern that with stricter protection of Southern Residents, more of the whale-watching attention (including diving with the whales) is shifting to Northern Residents and West Coast Transients. Also, vessels from fishing lodges are often 'repurposed' to go whale-watching when the fishing is not good, and operators of such vessels may be less skilled and conscientious than those who regularly engage in whale-watching.
6.2	War, civil unrest & military exercises						Military sonar (9.6) and live-fire exercises at sea can cause serious behavioral disturbance and, in some instances, physiological damage or even death of cetaceans. Vessel traffic associated with military activities can cause noise disturbance (9.6) as well as death from ship strike (4.3). Northern Residents are known to occur off western Vancouver Island in areas where military exercises take place.
6.3	Work & other activities		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Non-lethal and largely non-invasive research (e.g., hand-held and drone photography, biopsy sampling, suction-cup tagging) is directed at these whales.
7	Natural System Modifications	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use						
7.3	Other ecosystem modifications	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	A major way in which a wide variety of human activities affect these whales is by reducing, or otherwise altering, the availability of Chinook Salmon, their preferred prey as well as Chum Salmon and other fish prey that are taken when Chinook are in short supply. Historical anthropogenic reduction of the productivity and carrying capacity of freshwater spawning, rearing, and migratory habitat (e.g., by dams and diversions), together with large-scale ocean fishery removals and unfavorable ocean conditions that affect the survival and maturation of juvenile salmon (driven at least in part by climate change), may limit the recovery potential of this Killer Whale population. Starvation or poor nutrition due to lack of access to adequate high-quality prey may increase the whales' susceptibility to disease and parasitism. Their susceptibility may be amplified by the immunosuppressive effects and reduced fecundity caused by pollutants (such as PCBs).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8	Invasive & other problematic species & genes						
8.1	Invasive non-native/alien species/diseases						
8.2	Problematic native species/diseases						Although there is evidence that some stranded Killer Whales in the eastern North Pacific have died from (or at least suffered from) bacterial infections such as sarcocystis and toxoplasmosis, there is no reason to think that disease is a current threat to Northern Residents. Domoic acid toxicosis is a major problem for some other marine mammals in the eastern North Pacific, but there is currently no evidence that it is a problem for Killer Whales. It is also worth noting that cryptococcosis is pervasive in the eastern North Pacific and affects porpoises in BC (G. Ellis, pers. comm.).
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Killer Whales tend to have very high body burdens of toxic chemicals in their tissues (PCBs, pesticide residues, flame retardant compounds, etc.). These chemicals, some of which are known or suspected to cause reproductive impairment, skeletal abnormalities, endocrine disruption, and immunosuppression, can come from many sources and be airborne, waterborne or acquired through maternal transfer or ingestion of contaminated prey.
9.1	Domestic & urban waste water						
9.2	Industrial & military effluents						Oil spills are an ever-present threat in many areas throughout the population's range. Killer Whales do not appear to avoid such spills, as demonstrated by a diesel fuel spill in Johnstone Strait in 2007 and the infamous Exxon Valdez spill in 1989 (from which the most heavily affected pod of Residents has still not recovered). It is assumed that inhalation of toxic petroleum vapours was responsible for the very high mortality. Increasing ship traffic throughout their range increases the risk of oil and fuel spills.
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						Ingestion of microplastic particles is an emergent concern for many marine organisms. Entanglement in derelict fishing gear ('ghost' gear) is another concern but it is not (yet) regarded as a problem for these Killer Whales.
9.5	Air-borne pollutants						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.6	Excess energy	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Acoustic disturbance by anthropogenic sound (noise) is a major concern for Killer Whales. Sources of greatest concern are geophysical (including seismic) surveys, military sonar, military live-fire exercises at sea, pile-driving (a major noise source associated with offshore wind development), and vessel traffic. Noise can impair the whales' ability to detect and capture prey, communicate with one another, and more generally acquire information about their environment. Impacts are mostly sublethal. Efforts have been made in both Canada and the U.S. to mitigate this threat.
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Habitat shifts and disturbances due to climate change are probably affecting and will continue to affect, this Killer Whale population. Some of the effects, such as sea level rise, ocean acidification, and marine heatwaves (e.g., The Blob in 2013 and 2018), on the whales and/or their prey may be positive and others negative.
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						There is concern that increased wave action will negatively affect these whales' rubbing beaches.
11.5	Other impacts						There is concern about climate-driven increases in the frequency and severity of harmful algal blooms.

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).

