COSEWIC
Assessment and Status Report

on the

Sei Whale
Balaenoptera borealis

Atlantic population

in Canada

ENDANGERED
2019

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:

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Sei Whale — Image collected under the NEFSC MMPA research permit 17355, Photographer: Peter Duley.

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COSEWIC
Assessment Summary

Assessment Summary – May 2019

Common name
Sei Whale - Atlantic population

Scientific name
Balaenoptera borealis

Status
Endangered

Reason for designation
This large whale occurs off Nova Scotia, Newfoundland, and Labrador. The population was greatly reduced by whaling that ended in 1972. Systematic surveys of Canadian Atlantic waters in 2007 and 2016 recorded few animals. The current population is likely fewer than 1,000 mature individuals and below its size at the end of whaling. Major current threats include collisions with ships, and underwater noise, especially that associated with shipping and petroleum exploration and production.

Occurrence
Atlantic Ocean

Status history
Species considered in May 2003 and placed in the Data Deficient category. Re-examined in May 2019 and designated Endangered.

COSEWIC
Executive Summary

Sei Whale
Balaenoptera borealis

Atlantic population

Wildlife Species Description and Significance

The Sei (pronounced “say”) Whale (*Balaenoptera borealis*) is a large, slim baleen whale. The name is an anglicization of “sejhval”, given by Norwegian whalers because its arrival in Scandinavian waters coincided with the “seje”, or pollock.

The species is grey in colour, with a variable white region on its underside. These areas may appear mottled, with grey or white circular scars caused by various predators or parasites. Both the lower left and right jaws are dark in colour. The dorsal fin is tall and slender.

Because the Sei Whale is rarely found near shore, it is not the primary target of whale watching operations. Sei Whales do not seem to have been an important resource for coastal Indigenous groups in Canada.

Distribution

Sei Whales are found in all the oceans of the world and generally make seasonal migrations from low-latitude wintering areas to high-latitude summer feeding grounds. While the whereabouts of the wintering grounds are unknown, Sei Whales are found in the summers in the Labrador Sea, off Newfoundland, and on the Scotian Shelf and Slope; and at least some individuals are present in these waters in the fall, winter and spring.

Habitat

Sei Whales use primarily pelagic habitats, and are most often found in waters from ~ 40 m to several thousand metres deep. They appear to be mainly associated with the continental shelf edge in the northwest Atlantic. The main characteristic of Sei Whale feeding habitat is likely a high pelagic concentration of zooplankton, especially copepods. Characteristics of preferred breeding grounds are unknown.

Biology

Sei Whales reach sexual maturity at between 5 and 15 years of age with a generation time of approximately 23 years. The average size for adults is 15 m and 19 tonnes. They may live to 60 years of age, and may be the fastest of the marine mammals, capable of short bursts in excess of 55 km/hour. The gestation period is estimated at 10–12 months with conception and calving occurring in warmer waters in winter. The calving interval is 2-3 years, and calves are weaned on the feeding grounds prior to the fall migration. This suggests a lactation period of about 6 months. Sei Whales exhibit a diversity of feeding strategies. This may allow them a more generalist diet than some other baleen whales, and likely explains the differences in diet composition reported in the different oceans of the world.

Population Sizes and Trends

Little is currently known about the population size of Sei Whales in the North Atlantic. Over 1 100 Sei Whales were caught in eastern Canadian waters between 1898-1972, with over 800 taken in a six-year period (1966-1972) off the coast of Nova Scotia. While Canadian whaling stopped in 1972, they continued to be hunted off Iceland until 1989 and as recently as 2006 in the Aboriginal subsistence hunt off western Greenland. Comprehensive aerial surveys of Canadian east coast waters in 2007 and 2016 identified only 7 Sei Whales, suggesting a population of a few hundred animals or less, and a substantial reduction from pre-whaling numbers.

Threats and Limiting Factors

Current threats to Sei Whales include the noise from seismic surveys, shipping and military exercises, vessel strikes, and entanglement in fishing gear. Insufficient access to prey may limit the productivity of Sei Whale populations.

Protection, Status and Ranks

The Sei Whale is listed globally as Endangered by the IUCN on the basis of large and rapid population declines and a reduction in range caused by 20th century exploitation. CITES lists the species under Appendix 1, the category that includes species threatened with extinction. It is listed as an Endangered species under the United States *Endangered Species Act*. In Canada, the Pacific population was assessed as Endangered by COSEWIC (2013) and is on Schedule 1 of the *Species at Risk Act* as Endangered. The Atlantic population was assessed by COSEWIC as Data Deficient in 2003, reassessed as Endangered in 2019, and is not currently listed under the *Species at Risk Act*. NatureServe has designated the species globally and within Canada as Vulnerable, which means it is at moderate risk for extinction. The species has not been ranked separately by any province.

TECHNICAL SUMMARY

Balaenoptera borealis

Sei Whale (Atlantic population)

Rorqual boréal (Population de l'Atlantique)

Range of occurrence in Canada (province/territory/ocean): Atlantic Ocean (off Nova Scotia, New Brunswick (Bay of Fundy), Newfoundland and Labrador, Nunavut. Occasional New Brunswick (Gulf of St. Lawrence), Prince Edward Island, Québec).

Demographic Information

Generation time (estimated using demographic model of life history parameters; Taylor *et al.* 2007)	23.3 years
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]	Unknown
Inferred percent reduction in total number of mature individuals over the last 3 generations.	Unknown, but likely >50% (commercial whaling and ongoing threats)
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
Inferred percent reduction in total number of mature individuals over any 3 generations period, over a time period including both the past and the future.	Unknown, but likely large (commercial whaling and ongoing threats)
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Yes (whaling), Unknown (other threats) b. Yes (whaling), No (other threats) c. Yes (whaling), No (other threats)
Are there extreme fluctuations in number of mature individuals?	Unlikely

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	> 20 000 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	> 2 000 km²
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. Unlikely b. No
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	Not applicable
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Unknown

* See Definitions and Abbreviations on COSEWIC web site and IUCN (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Unlikely
Is there an [observed, inferred, or projected] decline in number of “locations”?	Not applicable
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Unknown
Are there extreme fluctuations in number of subpopulations?	Unlikely
Are there extreme fluctuations in number of “locations”?	No
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)	
Nova Scotia Stock	unknown
Labrador Stock	unknown
Total	A few hundred individuals, or less

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	No analysis

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

Was a threats calculator completed for this species? Yes (estimated impact)

3.1 Noise from seismic exploration for oil and gas, drilling of oil/gas wells (medium-low)
4.3 Collisions with, and noise from, ships (low)
5.4 Entanglement in fishing gear, effects of fisheries, whaling (low)
6.2 Noise and explosions from naval exercises (low)

What additional limiting factors are relevant?

Small population size caused by heavy 20th Century whaling

Rescue Effect (immigration from outside Canada to North Atlantic population)

Status of outside population(s) most likely to provide immigrants to Canada.	If Canadian Sei Whales are part of a single North Atlantic population, rescue would have to occur from another ocean (the South Atlantic?); if there are separate North Atlantic populations, these could provide immigrants. Sei Whales are globally listed as Endangered by IUCN.
Is immigration known or possible?	Very unlikely to have immigration from South Atlantic or other oceans; more likely from other parts of the North Atlantic
Would immigrants be adapted to survive in Canada?	Likely
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?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

Species considered in May 2003 and placed in the Data Deficient category. Re-examined in May 2019 and designated Endangered.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2cd
Reasons for designation: This large whale occurs off Nova Scotia, Newfoundland, and Labrador. The population was greatly reduced by whaling that ended in 1972. Systematic surveys of Canadian Atlantic waters in 2007 and 2016 recorded few animals. The current population is likely fewer than 1,000 mature individuals and below its size at the end of whaling. Major current threats include collisions with ships, and underwater noise, especially that associated with shipping and petroleum exploration and production.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): The population may have declined more than 50% over the last 3 generations due to whaling and more recently due to other threats.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EOO and IAO well above criteria.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No indications of current decline.
Criterion D (Very Small or Restricted Population): Likely meets Threatened D1, as number of mature individuals is likely less than 1000 in Canadian waters.
Criterion E (Quantitative Analysis): Not applicable. No quantitative analysis.

PREFACE

Since the previous assessment of North Atlantic Sei Whales (2003) there has been greater interest in cetacean distribution in eastern Canadian waters. Many more sightings have been recorded; however, most of this research was not targeted to assess Sei Whale population size, seasonal distribution or habitat use. Two large-scale aerial surveys of Atlantic Canadian waters have been completed. A number of bottom-mounted hydrophones have been deployed in eastern Canada waters, which can be used to detect Sei Whale calls throughout the year. These recorders have started to provide information about the temporal and spatial distribution of vocalizing whales. Satellite tagging of Sei Whales off the Azores has also revealed details about the movements of some Sei Whales in the North Atlantic.

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
(2019)

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 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.

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TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

The Sei (pronounced "say") Whale (*Balaenoptera borealis*) (Lesson 1828) is the third largest member of the Balaenopteridae family, after the Blue (*B. musculus*) and Fin (*B. physalus*) Whales. The name is derived from "sejhval", the Norwegian name for the species. The species was so named by Norwegian whalers because its arrival in Scandinavian waters coincided with the "seje", or Pollock (*Pollachius virens*) (Andrews 1916). Other historical English names include coalfish whale, pollock whale, Rudolph's rorqual, sardine whale and Japan finner. French names include rorqual du nord, rorqual de Rudolph, rorqual boréal, and baleine noire (Gambell 1985), although baleine noire is now used to refer to the North Atlantic Right Whale (*Eubalaena glacialis*; see COSEWIC 2003).

Gambell (1985) lists purported "Eskimo" and Aleut names as Komovokhgak and Agalagitakg. However, these names are not familiar to Inuit groups in Canada, although Komovokhgak may have its origins in the western Arctic (see COSEWIC 2003). No Inuit names could be found.

As detailed in Horwood (1987), the classification of *B. borealis* is Lesson's Latin translation of Cuvier's "rorqual du Nord". A southern hemisphere form, *Sibbaldius schlegelii*, was first proposed by Flower in 1865 (as cited in COSEWIC 2003). Currently the species is split into two subspecies: the northern hemisphere form (*Baleanoptera borealis borealis*) and the southern hemisphere form (*Baleaenoptera borealis schlegelii*) although support for this split is weak (Perrin *et al.* 2009). Additionally, there is some suggestion that the North Atlantic Sei Whales are genetically distinct from those found in the North Pacific and the southern oceans (Baker *et al.* 2004; Huijser *et al.* 2018).

Morphological Description

Sei Whales are large (12-15m long as adults), but slim. They are generally dark steel to bluish-grey in colour (Figure 1), with a tendency towards lighter pigmentation down the sides and on the posterior of the ventral surface (Horwood 1987). The ventral grooves almost always exhibit a white or light-coloured area that extends back from the chin sometimes as far as the umbilicus. However, Andrews (1916) warns that the colour variation for this species is considerable. The lateral and ventral sides may appear mottled with grey or white circular scars caused by various parasites and predators including ectoparasitic copepods (*Pennella* spp.), lampreys (order Petromyzontiformes), and Cookie Cutter Sharks (*Isistius brasiliensis*) (Andrews 1916; Pike 1951; Rice 1977, Schevchenko 1977; Ivashin and Golubovsky 1978). The dorsal fin is tall and slender. It is further forward on the body when compared to the congeneric, but larger, Blue and Fin Whales (Andrews 1916). The baleen is much finer than that of the other Balaenopterids, making it a reliable feature for species identification of dead animals (Mead 1977).

Figure 1. Sei Whale (image collected under the NEFSC MMPA research permit 17355, Photographer: Peter Duley).

Sei Whales are easily confused with Bryde's Whales (*B. edeni*), especially in subtropical waters where the species historically overlapped. The morphological differences between Sei and Bryde's Whale are minor. However, Because Bryde's Whales tend to be restricted to warmer latitudes, generally below 40ºN (Omura 1959), this is not likely to be a source of confusion in Canadian waters. Sei Whales also resemble Omura's Whale (*B. omurai*); however, as Omura's Whales are restricted to the Indo-Pacific Ocean (Yamada 2009), confusion between these species is unlikely in the Atlantic Ocean.

Sei Whales can also be confused with Fin and Minke Whales (*B. acutorostrata*), especially by inexperienced observers (Horwood 1987). Dorsal fin shape is a key distinguishing characteristic with the dorsal fin of Sei Whales being relatively taller and more concave than those of Blue or Fin Whales. Additionally, Sei Whales can be differentiated from Fin Whales based on the colouration of the ventral side of the right jaw which is grey in Sei Whales and yellowish-white in Fin Whales (Horwood 2009). The possibility of underestimating population sizes for this species due to uncertainties in distinguishing between the two species has been noted for Atlantic Canada (Whitehead *et al.* 1998). Sightings databases (including those of DFO) often include a "Fin/Sei" category. Sei Whales can be distinguished from Minke Whales by size as Sei Whales are considerably larger and slimmer, and Minke Whales have white pectoral flipper stripes (Perrin and Brownell 2009).

Population Spatial Structure and Variability

Sei Whales are widely distributed through the world's oceans (Figure 2). Genetic analyses support a differentiation between Sei Whales in the North Pacific and the North Atlantic (Huijser *et al.* 2018) and between Sei Whales in the northern and southern hemispheres (Baker *et al.* 2004). As is typical of most baleen whales, Sei Whales in both hemispheres are generally thought to migrate from low-latitude wintering areas to high-latitude summer feeding grounds. There is evidence from catch records that migrations in all basins were segregated according to length (i.e., age), sex, and reproductive status. Pregnant females appear to lead the migration to the feeding grounds, while the youngest animals arrive last and leave first, and do not go as far poleward (Lockyer 1977, Horwood 1987, Gregr *et al.* 2000). However, in the Azores, recent biopsy analysis indicates that males are more common in the early spring when they are presumably moving north, with females following later (Prieto *et al.* 2012a). No clear breeding aggregation sites have been identified (Prieto *et al.* 2012b).

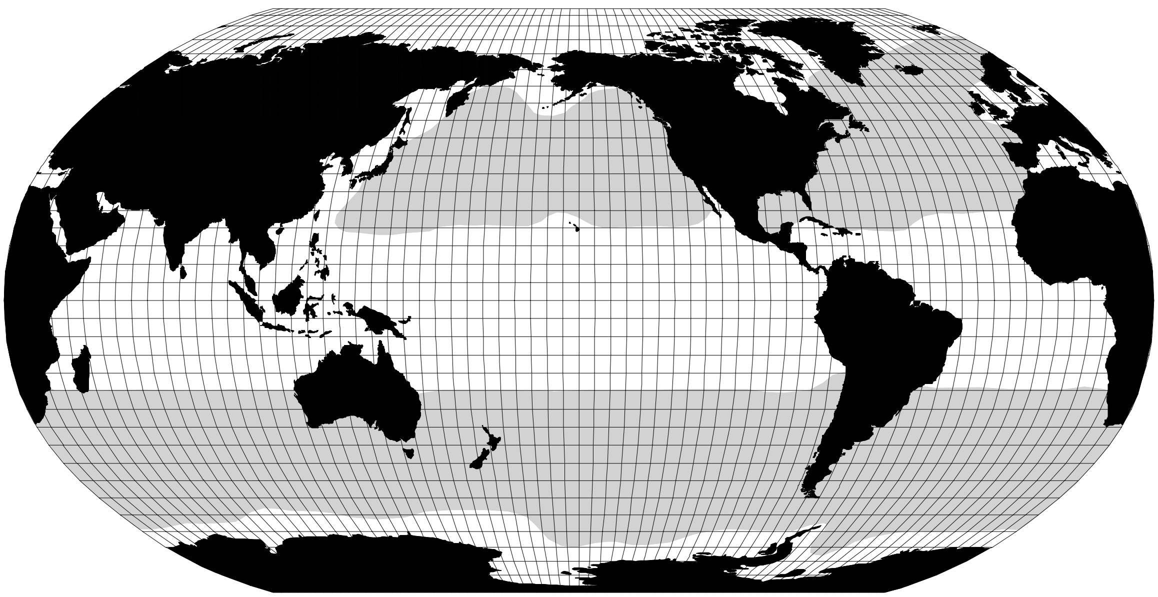

Figure 2. Approximate global distribution of Sei Whales (figure from COSEWIC 2003).

Passive acoustic monitoring along the east coast of Canada suggests that Sei Whales are present and vocalizing throughout most of the year (Delarue *et al.* 2018). Detections of vocalizations peak April through September, although there is variation throughout the range. The northernmost detection was ~55.6°N. Off the coast of Labrador there have been limited detections in spring (the first detection was in April). However, off the Grand Banks they have been detected in winter and early spring (January, March-June; Delarue pers. comm. 2018). Along the Scotian Shelf vocalizations were frequently detected in the warmer months (April-November) and only rarely in the winter (Krieg 2016; Emery and Moors-Murphy 2017; Sweeney 2017; Delarue pers. comm. 2018; Moors-Murphy pers. comm. 2018). However, there were no detections in the Gulf of St Lawrence, or in the Cabot Strait (Figure 3).

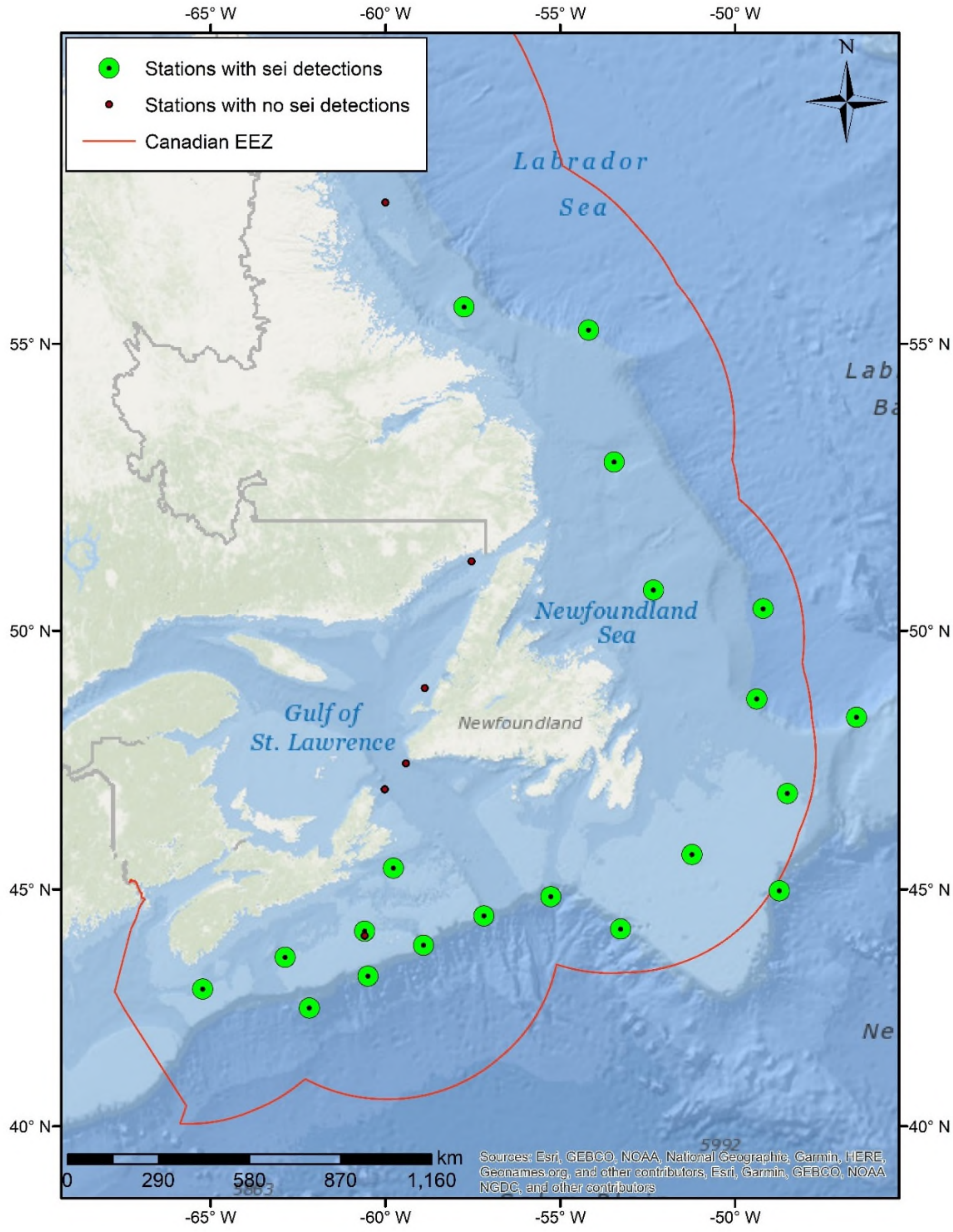

Figure 3. Positions of acoustic monitoring stations with and without Sei Whale detections. Note that this figure includes data from JASCO Applied Sciences (Delarue *et al.* 2018) and Fisheries and Oceans Canada (Emery pers. comm. 2018; Moors-Murphy pers. comm. 2018); additional data from other sources (e.g. Fisheries and Oceans Canada Newfoundland and Québec, Slocum glider deployments) are discussed in the report text. Note that this figure only indicates presence/absence of Sei Whale sounds recorded at each position, and does not reflect differences in methodology such as deployment period, duty cycle, sample rate and call identification criteria. Details of the deployments (e.g. study duration, recording details) are found in the report text.