<b>Species or Ecosystem Scientific Name</b>	Orcinus orca Killer Whale Northeast Pacific Transient (Bigg's) population (DU-3)		
<b>Element ID</b>		<b>Elcode</b>	
<b>Date (Ctrl + ";" for today's date):</b>	2023-03-30		
<b>Assessor(s):</b>	Randall Reeves, John Ford, Hal Whitehead, Dwayne Lepitzki, Karen Timm, Greg Wilson, Shannan May-McNally, Andrew Trites, Kim Parsons, Viv Tulloch, Katie Kowarski, Thomas Doniol-Valcroze, Sheila Thornton, Rianna Burnham, Graeme Ellis, Rowshyra Castaneda, Sam Iverson, Jordan Hoffman, Erika Thorleifson, Alana Philips, Bronwyn Harvey, Jennifer Yakimishyn, Larry Johnson, Katarina Duke, Aline Carrier, Brett Freake, Carilia Horning		
<b>References:</b>	Draft COSEWIC report and calculator prepared by R. Reeves.		
<b>Overall Threat Impact Calculation Help:</b>		<b>Level 1 Threat Impact Counts</b>	
	<b>Threat Impact</b>		<b>high range</b>
	A	Very High	0
	B	High	1
	C	Medium	1
	D	Low	3
<b>Calculated Overall Threat Impact:</b>		High	High
<b>Assigned Overall Threat Impact:</b>		BC = High - Medium	
<b>Impact Adjustment Reasons:</b>		Overlapping threats, population increasing	
<b>Overall Threat Comments</b>		Generation time 26-29 years therefore timeframe for severity and timing is 78-87 years into the future; eat marine mammals and occasionally sea birds; population has been increasing in recent decades; no continuing population decline; no continuing decline in habitat; 381 mature individuals; no PVA; met EN D1 but TH D1 because of population increase since the 1970s (2008).	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
1.1	Housing & urban areas						Transient (Bigg's) Killer Whales in BC (and in US waters of southern Alaska, Washington State, Oregon, and California) range widely and frequent inshore and nearshore waters where they come close to large urban and residential areas. As bold hunters, they may enter places very near shore (even Vancouver and Victoria harbours) in search for or pursuit of prey. While it is hard to specify how and to what degree of severity such proximity itself affects the animals, it almost certainly increases the likelihood of exposure to specific threats such as those considered under 1.2, 2.4, 3.1, 3.3, 4.3, 5.4, 6.1, 9.1, 9.2, 9.3, 9.4, 9.5, and 9.6.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.2	Commercial & industrial areas		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	The same point as made for 1.1 applies here. Also, among other specific things, expansion of Roberts Bank Terminal, Port of Vancouver, and the liquid natural gas terminals at Kitimat currently under construction are likely to cause temporary and/or permanent displacement and the Kitimat developments will definitely result in a major increase in large vessel traffic through Douglas Channel, creating more chronic noise (9.6) and increasing the risk of ship strikes (4.3) as well as fuel oil spills (9.2). Ongoing and future construction or expansion of power plants, shipyards, and permanent port structures is a concern. Mitigation is needed both in design and during construction/operation of approved developments.
1.3	Tourism & recreation areas						
2	Agriculture & aquaculture		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	A study in BC from 1985 to 2000 showed that noise from acoustic harassment devices intended to deter seals away from salmon aquaculture pens displaced Killer Whales (including Bigg's Killer Whales) away from waters nearby (Morton and Symonds 2002). This displacement effect apparently ended when the devices were no longer being used in the area (Broughton Archipelago). Acoustic harassment devices are no longer being used in BC aquaculture facilities. Aquaculture facilities in BC are not known to represent a significant entanglement problem for this DU at present, but such facilities (mainly for salmon or shellfish) exist in parts of the range of Bigg's Killer Whales (e.g., Clayoquot Sound, Baynes Sound), and facilities are often being relocated, so it is important to at least monitor the industry's development and seek to identify and investigate facilities that overlap habitat used by mammal-eating Killer Whales. These whales can be attracted to prey upon other marine mammals there to depredate the fish or shellfish.
3	Energy production & mining		Negligible	Pervasive (71-100%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.1	Oil & gas drilling						Oil and gas development including offshore exploration, drilling, and production (scored here) as well as transport (e.g., tankers; 5.4) brings risks of oil spills (9.2). Noise associated with related activities, such as seismic surveys and vessel traffic, can disrupt communication and hunting by mammal-eating Killer Whales (9.6). Although there is currently no offshore oil and gas development activity in BC, tankers regularly move through BC waters. Ongoing and future climate change will heighten the risks of exposure to oil and disturbing noise in BC and waters outside Canada used by Bigg's Killer Whales. The devastating effect of the Exxon Valdez crude oil spill on the AT1 Transient Killer Whale population in southern Alaska is a cautionary example of these whales' susceptibility (9.2).
3.2	Mining & quarrying						Deep-sea mining for polymetallic nodules is still in a developmental stage but could become a source of disturbance to these Killer Whales and/or their prey.
3.3	Renewable energy		Negligible	Pervasive (71-100%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Offshore renewable energy development (mainly wind and hydrokinetic) is expected to expand rapidly along the BC and U.S. west coasts, including in areas frequented by Bigg's Killer Whales. Some physical and acoustic disturbance of the whales during turbine siting (high-resolution geophysical surveys) and installation (pile driving, explosives) is expected, but the greatest concern may be the increase in ship traffic associated with such development.
4	Transportation & Service Corridors	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Ship traffic is regarded as a significant (and growing) threat to Bigg's Killer Whales. Vessel strike is a known cause of serious injury and mortality, with small high-speed skiffs as well as large tugboats involved. There is a trend for vessel speeds to increase (particularly high-speed ferries). Though vessel strikes are rarely reported, it is reasonable to assume that some go undetected and therefore are not reported. Mitigation measures (e.g., seasonal closures to vessel traffic in specific areas, voluntary and mandatory vessel speed limits) may help reduce the severity of strike risk but their effectiveness needs to be evaluated regularly and adjustments made as appropriate.
4.4	Flight paths						
5	Biological Resource Use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Northeast Pacific Transient (Bigg's) Killer Whales are not hunted anywhere in their range, and full legal protection is expected to continue. However, bycatch (entanglement) in fishing gear is ongoing and, although not frequent or at a high level in absolute terms, may be a significant threat to Bigg's Killer Whales in BC and adjacent waters. Some of the few mammal-eating Killer Whales known to have died in fishing gear in the eastern North Pacific were entangled in pollock trawl nets and crab pot lines, and it was assumed they were following pinnipeds (sea lions) attracted to the operations. Human harvesting of marine mammals that are preyed upon by Bigg's Killer Whales can have significant effects, as evidenced by the pronounced increase in whale numbers in BC and Washington after Harbour Seal populations (long suppressed by harvests and culling) were given legal protection in the early 1970s.
6	Human intrusions & disturbance	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	As regular objects of attention by "eco"tourism (whale watching), Bigg's Killer Whales are at risk of being disturbed by the close approach and physical presence of vessels and by vessel noise (9.6). Disturbance by whale-focused tourism can impair the ability of the Killer Whales to detect and capture their mammalian prey, to socialize, and to rest.
6.2	War, civil unrest & military exercises		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Military sonar and live-fire exercises at sea can cause serious behavioral disturbance and, in some instances, physiological damage or even death of cetaceans (9.6). Transients are known to pass through naval exercise and live-fire ranges (e.g., area WG in the Strait of Georgia, WH in Juan de Fuca Strait). Vessel traffic associated with military activities can cause noise disturbance as well as death from ship strike (4.3). Mitigation may help prevent impacts but does not eliminate the risk.
6.3	Work & other activities		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Non-lethal and largely non-invasive research (e.g., hand-held camera and drone photography, biopsy sampling, feces collection, suction-cup tagging) is directed at these whales. Some satellite tagging (using "limpet"-type attachment) takes place in the U.S. (including SE Alaska).
7	Natural System Modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Human harvesting of marine mammals that are preyed upon by Bigg's Killer Whales can have significant effects, as evidenced by the pronounced increase in whale numbers in BC and Washington after Harbour Seal populations (long suppressed by harvests and culling) were given legal protection in the early 1970s. Recent and ongoing proposals to re-initiate pinniped culling in BC have medium- and long-term implications for these whales.
8	Invasive & other problematic species & genes						
8.1	Invasive non-native/alien species/diseases						
8.2	Problematic native species/diseases						Although there is evidence that some stranded Killer Whales in the eastern North Pacific have died from (or at least suffered from) bacterial infections such as sarcocystis and toxoplasmosis, there is no reason to think that disease is a current threat to Bigg's Killer Whales. Domoic acid toxicosis is a major problem for some other marine mammals in the eastern North Pacific, but there is currently no evidence that it is a problem for Killer Whales. It is also worth noting that cryptococcosis is pervasive in the eastern North Pacific and affects porpoises in BC (G. Ellis, pers. comm. 2022). A Killer Whale killed in the eastern Canadian Arctic in 2022 tested positive for <i>Trichinella</i> .
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						Cetaceans are susceptible to viral outbreaks but so far there is no evidence that this is a threat to Killer Whales in this DU.
8.6	Diseases of unknown cause						
9	Pollution	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Killer Whales, especially those that prey on mammals, tend to have very high body burdens of toxic chemicals in their tissues (PCBs, pesticide residues, flame retardant compounds, etc.). These chemicals, some of which are known or suspected to cause reproductive impairment, skeletal abnormalities, endocrine disruption, and immunosuppression, can come from many sources and be airborne, waterborne or acquired through maternal transfer or ingestion of contaminated prey. Blubber concentrations of PCBs, along with the next most common groups of PBTs (chlordane and DDT) found in some mammal-eating Killer Whales, exceed thresholds that cause physiological, reproductive, and immune impairments.