Sighting data (Figure 4) indicate that Sei Whales are present year-round in Canadian waters, typically in offshore waters along the Scotian Shelf, around the Grand Banks and along the coast of Labrador as far north as 68°N. Fewer sightings have been made in winter months when search effort is much lower; however, Sei Whales can be sighted even in December and January both on the Scotian Shelf and off Labrador. Sighting data were obtained from a variety of different sources (e.g. OBIS - Ocean Biogeographic Information System, NARWC - North Atlantic Right Whale Consortium, Fisheries and Oceans Canada) and represent hundreds of different cruises from numerous different platforms. The vast majority of these cruises were not targeted at Sei Whale sightings, and thus these represent incidental sightings. These sightings cannot be corrected for effort.

While there are no geographic barriers that would create population structuring, Mitchell and Chapman (1977) suggested based on catch data that two stocks occurred in Canadian waters, a 'Nova-Scotia' stock which was exploited by the Blandford, Nova Scotia, whaling station and a 'Labrador' stock located in the Labrador Sea. Additional support for the two-stock hypothesis includes three arguments. Males caught off the coast of Nova Scotia may have been smaller than those caught in the Eastern Atlantic, suggesting population level differences between Sei Whales from Nova Scotia and off the European Atlantic coast (Horwood 1987), although no direct comparisons were made with Sei Whales caught off Labrador. Relatively few sightings have been made off the south coast of Newfoundland (Figure 4), approximately where Mitchell and Chapman (1977) suggested the northernmost limit for the Nova Scotia stock would be. Recent satellite tracking data indicate a clear migration route between the Azores and the Labrador Sea, but no individuals moving between the Azores and the Scotian Shelf (Figure 5; Olsen *et al.* 2009; Prieto *et al.* 2014).

However, evidence for the two-stock structure is far from clear. It is not clear that males caught off the coast of Nova Scotia were sexually mature; therefore smaller body size may reflect age rather than population differences (Prieto *et al.* 2012b). The low sighting numbers off the south coast of Newfoundland may reflect low survey effort rather than low density especially as analysis of historical catch data suggests that Sei Whales were once relatively common off the south coast of Newfoundland (Abgrall 2009). The satellite tracking data are compelling; however, results are based on only seven tagged whales moving northward from the Azores; tag duration was insufficient to investigate the southern return from the Labrador Sea. There are no comparable data to indicate whether all Sei Whales from the Labrador Sea migrate to the Azores or if a proportion of the Labrador population migrate along the Scotian Shelf (Olsen *et al*. 2009; Prieto *et al.* 2014). Recent genetic analyses did not find significant differences between samples collected in the Gulf of Maine, off Iceland and the Azores (Huijser *et al.* 2018). However, Huijser and colleagues (2018) also could not reject the hypothesis of multiple stocks. Additional sampling, especially in Canadian waters, may assist in resolving the stock structure of Sei Whales in the North Atlantic.

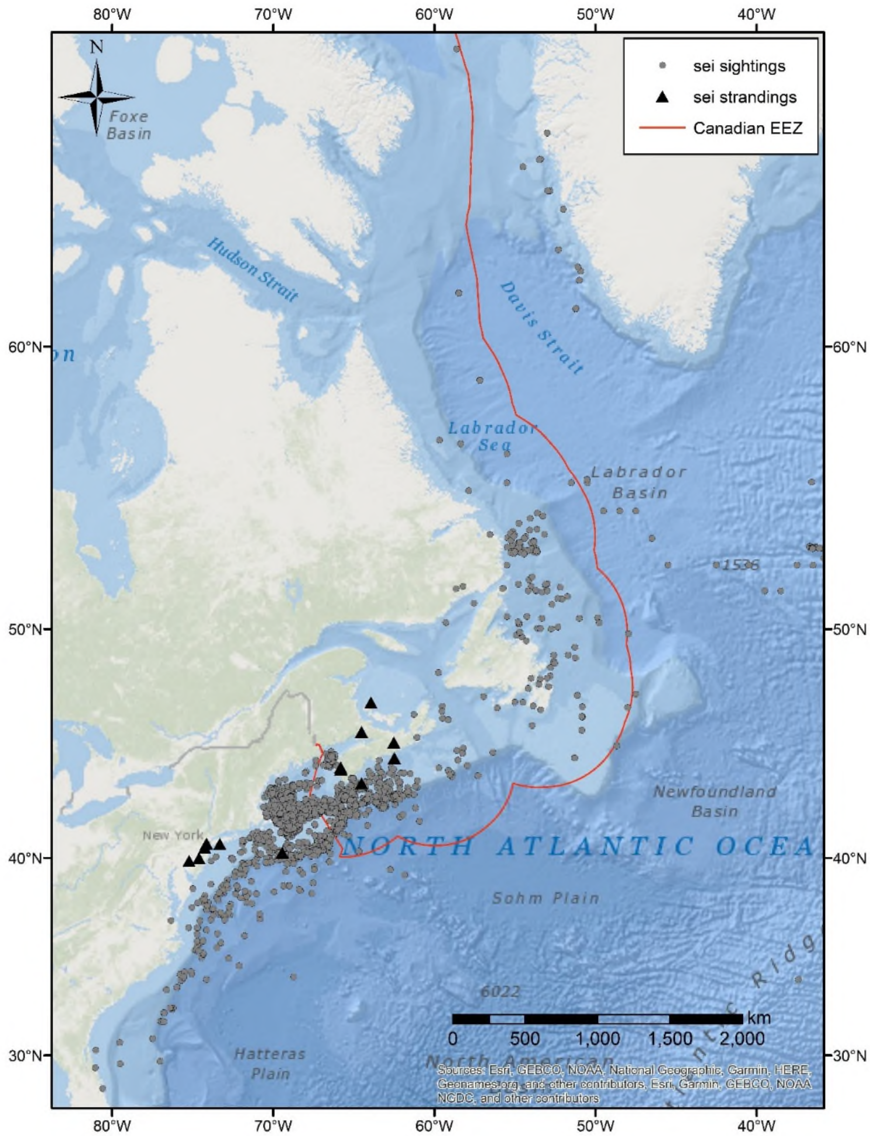

Figure 4. Sightings (circles) and strandings (triangles) of Sei Whales in the western North Atlantic between the years of 1900-2017 (no whaling catch data are included). Each circle denotes a single sighting and may represent multiple individuals. Sighting data sources: North Atlantic Right Whale Consortium database (North Atlantic Right Whale Consortium 2017)[1]; Ocean Biographic Information Systems (OBIS 2017); Fisheries and Oceans Canada - Newfoundland (Lawson pers. comm. 2018); Whalesitings Database, Ocean and Ecosystem Sciences Division, Dartmouth, NS (Emery pers. comm. 2017), Whitehead Lab (Whitehead pers. comm. 2018). Stranding data sources: Southeast US Marine Mammal Stranding Network (Stratton pers. comm. 2017); Northeast US Marine Mammal Stranding Network (Garron pers. comm. 2018); Marine Animal Response Society[2] (Wimmer pers. comm. 2018). Note that data were collected using multiple methodologies and are not normalized for search effort. Additional notes from data sources: [1]Raw sighting data from the NARWC database are not effort-corrected and the management documents in which they are used are not peer-reviewed. Distributional patterns based on these data are likely to be biased by where, and when, surveys were conducted.[2] Response to most strandings is very limited. Not all incidents are reported and many incidents cannot be investigated nor can assessments of human interaction and complete necropsies to determine cause of death be completed. As such, the numbers provided here are likely underestimates of actual injuries and mortality as well as cause of death and incidence of human interactions.

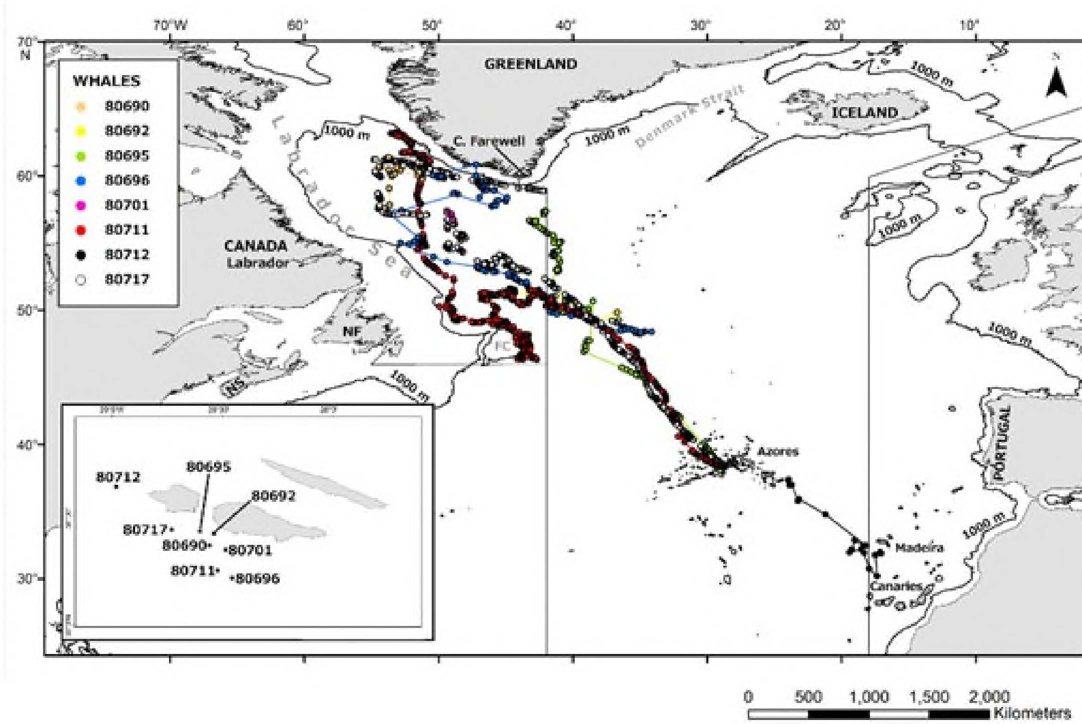

Figure 5. Sei Whale tracks derived from raw ARGOS satellite telemetry data. Tagging positions in the Azores are shown in the inset. International Whaling Commission stock boundaries for the species in the North Atlantic are shown as narrow lines. NS: Nova Scotia; NF: Newfoundland; FC: Flemish Cap. Modified from Prieto *et al.* (2014). Reprinted with permission.

Designatable Units

The geographical separation and genetic segregation (mtDNA $\Phi ST = 0.72$, microsatellite Weir and Cockerham's $\Theta = 0.20$) between the North Pacific and North Atlantic Sei Whales is sufficient to treat these two populations as separate designatable units (Huijser *et al.* 2018). There are currently insufficient data to separate the Labrador and Nova Scotia stocks of Sei Whales as separate designatable units in the North Atlantic.

Special Significance

The significance of the Sei Whale to the whaling industry was largely a function of its high quality meat (Andrews 1916) and the availability of other whales (Horwood 1987). Thus, the Sei Whale did not become a target species until the importance of whale meat surpassed that of oil (Andrews 1916) and after the depletion of other more valuable species such as Fin, Blue and Humpback Whales (*Megaptera novaeangliae*, Horwood 1987). In the eastern North Atlantic, Sei Whales were hunted from the late 1800s (Jonsgård and Darling 1977). In Atlantic Canada and Newfoundland whaling began in the late 1800s and continued until 1972 with a total reported catch of 1 116 Sei Whales (Table 1).