9.1	Domestic & urban waste water						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.2	Industrial & military effluents						Oil spills are an ever-present threat in many areas throughout the population's range. Killer Whales do not appear to avoid such spills, as demonstrated by a diesel fuel spill in Johnstone Strait in 2007 and the infamous Exxon Valdez spill in 1989 (from which the most heavily affected pod of Residents has still not recovered). It is assumed that inhalation of toxic petroleum vapours was responsible for the very high mortality. Increasing ship traffic throughout their range increases the risk of oil and fuel spills.
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						Ingestion of microplastic particles is an emergent concern and high levels of these pollutants have been found in various prey species of mammal-eating Killer Whales. Entanglement in derelict fishing gear ("ghost" gear) is another concern but it is not (yet) regarded as a problem for these Killer Whales.
9.5	Air-borne pollutants						
9.6	Excess energy	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Acoustic disturbance by anthropogenic sound (noise) is a major concern for Killer Whales. Sources of greatest concern are geophysical (including seismic) surveys, military sonar, military live-fire exercises at sea, pile driving (a major noise source associated with offshore wind development), and vessel traffic. Noise can impair the whales' ability to detect and capture prey, communicate with one another, and more generally acquire information about their environment. Impacts are mostly sublethal. Efforts are made in both Canada and the U.S. to mitigate this threat, but there is concern that because Bigg's Killer Whales tend to vocalize less frequently or more cryptically than Residents, and detect their prey by listening, they are at greater risk from acoustic "masking."
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Habitat shifts and disturbances due to climate change are probably affecting and will continue to affect this Killer Whale population. Some of the effects, such as sea level rise, ocean acidification, and marine heatwaves (e.g., The Blob in 2013 and 2018), on the whales and/or their prey may be positive and others negative.
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.5	Other impacts						There is concern about climate-driven increases in the frequency and severity of harmful algal blooms.

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).

<b>Species or Ecosystem Scientific Name</b>	Orcinus orca Killer Whale Northeast Pacific Offshore population (DU-4)		
<b>Element ID</b>	-	<b>Elcode</b>	
<b>Date (Ctrl + ";" for today's date):</b>	2023-03-30		
<b>Assessor(s):</b>	Randall Reeves, John Ford, Hal Whitehead, Dwayne Lepitzki, Karen Timm, Greg Wilson, Shannan May-McNally, Andrew Trites, Kim Parsons, Viv Tulloch, Katie Kowarski, Thomas Doniol-Valcroze, Sheila Thornton, Rianna Burnham, Graeme Ellis, Rowshyra Castaneda, Sam Iverson, Jordan Hoffman, Erika Thorleifson, Alana Philips, Bronwyn Harvey, Jennifer Yakimishyn, Larry Johnson, Katarina Duke, Aline Carrier, Brett Freake, Carilia Horning		
<b>References:</b>	Draft COSEWIC report and calculator prepared by R. Reeves.		
<b>Overall Threat Impact Calculation Help:</b>	<b>Level 1 Threat Impact Counts</b>		
	<b>Threat Impact</b>		<b>high range</b>
	A	Very High	0
	B	High	1
	C	Medium	1
	D	Low	3
<b>Calculated Overall Threat Impact:</b>			High
<b>Assigned Overall Threat Impact:</b>	BC = High - Medium		
<b>Impact Adjustment Reasons:</b>	Overlapping threats, no evidence to suggest population decline;		
<b>Overall Threat Comments</b>	Generation time 26-29 years therefore timeframe for severity and timing is 78-87 years into the future; eat sharks and other upper-trophic fishes; no population trend info; no continuing decline in habitat; ~300 individuals, 130 mature; no PVA; met EN D1 but TH D1 because population appears to be stable and threats do not appear to be severe enough currently to be negatively affecting the population (2008).		

Threat	Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1 Residential & commercial development					
1.1 Housing & urban areas					Offshore Killer Whales in BC (and in US waters of southern Alaska, Washington State, Oregon, and California) range widely and only infrequently enter inshore and nearshore waters where they come close to large urban and residential areas. Therefore, they are probably not as at risk of this threat as other DUs.
1.2 Commercial & industrial areas					These whales come inshore but not often so they probably aren't as exposed to the same degree of risk as other DUs.
1.3 Tourism & recreation areas					
2 Agriculture & aquaculture					
2.1 Annual & perennial non-timber crops					
2.2 Wood & pulp plantations					

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						
3	Energy production & mining		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
3.1	Oil & gas drilling		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Oil and gas development including offshore exploration, drilling, and production (scored here) as well as transport (e.g., tankers; 5.4) brings risks of oil spills (9.2). Noise associated with related activities, such as seismic surveys. And vessel traffic can disrupt communication and foraging (9.6). Although there is currently no offshore oil and gas development activity in BC, tankers regularly move through BC waters. Also, these whales range all the way south to California and north to the Aleutians so they do come close to offshore oil and gas operations. Ongoing and future climate change will heighten the risks of oil exposure and disturbing noise in BC and waters outside Canada used by Offshore Killer Whales.
3.2	Mining & quarrying						Deep-sea mining for polymetallic nodules is still in a developmental stage but could become a source of disturbance to these Killer Whales and/or their prey. Seamounts, in particular, are areas where Offshore Killer Whales often forage on benthic prey that may be at high risk from seabed mining.
3.3	Renewable energy		Negligible	Large (31-70%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Offshore renewable energy development (mainly wind and hydrokinetic) is expected to expand rapidly along the BC coast, probably including in some areas visited by Offshore Killer Whales. When there is overlap or close proximity, some physical and acoustic disturbance of the whales during turbine siting (high-resolution geophysical surveys) and installation (pile driving, explosives) would be expected, but the greatest concern may be the increase in ship traffic associated with such development. Increases in ship traffic bring the risk of more chronic noise disturbance (9.6), vessel strikes (4.3), and fuel spills (9.2).
4	Transportation & Service Corridors	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Ship traffic may be a threat to Offshore Killer Whales. Vessel strike is a known cause of serious injury and mortality of other ecotypes, and the physical and acoustic disturbance associated with ship traffic could pose some risk to Offshore Killer Whales (see 9.6).
4.4	Flight paths						
5	Biological Resource Use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Northeast Pacific Offshore Killer Whales are not known to be hunted anywhere in their range, and full legal protection (at least in Canada and the USA) is expected to continue. Bycatch (entanglement) in fishing gear is a potential concern. Although there is little evidence of Offshores being taken as bycatch, drift gillnetting still occurs in parts of California and Alaska, and a great deal of trawling and longlining occurs along the shelf edge where these whales spend much of their time. A couple of individuals with missing dorsal fins have been observed (G. Ellis, pers. comm. 2022).
6	Human intrusions & disturbance	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	As regular objects of attention by “eco”-tourism (whale watching), all Killer Whales, including Offshores, are at risk of being disturbed by the close approach and physical presence of vessels and by vessel noise (9.6) when they come within range of tour boats (which they may do relatively often in California). Disturbance by whale-focused tourism can temporarily impair a whale’s ability to detect and capture prey, to socialize, and to rest.
6.2	War, civil unrest & military exercises						Military sonar and live-fire exercises at sea can cause serious behavioral disturbance and, in some instances, physiological damage or even death of cetaceans (see 9.6). Vessel traffic associated with military activities can cause noise disturbance (see 9.6) as well as death from ship strike (see 4.3).
6.3	Work & other activities		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Opportunistic non-lethal and largely non-invasive research (e.g., hand-held camera and drone photography, biopsy sampling, feces collection, suction-cup tagging) is directed at these whales. Some satellite tagging (using “limpet”-type attachment) takes place in the U.S. (including SE Alaska).
7	Natural System Modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Human harvesting (including bycatch) of sharks almost certainly has affected the prey base of Offshores, which are thought to be shark specialists. Large fisheries depleted Dogfish populations in the eastern North Pacific in the past, likely affecting Offshore Killer Whales. Also, the near eradication of Basking Sharks in the region, if they were a significant prey, could have had a significant impact, and may help explain why the population of Offshores is so small (only a few hundred individuals).
8	Invasive & other problematic species & genes						
8.1	Invasive non-native/alien species/diseases						
8.2	Problematic native species/diseases						Although there is evidence that some stranded Killer Whales in the eastern North Pacific have died from (or at least suffered from) bacterial infections such as sarcocystis and toxoplasmosis, there is no reason to think that disease is a current threat to Offshore Killer Whales. Domoic acid toxicosis is a major problem for some other marine mammals in the eastern North Pacific, but there is currently no evidence that it is a problem for Killer Whales. It is also worth noting that cryptococcosis is pervasive in the eastern North Pacific and affects porpoises in BC (G. Ellis, pers. comm. 2022).
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						Cetaceans are susceptible to viral outbreaks but so far, there is no evidence that this is a threat to Killer Whales in this DU.
8.6	Diseases of unknown cause						
9	Pollution	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Killer Whales tend to have very high body burdens of toxic chemicals in their tissues (PCBs, pesticide residues, flame retardant compounds, etc.). These chemicals, some of which are known or suspected to cause reproductive impairment, skeletal abnormalities, endocrine disruption, and immunosuppression, can come from many sources and be airborne, waterborne or acquired through maternal transfer or ingestion of contaminated prey. Given the high trophic level at which they feed, it is assumed that the contaminant loads of Offshore Killer Whales are more similar to those of Transients (Bigg's) Killer Whales than those of Residents.