Because Sei Whales are not commonly near shore (Figure 4), they are not a primary target of whale watching operations, although some whale watching operators observe Sei Whales on occasion. While Sei Whales are hunted for subsistence by Indigenous people in Greenland, historical information suggests they were not an important resource for coastal Mi'kmaq who were seasonal hunters of small whales and other marine mammals (Hoffman 1955).

Table 1. Catch records for Sei Whales from Atlantic Canada and adjacent waters.

Area	Dates	Number caught	Comments and sources
Canada – Nova Scotia	1966-1972	825	Catches landed in Blandford, N.S. (Mitchell and Chapman 1977)
Canada – Newfoundland	1898-1918 1923-1937 1939-1951 1952-1972 **TOTAL**	93 37 33 20 **183**	Whales were either caught in NAFO regions 3K, 3L, 3Pn, 3Ps, 4R, 4S or the carcasses processed in shore stations in the region. Whaling did occur between 1918-1923 although catch records were not available (Abgrall 2009)
Canada – Labrador	1898-1918 1923-1937 1939-1951 1952-1972 **TOTAL**	0 30 67 11 **108**	Whales were either caught in NAFO regions 2H, 2J or the carcasses processed in shore based stations in the region. Whaling did occur between 1918-1923 although catch records were not available (Abgrall 2009)
Greenland	1924-1976 1985-2016 **TOTAL**	13 3 **16**	1924-1976: commercial whaling, western Greenland, eight may have been misidentified Right Whales (Kapel 1979), 1985-2016: Aboriginal subsistence whaling, western Greenland (IWC 2018a), no data available 1977-1984
Iceland	1986-1989 2003-2007 **TOTAL**	70 0 **70**	IWC Special Permit whaling conducted by Iceland only in years shown, all whales caught in Icelandic waters (IWC 2018b), no data available prior to 1986

DISTRIBUTION

Global Range

Sei Whales occur in all the world's oceans (Figure 2). However, they appear somewhat restricted to temperate waters, occurring within a more reduced range of latitudes than most other rorquals. They are found throughout the North Atlantic (Figure 6). In the western North Atlantic, both whaling data and recent satellite tags indicate that Sei Whales occur as far north as the Labrador Sea (Prieto *et al.* 2012b; Prieto *et al.* 2014; Figure 4). In the eastern North Atlantic, Sei Whales were regularly caught between 60º and 65ºN (Jonsgård and Darling 1977, Mitchell and Chapman 1977). Sei Whales are routinely found as far south as the Canary Islands, and Hydrographers Canyon off the USA, and may occur as far south as the Gulf of Mexico and Mauritania. However, the difficulty of distinguishing between Bryde's and Sei Whales has limited the detection of Sei Whales in their southern North Atlantic ranges (Prieto *et al.* 2012b; Hayes *et al*. 2017).

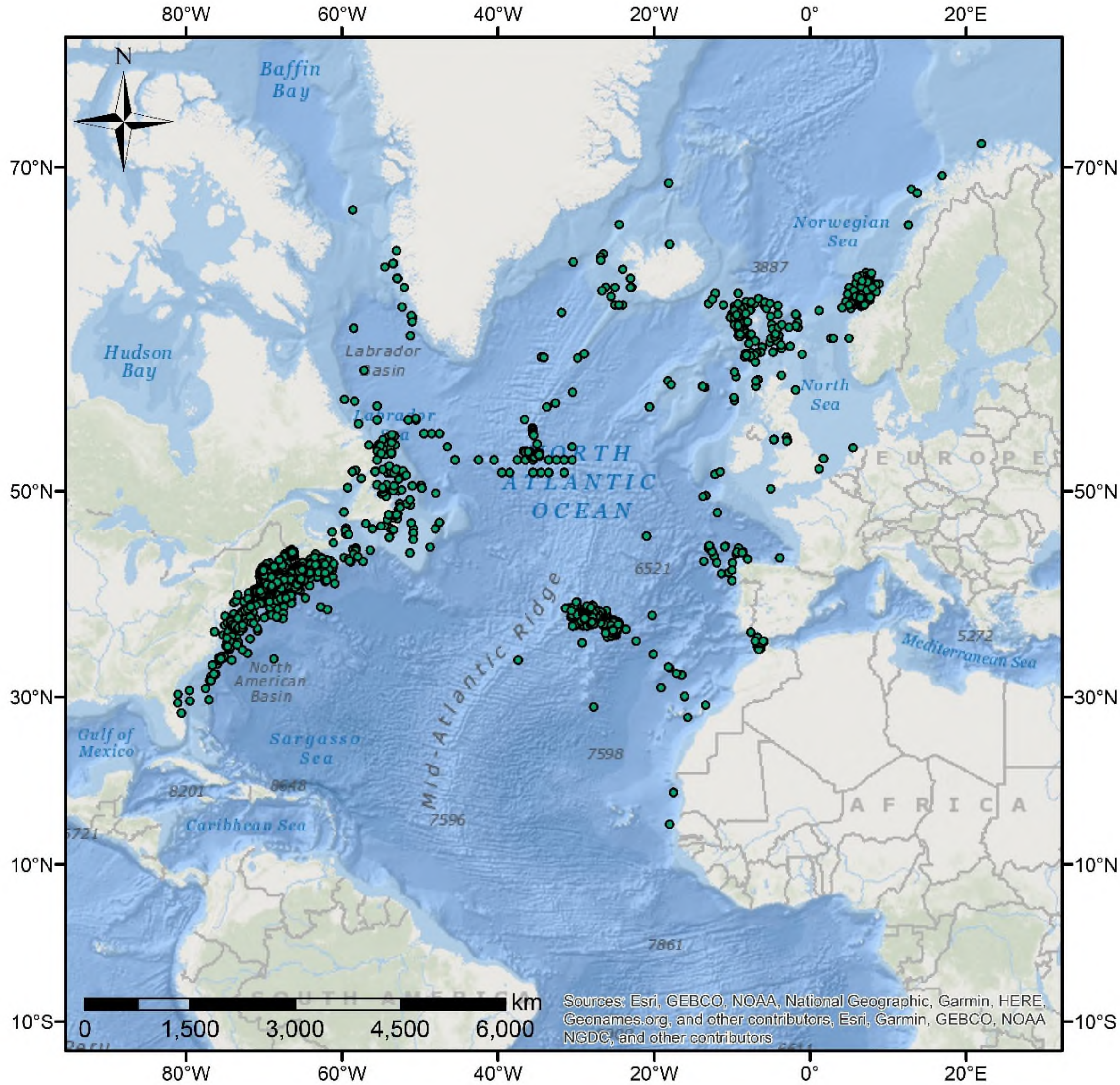

Figure 6. Sightings and captures (circles) of Sei Whales in the North Atlantic. Each circle represents a single sighting and may represent multiple individuals. Sighting data sources: North Atlantic Right Whale Consortium database (North Atlantic Right Whale Consortium 2017)[1]; Ocean Biographic Information Systems (OBIS 2017); Fisheries and Oceans Canada - Newfoundland (Lawson pers. comm. 2018); Fisheries and Oceans Canada - Maritimes (Emery pers. comm. 2017), Whitehead Lab (Whitehead pers. comm. 2018). Some of the more southerly positions may actually be Bryde's Whales. Additional notes from data sources: [1]Raw sighting data from the NARWC database are not effort-corrected and the management documents in which they are used are not peer-reviewed. Distributional patterns based on these data are likely to be biased by where, and when, surveys were conducted.

Canadian Range

The northern limit of confirmed sightings of Sei Whales in Canadian waters is between Baffin Island and Greenland at ~ 68°N (Figure 4). The southern limit of distribution in Canadian waters should be considered the border between Canadian and US waters as there are numerous sightings of Sei Whales along the Scotian Shelf and in the Bay of Fundy. The species can be found in both nearshore waters (typically deeper than ~ 40m) throughout the continental shelf and offshore to the edge of the EEZ and beyond. Sightings are clustered in southern Canadian waters and north of Belle Isle. However, these concentrations may reflect survey effort rather than Sei Whale distributions. Sightings are rare in the Gulf of St. Lawrence and this area does not appear to be key habitat for Sei Whales (Michaud pers. comm. 2017; Measures, pers. comm. 2017; Sears pers. comm. 2017; Figure 4).

There are relatively few stranding records of Sei Whales in Canada (Table 2). Few large whales are necropsied and many strandings are not recorded to species (Wimmer pers. comm. 2018). Stranding data were unavailable for Newfoundland and Labrador. The stranding data do confirm Sei Whales will enter the Gulf of St. Lawrence, but the stranding data also support that their presence is uncommon (Table 2; Figure 4).

Table 2. Stranding reports for Sei Whales from the Maritimes and the east coast of the US. Stranding data sources: Southeast US Marine Mammal Stranding Network (SE MMSN; Stratton pers. comm. 2017); Northeast US Marine Mammal Stranding Network (NE MMSN; Garron pers. comm. 2018); Marine Animal Response Society (MARS; Wimmer pers. comm. 2018). The only stranding in the Gulf of St. Lawrence was reported in 1998; no recent strandings have been reported (Measures pers. comm. 2017, Michaud pers. comm. 2017, Sears pers. comm. 2017, Wimmer pers. comm. 2018). NOTE: Response to most strandings is very limited. Not all incidents are reported, many incidents cannot be investigated, and assessments of human interaction and complete necropsies to determine cause of death cannot be completed. As such, the numbers provided here are likely underestimates of actual injuries and mortality as well as cause of death and incidence of human interactions.