9.1	Domestic & urban waste water						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.2	Industrial & military effluents						Oil spills are an ever-present threat in many areas throughout the population's range. Killer Whales do not appear to avoid such spills, as demonstrated by a diesel fuel spill in Johnstone Strait in 2007 and the infamous Exxon Valdez spill in 1989 (from which the most heavily affected pod of Residents has still not recovered). It is assumed that inhalation of toxic petroleum vapours was responsible for the very high mortality. Increasing ship traffic throughout their range increases the risk of oil and fuel spills. Oil spills may be less of a concern for this DU than for some of the others, except when they occasionally move inshore.
9.3	Agricultural & forestry effluents						Because these whales tend to spend much of their time off California, they are likely exposed to more pollution from agricultural runoff than DU-1, DU-2, and DU-3 whales.
9.4	Garbage & solid waste						Ingestion of microplastic particles is an emergent concern. Entanglement in derelict fishing gear ("ghost" gear) is another concern but it is not (yet) regarded as a problem for these Killer Whales.
9.5	Air-borne pollutants						
9.6	Excess energy	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Acoustic disturbance by anthropogenic sound (noise) is a major concern for Killer Whales. Sources of greatest concern are geophysical (including seismic) surveys, military sonar, military live-fire exercises at sea, pile driving (a major noise source associated with offshore wind development), and vessel traffic. Noise can impair the whales' ability to detect and capture prey, communicate with one another, and more generally acquire information about their environment. Impacts are mostly sublethal. Given the amount of time spent offshore by this population, it may be somewhat less exposed to this threat, at least in Canada, except when animals move inshore.
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Habitat shifts and disturbances due to climate change are probably affecting and will continue to affect, this Killer Whale population. Some of the effects, such as sea level rise, ocean acidification, and marine heatwaves (e.g., The Blob in 2013 and 2018), on the whales and/or their prey may be positive and others negative.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						
11.5	Other impacts						

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).

<b>Species or Ecosystem Scientific Name</b>	Orcinus orca Killer Whale Northwest Atlantic / Eastern Arctic population (DU-5)		
<b>Element ID</b>	-	<b>Elcode</b>	
<b>Date (Ctrl + ";" for today's date):</b>	2023-03-29		
<b>Assessor(s):</b>	Randall Reeves, John Ford, Hal Whitehead, Dwayne Lepitzki, Karen Timm, Felix Boulanger, Nancy Bouchard, Andrew Trites, Steve Ferguson, Marie Auger-Methe, Viv Tulloch, Katie Kowarski, Hilary Moors-Murphy, Jeremy Kiska, Stephen Petersen, Colin Garroway, Fernando Ugarte, William Halliday, Kristin Westdal, Rianna Burnham		
<b>References:</b>	Draft COSEWIC report and draft calculator prepared by R. Reeves.		
<b>Overall Threat Impact Calculation Help:</b>		<b>Level 1 Threat Impact Counts</b>	
	<b>Threat Impact</b>		
		<b>high range</b>	<b>low range</b>
	A	Very High	0
	B	High	0
	C	Medium	0
	D	Low	1
<b>Calculated Overall Threat Impact:</b>		High	Low
<b>Assigned Overall Threat Impact:</b>		BD = High - Low	
<b>Impact Adjustment Reasons:</b>			
<b>Overall Threat Comments</b>		Generation time 26-29 years therefore timeframe for severity and timing is 78-87 years into the future; whales of this DU eat marine mammals and fish; trends in population size and habitat condition are unknown; no good estimate of population size but at least 160 individuals (at least 70 of which are presumed mature) photo-identified in eastern Canadian Arctic; range expanding due to climate change; no PVA; assessed as Special Concern in 2008.	

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & Commercial Development	Negligible	Large - Restricted (11-70%)	Negligible (<1%)	High (Continuing)	
1.1	Housing & urban areas					
1.2	Commercial & industrial areas	Negligible	Large - Restricted (11-70%)	Negligible (<1%)	High (Continuing)	New or expanded shipyards to support iron mining (Mary River Project) will involve noise from pile driving and associated construction activities (see 9.6), and also cause considerable additional ship traffic locally in Eclipse Sound and likely Foxe Basin as well as more generally in Baffin Bay and Davis Strait (and possibly Hudson Strait) (see 4.3). The footprint of the shipyards themselves should not have a significant long-term impact on Killer Whales. The development and/or expansion of small craft harbours is ongoing and likely to continue into the future in Hudson Bay and elsewhere in Nunavut. Also, a large port facility is planned in Melville Bay and other such developments are expected elsewhere in West Greenland.