Date	Location	Details	Source
Nov 18 1990	Nail Pond PEI (46.98°N, 63.94°W)	No details available	MARS
Apr 8 1995	Mavillette Beach NS (44.08°N, 65.79°W)	No details available	MARS
Jun 11 1997	Halifax Harbour NS (44.58°N, 62.48°W)	Newspaper report, ship strike	MARS
Jun 20 1998	Shubenacadie River NS (45.27°N, 62.52°W)	No details available	MARS
Apr 20 2001	Offshore (40.26°N, 69.45°W)	Video of floating whale, could not determine cause of death	NE MMSN
May 3 2001	New York NY (40.66°N, 74.11°W)	Ship strike	NE MMSN
Oct 10 2001	Comeau Beach NS (44.17°N, 65.82°W)	No necropsy, no cause of death determined	MARS

Date	Location	Details	Source
Nov 20 2002	Offshore (28.93°N, 93.94°W)	Skull recovered from shrimper trawl (not responsible for death)	SE MMSN
Sep 12 2002	Babylon NY (40.67°N, 73.32°W)	No human interaction determined - Emaciated	NE MMSN
Feb 19 2003	Norfolk VA (36.97°N, 76.34°W)	Ship strike	NE MMSN
Feb 18 2004	Corolla NC (36.26°N, 75.79°W)	No human interaction determined - Emaciated	SE MMSN
May 21 2004	Port Elizabeth NJ (40.68°N, 74.15°W)	Ship strike	NE MMSN
Apr 17 2006	Annapolis MD (39.02°N, 76.39°W)	Ship strike and fisheries interaction	NE MMSN
May 16 2006	Edgartown MA (41.35°N, 70.48°W)	Poor condition not well examined	NE MMSN
Sep 24 2006	Baccaro Pt. NS (43.46°N, 64.52°W)	No necropsy, not well examined	MARS
May 30 2007	Manchester MA (42.56°N, 70.77°W)	Ship strike likely	NE MMSN
Jul 2 2008	Slack's Cove NB (45.72°N, 64.53°W)	Entanglement evidence present	MARS
May 1 2009	Edgarton MA (41.35°N, 70.52°W)	No necropsy, not well examined	NE MMSN
May 20 2009	Dewey Beach DE (38.65°N, 75.07°W)	Could not determine if human interaction was present	NE MMSN
Mar 27 2011	Virginia Beach VA (36.70°N, 75.93°W)	Ship strike, plastic in stomach	NE MMSN
Mar 29 2014	South Core NC (34.61°N, 76.54°W)	Could not determine if human interaction was present	SE MMSN
May 4 2014	Manhattan NY (40.77°N, 74.00°W)	Ship strike	NE MMSN
May 9 2014	Philadelphia PA (39.67°N, 75.23°W)	Ship strike	NE MMSN
Aug 14 2014	Craney Island VA (36.93°N, 76.38°W)	Ship strike, plastic in stomach	NE MMSN
Jun 9 2015	Washington ME (44.48°N, 67.60°W)	Possible fisheries interaction	NE MMSN
Dec 22 2015	Galveston TX (29.13°N, 95.06°W)	No indication of cause of death, full necropsy	SE MMSN
Apr 25 2017	Normandy Beach NJ (40.00°N, 74.61°W)	Possible ship strike (poor condition and limited necropsy)	NE MMSN

Detections of Sei Whale vocalizations support this general distribution pattern. They are frequently detected acoustically along the Scotian Shelf, the Grand Banks and off Labrador to ~55.6°N (Krieg 2016; Emery and Moors-Murphy 2017; Sweeney 2017; Delarue *et al.* 2018; Moors-Murphy pers. comm. 2018). Vocalizing Sei Whales were not detected by the JASCO recorders deployed in the northern Gulf of St. Lawrence and Cabot Strait (Figure 3; Delarue *et al.* 2018). Slocum glider based hydrophones did record a few detections east of the Gaspé Peninsula; however, many more were detected on the Scotian Shelf (Johnson pers. comm. 2018).

Extent of Occurrence and Area of Occupancy

Given the widespread distribution of this species (Figure 4), the extent of occurrence (EOO) for Sei Whales greatly exceeds the COSEWIC threshold for EOO of 20 000 km^2. Similarly, the index of area of occupancy (IAO) for Sei Whales greatly exceeds the COSEWIC threshold for IAO of 2 000 km^2.

Search Effort

Survey effort for cetaceans in Atlantic Canada has been limited. However, there has been increased search effort in Canadian and US waters to locate Sei Whales. There have been comprehensive aerial surveys in eastern Canadian waters in 2007 and 2016 (Lawson and Gosselin 2009, 2018). Additionally, the United States National Marine Fisheries Service (NMFS) recovery plan for Sei Whales focuses on conducting research to assess Sei Whale population abundance, trends and structure as well as assessing limiting factors (NMFS 2011; NMFS 2012). Despite increasing survey efforts in both US and southern Canadian waters, Sei Whales are often not identified to species, being reported as “Fin/Sei Whale”, “unidentified large whale” or similar.

Acoustic methods to detect Sei Whales are increasingly being used. This report references acoustic detection results from Kreig (2016), Emery and Moors-Murphy (2017), Sweeney (2017), and Delarue *et al.* (2018) using bottom-mounted JASCO Applied Sciences Autonomous Multichannel Acoustic Recorders (AMARs).

Recordings using AMARs took place from approximately October 2012 to September 2014, and May 2015 to July 2017, with AMARs deployed on the continental shelf and slope from off Labrador to Nova Scotia (Kreig 2016, Emery and Moors-Murphy 2017, Sweeney 2017, Delarue *et al.* 2018, see Figure 3 of this report). Low-frequency channels recorded at sample rates of 8 kHz – 32 kHz, 24-bit resolution, and duty cycles ranged from 2 min / 20 min to 13.8 min / 15 min. High-frequency channels recorded at sample rates of 250 kHz – 375 kHz, 16-bit resolution, and duty cycles ranged from 1.1 min / 20 min to 17.8 min / 20 min. Delarue *et al.* (2018) reported nominal ceilings for low-frequency recordings of 164-165 dB re 1 μPa, and for high-frequency recordings of 171 – 173 dB re 1 μPa. All hydrophones were omnidirectional. Most studies (except Sweeney 2017) utilized a combined automated detector and manual review process to identify Sei Whale sounds. The automated detector used a contour-following algorithm and a species-specific sorting algorithm to identify marine mammal tonal sounds (Delarue *et al.* 2018). The automated detector was not reliable enough to be used alone for Sei Whale sounds (e.g. 50% false positive rate, Kreig 2016) and requires further development (Delarue, pers. comm. 2018). Therefore, manual verification of detections was necessary (e.g. Delarue *et al.* 2018). In most cases this involved the analysis of a subset of detection data, although all detections between 2012 and 2014 were verified in Emery and Moors-Murphy (2017).

Stranding networks in Atlantic Canada and the US have become more active since the late 1970s and the number of strandings reported has increased (Table 2). It is difficult to determine if this increase is due to increased outreach and reporting or an increased number of carcasses ashore. In Atlantic Canada many strandings of baleen whales are not identified to species and necropsies are not always conducted, with the exception of strandings of North Atlantic Right Whales (Wimmer pers. comm. 2018).

HABITAT

Habitat Requirements

The primary characteristic of Sei Whale feeding habitat is likely a high concentration of prey organisms, particularly copepods. However, Nemoto and Kawamura (1977) suggested that the Sei Whale's partiality for open, pelagic waters may be more important than a preference for any particular prey, as the species was rarely observed in inland seas or gulfs, despite high concentrations of copepods found there.

Studies of the distribution of baleen whales in relation to oceanographic conditions indicate a strong association with oceanographic fronts (Uda 1954; Nasu 1966; Prieto *et al.* 2014). Sei Whales are spatially associated with major mixing zones and eddies formed at oceanographic fronts, topographic features and major ocean currents (Horwood 1987).

In the Gulf of Maine, Sei Whales appear to forage intensively during the night when copepods are closer to the surface, and they were more abundant during times of weak diel vertical migration (Baumgartner and Frantoni 2008; Baumgartner *et al.* 2011). Sei Whales have unique baleen morphology which permits them both ram filter feeding on copepods and euphausiids as well as lunge feeding on fish. However, Baumgartner and Frantoni (2008) suggest that this morphology may limit their ability to forage on copepods and euphausiids at depth. Additionally, Baumgartner and colleagues (2011) suggest that Sei Whales may concentrate in the Gulf of Maine in early May when the diel vertical migration of copepods is relatively weak.

Habitat Trends

Describing the change in habitat over time for a migratory, pelagic species is a difficult task. Sei Whales are capable of searching large areas for suitable habitat. Thus, while localized, periodic changes in habitat quality may alter the spatial distribution of the species, it is unlikely that this variability reduces the overall habitat available. The effects of long-term oceanographic patterns (such as ocean warming and the Atlantic Multidecadal Oscillation) are less clear, and depend on the trophic interactions between Sei Whales, their prey, and their competitors.

Close examination of whaling records has suggested some shifts in distribution over time; however, whaling records are often not directly comparable to current sighting data as whalers rarely recorded non-target species. In addition, neither whaling nor recent sighting data can be corrected for search effort. Whaling catch data suggest that Sei Whales were relatively rare in the Davis Strait prior to the 1950s but appear to be more common now (Prieto *et al*. 2012b). Similarly, whaling data suggest that Sei Whales were caught relatively frequently along the south coast of Labrador, and the south coast of Newfoundland, and less frequently along the east and west coasts of Newfoundland. In contrast, more recent sighting data indicated fewer Sei Whales along the south coast of Newfoundland, with Sei Whales more abundant off eastern Newfoundland and southern Labrador (Abgrall 2009). Little is known about the historical distribution of Sei Whales on the Scotian Shelf and Scotian Slope other than the catches of Sei Whales along the Atlantic Coast from the Blandford whaling station between 1966 and 1972 (Mitchell and Chapman 1977).

BIOLOGY

Life Cycle and Reproduction

Sei Whales reach sexual maturity between 5 and 15 years of age. In both hemispheres the apparent age at sexual maturity declined from 10-11 years to 8 years between the 1930s and the 1960s (IWC 1977). Estimates of pregnancy rates towards the end of the fishery ranged from 30 to 69% of mature females (Mizroch 1980). While it was thought for a time that the Antarctic baleen whale stocks were responding to depletion with an increased pregnancy rate, Mizroch (1980) demonstrated that this assumed density-dependent response was spurious, and likely the result of inappropriate pooling of data.

The gestation period is estimated at 10.5 months (North Pacific: Masaki 1977) to 12 months (Antarctic: Gambell 1968), and is 11 months for the North Atlantic population (Kjeld 2003). In the North Atlantic conception peaks from November to December with a peak in births around late November (Kjeld 2003). Calves are weaned on the feeding grounds after a lactation period of about 6 months, and the calving interval is 2 – 3 years (Gambell 1985). In the North Atlantic in the 1980s the pregnancy rate was estimated at 0.41 (Kjeld 2003). Taylor *et al.* (2007) used a life history model based on age of first reproduction, inter-birth interval, maximum age of reproductive females, calf survival rate, and non-calf survival to estimate the pre-exploitation generation time as 23.3 years.

Physiology and Adaptability

The flexible feeding strategy of Sei Whales is at least partially a function of baleen plates that are intermediate between the fine sieves of North Atlantic Right Whales and the coarser plates of most Balaenopterids that facilitate gulping. With its ability to apply both skimming and gulping feeding strategies, the Sei Whale is also better able to adapt to fluctuations in prey availability than the more stenophagic North Atlantic Right Whale, but perhaps not as well as the more generalist Fin Whale. If competition is primarily with other planktivores (whales or fishes), then the ability to take advantage of a variety of prey items that become abundant under different oceanographic conditions or in different areas will enhance the survival of the species. However, this foraging flexibility may come at a cost such that the ability of Sei Whales to feed on copepods or euphausiids may be compromised at depth and may be limited predominantly to foraging at night when copepods are closer to the surface (Baumgartner and Frantoni 2008).