1.3	Tourism & recreation areas					
2	Agriculture & Aquaculture					

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.1	Annual & perennial non-timber crops					
2.2	Wood & pulp plantations					
2.3	Livestock farming & ranching					
2.4	Marine & freshwater aquaculture					
3	Energy Production & Mining	Unknown	Restricted (11-30%)	Unknown	High (Continuing)	
3.1	Oil & gas drilling	Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Oil and gas development including offshore exploration, drilling, production and transport (e.g., tankers) brings risks of oil spills (see 9.2). Noise associated with related activities (seismic surveys in particular, vessel traffic, etc.) can disrupt communication and foraging/hunting by Killer Whales (see 9.6). Oil and gas development in Newfoundland and Labrador is a present and ongoing concern. Ongoing and future climate change will heighten the risks of oil exposure and disturbing noise in higher latitudes including in the Arctic.
3.2	Mining & quarrying					
3.3	Renewable energy	Unknown	Small (1-10%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Offshore renewable energy projects are expanding rapidly along the US Atlantic coast and are expected to also expand rapidly in the Maritimes in coming decades. Some physical and acoustic disturbance of cetaceans is expected, but the greatest concern may be the increase in ship traffic associated with such developments (see 4.3). Exactly when and where offshore wind energy will be developed within the range of this Killer Whale populations is unknown.
4	Transportation & Service Corridors	Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
4.1	Roads & railroads					
4.2	Utility & service lines	Negligible	Negligible (<1%)	Negligible (<1%)	High – Moderate	A communications cable is planned to be laid on the seabed of Davis Strait-Baffin Bay-Lancaster Sound within the next decade (survey work to begin in summer 2023). It is unknown if or how this work might affect Killer Whales.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.3	Shipping lanes		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Although shipping lanes are known to be risk areas for some cetaceans (mainly due to vessel strikes and noise), they are not known to be a significant threat to DU-5 Killer Whales at present although the detection and reporting of injuries or deaths due to ship strike is probably far from complete. All whales in this DU are exposed, in varying degrees, to ship traffic, and vessel strike is a known cause of injury and mortality of Killer Whales elsewhere. Therefore, ship traffic is a concern due not only to the potential for injury or mortality but also to the associated physical and acoustic disturbance (see 9.6). Ship traffic throughout the range of this DU is bound to increase under climate change. Although mitigation of ship strike risk by relocating shipping lanes and imposing ship speed rules has been implemented in a few areas to protect large whales (right whales, blue whales etc.), such efforts are not expected to significantly reduce the risk to DU-5 Killer Whales.
4.4	Flight paths						
5	Biological Resource Use	BD	High – Low	Pervasive (71-100%)	Serious – Slight (1-70%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	BD	High – Low	Pervasive (71-100%)	Serious – Slight (1-70%)	High (Continuing)	Whales in this DU have been killed deliberately, mainly for control purposes but also for subsistence. In the Eastern Canadian Arctic and Greenland. In both regions there is interest in continuing or expanding this hunting. Killer Whales, possibly all or some of them migrants from this DU, are also hunted for subsistence and control purposes in St. Vincent and the Grenadines (Caribbean Sea). The hunting in all areas is opportunistic and unregulated, and the reporting of killing and wounding is incomplete and unreliable so the impact of “control” shooting in particular may be underestimated. It’s important to emphasize that the life history and socio-cultural characteristics of Killer Whales make “sustainable” exploitation unrealistic. Some bycatch (entanglement) in fishing gear occurs in Atlantic Canada. Most documented cases in eastern Canada have involved gillnets but Killer Whales elsewhere also die incidentally in demersal longline and trawl gear. Another way in which harvesting of aquatic resources affects Killer Whales, either directly or indirectly, is by reducing, or otherwise altering, the availability of prey (both marine mammals and fish in Atlantic Canada and the Eastern Arctic) (see 7.3).
6	Human Intrusions & Disturbance		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.1	Recreational activities		Negligible	Large – Restricted (11-70%)	Negligible (<1%)	High (Continuing)	Whale-watching tourism is not generally directed at Killer Whales in Atlantic Canada or the Eastern Arctic, and if it were, the disturbance effects would likely be minor and transitory. Increasing tourism in the Arctic due to climate change is likely to make interactions between whale watching and DU-5 Killer Whales more frequent. Although there could be conservation benefits from this type of “non-consumptive use” of Killer Whales, any such benefits would likely be offset by the enmity toward Killer Whales as perceived competitors on the part of subsistence hunters and commercial fishers.
6.2	War, civil unrest & military exercises		Unknown	Small (1-10%)	Unknown	High (Continuing)	NATO naval exercises occur at least biennially off Nova Scotia and Newfoundland. Military sonar and live-fire exercises at sea can cause serious behavioural disturbance and, in some instances, physiological damage or even death of cetaceans (9.6). Vessel traffic associated with military activities can cause noise disturbance as well as death from ship strike (4.3). Mitigation may help prevent impacts but does not eliminate the risk.
6.3	Work & other activities		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Non-lethal research (e.g., biopsy sampling, satellite-linked tagging) on this DU in the Arctic, and less extensively thus far in Newfoundland-Labrador and the Maritimes, will continue. One Killer Whale died in BC as a result of tagging (non-sterile dart) but this outcome is regarded as a once in 100 times event.
7	Natural System Modifications		Unknown	Unknown	Unknown	High (Continuing)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use						
7.3	Other ecosystem modifications		Unknown	Unknown	Unknown	High (Continuing)	Changes in the prey base of DU-5 Killer Whales are likely occurring and will continue to occur, but it is not possible to predict the scale or direction of the effects on the whale population. Not enough is known about Killer Whales around Newfoundland and Labrador to predict how they might be affected by changes in the marine mammal or fish populations, nor is it possible to predict with confidence how prey populations in the Arctic will be affected by the reduction in sea ice and other effects of climate change.
8	Invasive & Other Problematic Species & Genes						
8.1	Invasive non-native/alien species/diseases						The possibility of a “whale sanctuary” in Nova Scotia that might host Killer Whales captured outside the natural range of DU-5 has been mooted ( <a href="https://www.cbc.ca/news/canada/nova-scotia/nova-scotia-whale-sanctuary-behind-schedule-1.6627015">https://www.cbc.ca/news/canada/nova-scotia/nova-scotia-whale-sanctuary-behind-schedule-1.6627015</a> ).
8.2	Problematic native species/diseases						A Killer Whale killed in Pond Inlet in 2022 tested positive for <i>Trichinella</i> ( <a href="https://nunatsiaq.com/stories/article/orca-harvested-in-pond-inlet/">https://nunatsiaq.com/stories/article/orca-harvested-in-pond-inlet/</a> ).
8.3	Introduced genetic material						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						Cetaceans are susceptible to viral outbreaks but so far, there is no evidence that this is a threat to Killer Whales in this DU.
8.6	Diseases of unknown cause						
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Killer Whales, especially those that prey on mammals (as nearly all if not all the whales in this DU do), tend to have very high body burdens of toxic chemicals in their tissues (PCBs, pesticide residues, flame retardant compounds, etc.). These chemicals, some of which are known or suspected to cause reproductive impairment, skeletal abnormalities, endocrine disruption and immunosuppression, can come from many sources and be airborne, waterborne or acquired through maternal transfer or ingestion of contaminated prey. Blubber concentrations of PCBs, along with the next most common groups of PBTs (chlordanes and DDT) found in some North Atlantic Killer Whale populations, exceed thresholds that cause physiological, reproductive, and immune impairments.
9.1	Domestic & urban waste water						
9.2	Industrial & military effluents						Oil spills from operations around offshore platforms (e.g., Hebron, Terra Nova, Hibernia) and tankers are always a rare-event concern. Also, with increased vessel traffic throughout the range of DU-5 Killer Whales, but especially in the Northwest Passage with the decline of sea ice, there is an increased risk of accidental spills.
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						Ingestion of microplastics is an emergent concern, and high levels of these pollutants have been documented in beluga whales, which are among the prey species of Killer Whales in the Arctic. Microplastics have been found in fecal samples from Killer Whales in Washington State and Alaska. Entanglement in derelict fishing gear ("ghost" gear) is another concern that is not (yet) regarded as a problem for Killer Whales but likely occurs at least occasionally.
9.5	Air-borne pollutants						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.6	Excess energy		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Acoustic disturbance by anthropogenic sound (noise) is a major concern for Killer Whales. All whales are exposed to increasing noise in the ocean. Sources of greatest concern are seismic surveys, military sonar, military live-fire exercises at sea, pile driving (a major noise source associated with offshore wind energy and port/harbour development), and vessel traffic. Noise can impair the whales' ability to detect and capture prey, communicate with one another, and more generally acquire information about their environment. Effects are mostly sub-lethal as far as known, but military sonar evokes a strong avoidance reaction by Killer Whales and exposure to loud noise can impair hearing either temporarily or permanently (if permanent, it is assumed to be effectively lethal).
10	Geological Events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate Change & Severe Weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Climate change is having major effects on Killer Whales in the Eastern Arctic and Atlantic Canada. These effects are both positive for the whales, enabling them to move safely into areas previously inaccessible due to sea ice, and negative, allowing the scope and scale of human activities to expand and thereby increasing the whales' exposure to noise, physical disturbance, vessel strike, spills of oil and other toxic substances, etc.
11.1	Habitat shifting & alteration						
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						
11.5	Other impacts						There is concern about climate-driven increases in the frequency and severity of harmful algal blooms.

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).