The diet information from the North Pacific suggests that Sei Whales can adapt their foraging to different prey distributions. While stomach contents of North Pacific Sei Whales are dominated by copepods; euphausiids, fish and squid also appear to be important components of the diet (Nemoto and Kawamua 1977, Kawamura 1982). Nemoto and Kawamua (1977) also suggested that Sei Whales caught in coastal waters had a more diverse diet. This was corroborated by Flinn *et al.* (2002), whose analysis of stomach contents from coastal British Columbia stations showed that copepods dominated the diet in three of five years, while fish and euphausiids each dominated in one of the other years. The relative importance of different prey types appears to have a seasonal component (Rice 1977; Flinn *et al.* 2002).

However, this diversity in prey may not be the case in the North Atlantic, where Sei Whales appear to be much more stenophagous (i.e. with a restricted diet). Of 52 stomachs examined at Norwegian whaling stations in 1952 and 1953, all were either empty or contained only crustaceans (copepods or euphausiids) (Jonsgård and Darling 1977). On the Scotian Shelf, Mitchell *et al.* (1986) reported that only about 1% (0 of 134 stomachs examined in 1972, and 2 of 68 stomachs examined between 1966 and 1972) contained fish or squid. More recent observations of free-ranging Sei Whales in the North Atlantic also support a relatively stenophagous diet (Schilling *et al.* 1992; Baumgartner and Fratantoni 2008). A greater proportion of planktonic crustaceans in stomach contents in Atlantic Sei Whales is similar to results for Antarctic Sei Whales (Nemoto and Kawamura 1977). Nemoto and Kawamura (1977) attributed the difference in stomach contents between the crustacean-dominated diet of Antarctic Sei Whales and the more generalist diet of Pacific Sei Whales to different trophic structures in the two ocean basins.

Their streamlined shape, speed and size suggest that Sei Whales may have particularly efficient locomotion, and thus be able to effectively exploit large spatial ranges.

Dispersal and Migration

Like many other baleen whales, Sei Whales are believed to alternate between foraging in higher latitudes during the summer and breeding during the winter in lower latitudes. However, unlike Humpback and North Atlantic Right Whales no clear breeding/calving aggregations have been identified for Sei Whales. Satellite tagging by Prieto and colleagues (2014) identified a clear migratory path between the Azores in the spring and Labrador by early June and suggested a wintering ground off northwestern Africa. Little foraging occurred until the whales reached 48°N. However, once the whales reached this latitude feeding frequently occurred (Prieto *et al.* 2014). Data from Newfoundland and Labrador whaling stations indicated foraging commonly takes place in Canadian waters (Abgrall 2009). While sightings of Sei Whales in Canadian waters are most frequent in summer and fall, coinciding with the bulk of survey effort, there have been sightings in all months of the year. Little is known about the dispersal of juvenile Sei Whales after the 6-month lactation period.

Interspecific Interactions

While Sei Whales have generally been described as opportunistic feeders, recent work in the North Atlantic have suggested that Sei Whales may rely heavily on copepods (primarily *Calanus finmarchicus*) and forage primarily at night (Baumgartner *et al.* 2011). The extensive, early depletion of North Atlantic Right Whales (by the end of the 19th century) in the North Atlantic may have allowed Sei Whale populations to increase as a result of reduced competition for copepods.

On the Scotian Shelf, Sei Whales were observed to have a sympatric distribution with North Atlantic Right Whales between 1966 and 1972 (Mitchell *et al.* 1986). Given the overlap in diets, this is not unexpected. Payne and colleagues (1990) noted that the observed distribution of Sei and North Atlantic Right Whales were mostly allopatric between 1982 and 1988, except in years of high copepod abundance. Payne and colleagues (1990) presented a strong argument for competition between North Atlantic Right Whales and Sandlance (*Ammodytes* spp.) for copepods, and suggested that planktivorous fishes may play a significant role in the distribution of baleen whale populations. More recent studies by Baumgartner *et al.* (2011) suggest that the relationship between North Atlantic Right and Sei Whales and zooplanktivorous fish may be more complicated. In deeper waters (>40 m) copepods may be able to evade zooplanktivorous fish during the day by migrating down in the water column. North Atlantic Right Whales appear able to feed on copepods at depth, while Sei Whales may be restricted to foraging at night when the copepods are closer to the surface. Thus, the intense foraging pressure on copepods by fish and the copepods' migratory response may limit Sei Whale foraging, especially over deeper waters (Baumgartner *et al.* 2011).

Predation by Killer Whales (*Orcinus orca*) on Sei Whales has been documented in the southern hemisphere and North Pacific, but not in the North Atlantic (Jefferson *et al.* 1991). Because the distribution of Killer Whales (Lawson *et al.* 2007, Lawson and Stevens 2014) overlaps the distribution of Sei Whales in eastern Canada and Killer Whales in the Northwest Atlantic are known to feed on cetaceans (Lawson *et al.* 2007), it is reasonable to think that they would prey on Sei Whales in Canadian waters.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

The key population assessment data come from comprehensive aerial surveys of the eastern Canadian continental shelf in 2007 and 2016, the TNASS and NAISS surveys (Lawson and Gosselin 2009, 2018). Aerial line-transect surveys were conducted from Cape Chidley, northern Labrador, down to the Scotian Shelf to meet the US study area, including the Gulf of St. Lawrence. The Canadian components of TNASS and NAISS provided full coverage of the Atlantic Canadian coast (except for one small gap on the Scotian Shelf in 2016).

The US recovery plan for Sei Whales focuses on conducting research which will allow for the assessment of Sei Whale populations in the US (NMFS 2011) and these surveys are underway but the work has not yet been completed.

Most of the older population estimates come from whaling data, especially catch per unit effort. Sei Whales were rarely the targeted species for whaling efforts, instead Sei Whale catches were often incidental when other species were less available or when species identity was uncertain. Therefore, catch effort was sporadic, and better reflects environmental conditions and/or the availability of other species of whales. However, Sei Whales were taken in eastern Canadian waters from the late 1800s until 1972 (Table 1). Sei Whales were also caught off the coasts of Greenland and Iceland more recently (IWC 2018a,b).

Abundance

Only three Sei Whales were sighted during the 2007 TNASS surveys (Lawson and Gosselin 2009), and four (plus three “Fin/Sei”) during the 2016 NAISS surveys (Lawson and Gosselin 2018) (Table 3). Because of the small number of sightings, Lawson and Gosselin (2009, 2018) made no attempt to estimate population size. However, by comparing sighting rates of Sei Whales with congeneric and sympatric Balaenopterids we can make some inference (see Table 3). It can be assumed that detection rates of Sei Whales will be intermediate between the larger Fin Whale and smaller Minke Whale (as indicated by estimated strip widths estimated by Lawson and Gosselin 2007, 2016). Thus, low estimates for Sei Whale numbers in eastern Canada (extrapolating from Fin Whales) are 3 x 1362 / 147 = 28 for 2007 (Sei Whales sighted x Fin Whale abundance / Fin Whales sighted), and 4 x 1664 / 95 = 70 for 2016. Using the same methodology and extrapolating from Minke Whales, high numbers are 57 (2007) and 177 (2016).

Table 3. Data from 2007 TNASS and 2016 NAISS surveys of eastern Canadian continental shelf for *Balaenoptera* species in order of size (Lawson and Gosselin 2009, 2018). Population estimates were only calculated for species with >20 sightings, and were not corrected for perception or availability bias.

Species	Number sighted			Population estimate (uncorrected for biases)	Sei estimate (prorated)
	Nfld/Lab	Scotian Shelf/ G. St. Lawrence	Total		
TNASS (2007):					
Blue Whale	11	6	17		
Fin Whale	51	96	147	1 362	28
Sei Whale	2	1	3		
Unknown large whale	107	7	114		
Minke Whale	113	57	170	3 242	57
NAISS (2016):					
Blue Whale	5	6	11		
Fin Whale	47	48	95	1 664	70
Sei Whale	4	0	4		
Fin/Sei Whale	3	-	3		
Unknown large whale	-	143	143		
Minke Whale	38	79	117	5 182	177

There are several reasons why these numbers may be underestimates for the number of Sei Whales using eastern Canadian waters. First, none of these estimates were corrected for availability or perception bias. Availability bias accounts for when whales dive and cannot be seen. However, Balaenopterids do not make particularly long dives. Most Sei Whale dives off Japan were approximately 3 minutes long and were followed by several minutes at the surface between dives (Ishii *et al*. 2017). Therefore, this bias is likely less than a factor of about 5. Second, Sei Whales are less easily identified to species than other eastern Canadian Balaenopterids. If some of the “Fin/Sei” or “unknown large whales” (Table 3) were actually Sei Whales, then estimates would be higher. Given that Fins were much more often identified than Seis, it seems unlikely that the great majority of the balaenopterids unidentified to species were actually Seis. Thirdly, the surveys may have been conducted at times of the year (17 July – 24 August 2007; 1 Aug – 26 Sept 2016) when Sei Whales were less likely to frequent Canadian waters; however, this seems unlikely as 47% of the Sei Whale sightings in Canadian waters occurred in July and August (value derived from data used to produce Figure 4 – although this time period also coincides with more effort and better weather). Finally, given the mobility of the species, the number of Sei Whales that “occur regularly in Canada” (COSEWIC definition, O&P manual E3) may be considerably greater than the number present at a particular time, and so available to be counted during a comprehensive aerial survey.

There are population estimates for Sei Whales from the whaling era (and still cited today) based primarily on catch per unit effort data. Estimates for the entire North Atlantic range from 4 000 (Braham 1984) to 12-13 000 (Cattanach *et al.* 1993). However, the estimate from Braham (1984) is considered imprecise (Perry *et al.* 1999), while that provided by Cattanach *et al.* (1993) combines Mitchell and Chapman's (1977) estimate for western Atlantic waters (2 248) with the results of a 1989 ship-based survey of Icelandic and adjacent waters (10 300 animals, CV=0.268). However, it has been suggested that pre-exploitation numbers in the North Atlantic were 10 600 (95% confidence interval 7 420 - 18 800) and 2001 estimates were 6 990 (5 240 - 9 240) indicating a 34% decline (Christensen 2006).

Mitchell and Chapman (1977) estimated the size of the Nova Scotia stock using mark-recapture and census data. The mark-recapture analysis estimated the stock at 1 393 - 2 248 animals. The census study estimated the Northwest Atlantic population at 2 078, with minimums of 870 for the Nova Scotia stock, and 965 for the putative Labrador Sea stock.

A CeTAP (Cetacean and Turtle Assessment Program) estimate of 253 Sei Whales between Cape Hatteras, North Carolina and Nova Scotia, on the continental shelf and shelf edge, was derived using data from aerial surveys conducted from 1978 to 1982 (Waring *et al.* 2001). This estimate, when corrected for dive time and probability of detection on the track line, is approximately the same as Mitchell and Chapman's (1977) mark-recapture estimate (Waring *et al.* 2001). The CeTAP data were also used to estimate a maximum population of 2 273 animals in U.S. Atlantic waters (Mizroch *et al.* 1984). However, these estimates are no longer considered reliable (Perry *et al.* 1999).

A ship-based line transect survey was conducted off west Greenland from shore out to the shelf break (up to 100 km offshore) in September 2005 and yielded a population estimate of 1 599 individuals (CV=0.42; 95% confidence interval 690-3 705) (Heide-Jørgensen *et al.* 2007). While only Greenlandic waters were surveyed it is likely that some Sei Whales move between Canadian waters off Labrador and Greenland. However, as this survey did not extend beyond the shelf break it is likely that it underestimated the total number of Sei Whales in Greenlandic waters, especially as many of the Sei Whale sightings occurred in deeper waters. Additionally, the estimate has not been corrected for dive time (this is a smaller correction for ship-based surveys than for aerial surveys), although they did correct for a species-specific detection probability (Heide-Jørgensen *et al.* 2007).

A combined ship-based and aerial survey was conducted along the US Atlantic coast between June and August 2011, from shore to the Gulf Stream (approximately 200 nautical miles offshore). This survey yielded a population estimate of 357 Sei Whales (CV=0.52; Palka 2012). Roberts and colleagues (2016) combined a large number of aerial and ship-based surveys along the east coast of the US spanning 1992-2014. Using density surface modelling, they estimated the Sei Whale population along the US Atlantic coast and the Scotian Shelf at 1 519 (CV=0.30) in July, and 98 (CV=0.25) in January, although the January estimate did not include Canadian waters.

All of these population estimates are unsatisfactory when assessing the Atlantic Canadian population of Sei Whales. They are either based on outdated methods (Mitchell and Chapman 1977), are crude extrapolations from uncorrected estimates for other species (TNASS, NAISS estimates above), or are principally for other, non-Canadian, waters (Heide-Jørgensen *et al.* 2007; Roberts *et al.* 2016). However, considered together, these sparse data suggest that the Atlantic Canadian population of Sei Whales was in the order of several thousand mature individuals pre-whaling and until whaling's final years in the mid-twentieth century (less than three generations or 70 years ago), and that the population in Canadian waters today numbers a few hundred mature individuals or fewer.

Fluctuations and Trends

Population estimates for Sei Whale populations are uncertain at best. We would not expect the population of a long-lived, slowly reproducing species like the Sei Whale to show much in the way of natural fluctuations, although the number regularly using Canadian waters could fluctuate over years or decades.

While it is problematic to compare whaling catch data with survey-based sighting data, in 1971 during the peak operating years of the Blandford whaling station, 234 Sei Whales, a target species, were caught (Mitchell 1975), while in 2007 and 2016 during the TNASS and NAISS surveys only seven Sei Whales were sighted (Lawson and Gosselin 2009, 2016).There are insufficient data to determine any current population fluctuations or changes, although the TNASS and NAISS surveys suggest that the population is considerably depressed below pre-whaling numbers, including that in 1949, three generations ago, and estimates calculated from catches and surveys during the final years of whaling (early 1970s).

Rescue Effect

It is not clear whether the Sei Whales that use Canadian waters are from a largely distinct northwest Atlantic population, or a quite well-connected population covering the whole temperate North Atlantic (Huijser *et al.* 2018). The tagging results of Prieto and colleagues (2014; Figure 5) suggest the latter. If so, rescue would have to come from a different ocean, and this is unlikely given the large spatial gap (Figure 2) and putative genetic differences (Baker *et al.* 2004; Huijser *et al.* 2018) between North Atlantic Sei Whales and those in other oceans. If, alternatively, the Sei Whales that use Canadian waters are from one of several populations that use the North Atlantic, then members of these populations could, perhaps, rescue the Canadian population. If site fidelity is strong then rescue to Canadian waters would be minimal.

THREATS AND LIMITING FACTORS

Threats

Noise is a particularly important channel by which anthropogenic activities affect Sei Whales. There are several important anthropogenic sources of ocean noise (see subsections below; Weilgart 2007; Gomez *et al.* 2016), but, as different sources may produce similar effects, these effects will be summarized first. Acute, intermittent noise such as from mineral exploration or military exercises is likely to elicit significant behavioural responses and, at sufficiently high levels, to result in mortality for some baleen whale species (Gailey *et al.* 2007; Dunlop *et al.* 2017; Harris *et al.* 2018). Chronic noise, such as that originating from oil platforms and shipping, has been shown to cause various behavioural changes such as alteration of foraging behaviour, avoidance responses and change in habitat use (Schick and Urban 2000; Blair *et al.* 2016). Increases in ambient noise can also cause interference with (masking) and changes in baleen whale acoustic communication (e.g. increases in call rate: Di Iorio and Clark 2010; increases in call amplitude: Parks *et al.* 2011).

A recent study has used cortisol signatures in baleen whale earplugs, which have annual layers, to relate stress levels in northern hemisphere Fin, Blue and Humpback Whales to anthropogenic factors (Trumble *et al*. 2018). There is a strong temporal correlation between cortisol level and historical industrial whaling pressure, and a post-1970s increase which correlates with increasing sea temperature anomalies (Trumble *et al*. 2018), but could be related to unmeasured factors such as ocean noise level, which is generally increasing in northern hemisphere environments (Weilgart 2007), and has been shown to have short-term inverse correlations with cortisol level in Right Whales (Rolland *et al*. 2012).

The threats to Sei Whale reviewed below are categorized following the IUCN-CMP (International Union for the Conservation of Nature – Conservation Measures Partnership) unified threats classification system. They are presented in decreasing order of assessed severity of impact. The assigned overall threat impact is High-Medium (see Appendix 1 for details).

<u>3.1 Oil & gas</u>

Offshore waters off Canada's East Coast have been the subject of intensive oil and gas exploration, particularly east of Newfoundland and southern Labrador, where effort has increased about sixfold since 2015 compared with 2000-2014 (CNSOPB 2018; CNLOPB 2018). These areas form the prime habitat of Sei Whales (Figs. 3 and 4). In recent years, multiple seismic surveys have been taking place simultaneously off the Grand Banks and the Labrador Shelf, starting as early as May and lasting until November, which raises concerns about the long-term effects of prolonged exposure to intense airgun impulses (Delarue *et al.* 2018). Seismic survey effort off Nova Scotia has been more intermittent and there is currently a ban on oil and gas exploration in the Gulf of St. Lawrence and on George's Bank. Recent oil exploration activities and the potential exploitation of reserves off

Atlantic Canada (on the Scotian Shelf, the Grand Banks and the southern Labrador Shelf; and further offshore) could result in habitat degradation for the species (CNSOPB 2018; CNLOPB 2018).

4.3 Shipping

Considered here is the potential risk of an encounter between a Sei Whale and a vessel anywhere within the range of the species, not only in designated shipping lanes, in which the risks would be elevated. Near the Atlantic coast of North America, vessel traffic is a serious threat to several whale species, and there have been several recent reports of Sei Whale mortality due to vessel strikes (Table 2). The annual rate of serious injury and mortality to Sei Whales due to anthropogenic effects has been calculated at 0.8 from 2010-2015 for the western North Atlantic (Henry *et al.* 2016, 2017). Ship-strikes were the most common source of human interaction; there were 10 confirmed ship-strike interactions and 2 more which were possible ship-strikes in the 27 stranding reports of Sei Whales that the report writers were able to locate. Three of the 10 confirmed ship strikes had additional sources of human interaction; two individuals had plastic in their stomachs, while one had interacted with fishing gear.

It is clear from these stranding records that ship strikes have the potential to harm Sei Whales. Recent work suggests that at least in the Great South Channel, Sei Whales forage predominately at the surface at night (Baumgartner and Frantoni 2008), which could lead to an increased susceptibility to vessel strikes. It is also likely that many vessel strikes are undetected, given the pelagic nature of the species.

The Canadian and American governments have enacted a number of measures to reduce the likelihood of vessel strikes on North Atlantic Right Whales along the Atlantic coast (Kraus *et al.* 2005; Vanderlaan and Taggart 2009). While these measures have largely targeted ship strikes with North Atlantic Right Whales, they have the potential to reduce ship strikes for other cetacean species. Van der Hoop and colleagues (2015) assessed the efficacy of the 2008 Vessel Strike Rule (which set maximum speeds for commercial vessels in 10 “Seasonal Management Areas” off the US east coast) to reduce vessel strikes and indicated that Sei Whales have likely benefited from these regulations when they are present in the protected areas. However, Sei Whales are frequently found outside the protected areas and are therefore still vulnerable to ship strikes.

Noise from shipping can negatively affect behaviour and habitat use of baleen whales (Schick and Urban 2000; Blair *et al.* 2016), and likely impacts Sei Whales.

5.4 Fishing and harvesting aquatic resources

North Atlantic Right Whales are frequently entangled in fishing gear, and this entanglement has the possibility for population-level effects (Fujiwara and Caswell 2001; Knowlton *et al.* 2012). Sei Whales frequently forage on the same prey as North Atlantic Right Whales and in similar places. Therefore, they too are likely vulnerable to fisheries entanglement. In comparison to ship strikes, fisheries interactions were less commonly encountered in the stranding data. Out of the 27 strandings (Table 2), only one of the stranded Sei Whales was confirmed to have been entangled in fishing gear and one other individual was suspected to have had a fisheries interaction. The pelagic nature of this species likely reduces the chances of fisheries interaction, but also increases the likelihood of undetected interactions with fishing gear. There could also be indirect ecological effects of fishing on Sei Whales.

Whaling in Iceland (70 reported caught from 1986-1988; IWC 2018b) or west Greenland (3 reported caught since 1985; IWC 2018a) could kill Sei Whales that use Canadian waters.

6.2 Military exercises

Naval exercises, especially involving mid-frequency sonars as well as explosions, are known to affect the behaviour and distribution of cetaceans and sometimes to kill them (Weilgart 2007). The Canadian Navy attempts to minimize the environmental impacts of its activities, but the range of Atlantic Canadian Sei Whale includes areas where the Canadian Navy, the US Navy, and other navies are active.

Other Threats

The development of offshore wind and tidal power along the east coast of North America has potential to disturb Sei Whales. For example, Sei Whales were routinely sighted in two designated Wind Energy Areas off the coasts of Massachusetts and Rhode Island (Stone *et al.* 2017). While the impacts of wind and tidal energy developments on Sei Whales are unknown, the increased interest in these forms of energy could potentially lead to disturbance in the future.

Plastic ingestion has been well documented in cetaceans including several baleen whales. There have been at least three reports of Sei Whales ingesting plastic, including two in Massachusetts (Baulch and Perry 2014; Garron pers. comm. 2017). Recently there has been concern about the extent of microplastic pollution in the ocean. While there have been no reports of microplastic contamination in Sei Whales, it has been found in Humpback Whales (Besseling *et al.* 2015) and theorized to be problematic for all filter feeders (Germanov *et al.* 2018). Copepods, including *Calanus* spp., have been documented ingesting microplastics (Cole *et al.* 2013). Therefore, bioaccumulation up the food chain is likely. The potential effects of plastic ingestion in Sei Whales is unknown.

While marine mammals generally appear to be at risk from immunotoxic chemicals (Ross 2002), O'Shea and Brownell (1994) concluded that there is no evidence of toxic effects from metal or organochlorine contamination on baleen species, largely because they feed at low trophic levels.

Trophic transfer of biotoxins from harmful algal blooms has been shown to be potentially fatal in baleen whales (Fire *et al*. 2010), and has been linked to the largest baleen whale mass mortality ever recorded: that of Sei Whales in Chilean Patagonia (Häussermann *et al*. 2017). Intensity and frequency of algal blooms are expected to increase with ocean warming (e.g. Gobler *et al*. 2017), especially in association with major upwelling systems (Trainer *et al*. 2010). More intense and/or frequent toxic blooms in winter/spring feeding areas may affect the recovery of species. Based on the findings from Häussermann *et al*. (2017), the effects can be potentially catastrophic for small populations, as hundreds of animals may die in a single episode. Sub-lethal effects may include lower reproductive success and increased susceptibility to other mortality causes (Leandro *et al*. 2010).

Limiting Factors

The Sei Whale population was heavily reduced by whaling in the 20th Century and is still well below pre-whaling numbers.

A potentially important factor is the replacement of large baleen whales in the ecosystem by ecologically equivalent finfish stocks (Payne *et al.* 1990). Although finfish may not compete directly with Sei Whales, their foraging behaviour may drive the diel vertical migration of copepods, which could in turn limit Sei Whale foraging at the surface (Baumgartner *et al.* 2011).

Sei Whale populations may be limited by prey availability. Two of the stranded individuals (Table 2) were considered emaciated. Reductions in North Atlantic Right Whale reproductive output and survival have been linked to large-scale oceanographic processes which influence the availability of the copepod prey which both Sei and North Atlantic Right Whales prefer. Variations in these oceanographic processes are likely in the future, which may influence Sei Whale population trajectories (COSEWIC 2013).

Baleen shedding disease has been documented in Sei Whales off California, but has not been documented in Sei Whales in the North Atlantic (Prieto *et al.* 2012b). Relatively few Sei Whales have been tested for parasitic infections, although a single Sei Whale examined off the coast of Scotland tested positive for the presence of *Toxoplasma gondii* (van de Velde *et al.* 2016). *Entamoeba* sp. and *Giardia* sp. were detected in faecal samples of Sei Whales collected in the Azores (Hermosilla *et al*. 2016). Occurrence of these human endo-parasites could be caused by contaminated runoffs/sewage from populated areas.

Number of Locations

Given the broad distribution and long-range movement patterns of Sei Whales there is no evidence to suggest that individuals reside in very small or restricted locations, within which a single threatening event could rapidly affect all individuals present. Thus, the concept of locations does not apply.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

As with all the large baleen whales, the Sei Whale is considered at risk worldwide. The severity of historical over-exploitation and the lack of contemporary data indicate a precautionary approach to assessing the status of this species. Sei Whales are protected from commercial whaling by the International Whaling Commission. Aboriginal subsistence catch quotas have permitted the take of three Sei Whales since 1985 (2 in 1989 and 1 in 2006). All three Sei Whales were caught off the west coast of Greenland and may have included individuals which used Canadian waters (IWC 2018a). A larger number of Sei Whales (70) were caught through the IWC Special Permit program between 1986 and 1988 off the coast of Iceland (IWC 2018b). It is not known if these could include animals that travelled through Canadian waters. Sei Whales are listed in Appendix I of the Convention on International Trade in Endangered Species (CITES), which prohibits commercial trade (CITES 2018). The Sei Whale is listed as Endangered by the IUCN on the basis of historical exploitation (Reilly *et al.* 2008).

The Nova Scotia Sei Whale stock has been listed as Endangered under the United States *Endangered Species Act* (ESA) since 1973. The lack of information on population trends and human-caused mortality is the basis on which it remains listed (Waring *et al.* 2001). The US recovery plan for Sei Whales was approved in 2011 and focused on a research strategy (NMFS 2011) which is ongoing. The latest NMFS stock assessment estimates the minimum population size at 236 and calculates a Potential Biological Removal at 0.5 (Hayes *et al.* 2017).

In Canada, the existing *Fisheries Act* and *Marine Mammal Regulations* prohibit disturbance of marine mammals without a permit except for purposes of hunting, for which a permit is required. This has been broadly interpreted as a prohibition on harassment and has evolved into a series of whale watching guidelines. There has been no hunting of Sei Whales in Canada for over 40 years and there is no indication that whaling on Sei Whales in Canadian waters will resume in the future. Sei Whales have been assessed by COSEWIC as Endangered in the North Pacific (originally assessed in 2003 and re-assessed in 2013). The Atlantic population was originally assessed by COSEWIC in 2003 as Data Deficient, and reassessed in 2019 as Endangered. The Pacific population of the Sei Whale is currently listed under the *Species at Risk Act* as Endangered, while the Atlantic population is currently not listed. In Québec, the Sei Whale is not listed as Threatened or Vulnerable under the *Loi sur les espèces menacées ou vulnérables* (RLRQ, c E-12.01) and is not on the *Liste des espèces susceptibles d'être désignées menacées ou vulnérables.*

Non-Legal Status and Ranks

The Sei Whale is globally listed as Endangered by the IUCN (Reilly *et al.* 2008). According to NatureServe the global status is listed as G3 and their rounded global status as G3 – Vulnerable (meaning that the species is at moderate risk of extinction; last reviewed in 1996). In Canada the national status is N3, Vulnerable (last reviewed in 2000) and in the United States the status is N2, Imperilled (meaning that the species is at high risk of extinction; last reviewed in 1997); see Table 4 for sub-national rankings (NatureServe 2018).

Table 4. NatureServe sub-national rankings (NatureServe 2018).

Country	State/Province	Status	Definition
Canada	Overall	N3	Vulnerable
	Labrador	SNR	Unranked
	Newfoundland Island	SNR	Unranked
	Québec	SNR	Unranked
	Nova Scotia	SNR	Unranked
	Prince Edward Island	SNR	Unranked
	New Brunswick	SNR	Unranked
United States	Overall	N2	Imperilled
	Maine	SNR	Unranked
	Massachusetts	S1	Critically Imperilled
	Rhode Island	SNRN	Unranked
	New York	SNA	Not Applicable
	Maryland	SNA	Not Applicable
	Virginia	SNR	Unranked
	North Carolina	SNA	Not Applicable
	South Carolina	S1	Critically Imperilled
	Georgia	SNR	Unranked
	Florida	SNR	Unranked

Habitat Protection and Ownership

Important habitat for Sei Whales has not been identified in the eastern North Atlantic. However, protection measures enacted for other species may also provide protection for Sei Whales. In Canada, Roseway Basin and Grand Manan Basin have been identified as critical habitat for North Atlantic Right Whales and the Gully has been designated as a Marine Protected Area, in part to protect Northern Bottlenose Whales (*Hyperoodon ampullatus*). Additionally, the Gully, Shortland and Halidimand canyons have been designated as critical habitat for Northern Bottlenose Whales. Fisheries and Oceans Canada has also established a number of marine refuges along the east coast which may provide some protection to Sei Whales from fishing gear entanglement (e.g. Funk Island Deep Closure, NL; Sambro Bank Sponge Conservation Area, NS; DFO 2018).

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Shannon Gowans: I have been researching cetaceans since 1993. I first worked on the distribution of small cetaceans in the offshore waters of Nova Scotia. My Ph.D. focused on the social organization and population size of Northern Bottlenose Whales in the Gully. During this time I also established a non-profit research organization (Blind Bay Cetacean Studies, with Peter Simard) to conduct research on cetaceans off the coast of Halifax (active research 1997-2007). From 2002-2004 I conducted post-doc research at Texas A&M investigating the social and population structure of Atlantic White-sided and White-beaked dolphins. Since September 2004, I have been working at Eckerd College, where I am currently an Associate Professor of Marine Science and Biology. My current research focuses on local Bottlenose Dolphins where I coordinate the Eckerd College Dolphin Project (ECDP), the longest running undergraduate marine mammal research program. Throughout my career the focus of my research has been on population size and trends as well as the social organization patterns including the evolution of social structure in dolphins. In addition, I have been teaching courses on marine mammals to undergraduate students since 1999, which keeps me up to date on many biological and conservation issues.

Peter Simard: I began my research career in 1994, working on the distribution of northern bottlenose whales in relation to bathymetry and physical oceanography of the Gully submarine canyon. Along with Shannon Gowans, I established Blind Bay Cetacean Studies to investigate distribution patterns and population structure of coastal cetaceans in Nova Scotia. In 2006 I began my Ph.D. work at the University of South Florida to investigate the distribution of dolphins along the West Florida Shelf. This work combined visual surveys and passive acoustic monitoring to investigate spatial and temporal patterns of dolphin distribution. My post-doctoral research investigated the impact of artificial reefs in the marine environment, specifically investigating the relative abundance of dolphins and recreational boats in relation to artificial and natural reefs. I currently study an inshore population of Bottlenose Dolphins with the Eckerd College Dolphin Project.

COLLECTIONS EXAMINED

For this report, the report writers examined databases from the North Atlantic Right Whale Consortium, Ocean Biogeographic Information System, Fisheries and Oceans Canada Newfoundland and Maritimes, Whitehead Lab, Marine Animal Response Society, and the Northeast and Southeast US Marine Mammal Stranding Networks.

Appendix 1. Threats Assessment for Sei Whale (Atlantic population).

Species or Ecosystem Scientific Name	*Balaenoptera borealis*	**Element ID**	Sei Whale, Atlantic population
Version Date:	1/29/2019		
Version Author(s):	Peter Simard, Shannon Gowans, Hal Whitehead, Kristiina Ovaska, Barrie Ford, Greg Wilson, Ruben Boles, Benoit Laliberte, Stephanie Ratelle, Mark Basterfield, Danielle Cholewiak, Katie Kawarski, Hilary Moors-Murphy, Rui Prieto, Tonya Wimmer, Per Palsboll, Thomas Doniol Valcroze, Scott Landry, Kim Parsons, John Ford, Steve Ferguson, Lea Gelling, Karen Timm		
References:	COSEWIC 6-month status report		
Generation Time:	23.3 yr		
Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
	Threat Impact	**high range**	**low range**
	A Very High	0	0
	B High	0	0
	C Medium	1	0
	D Low	3	4
	Calculated Overall Threat Impact:	**High**	**Medium**
	Assigned Overall Threat Impact:	**BC = High - Medium**	
	Impact Adjustment Reasons:		
	Overall Threat Comments	Population size: A few hundred individuals, or less	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	Insignificant/negligible or past	
1.1	Housing & urban areas						
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas						
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	Insignificant/negligible or past	
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	CD	Medium - Low	Pervasive (71-100%)	Moderate - slight	High (continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.1	Oil & gas drilling	CD	Medium - Low	Pervasive (71-100%)	Moderate - slight	High (continuing)	Seismic exploration for oil and gas, as well as the drilling of oil/gas wells, is common in much of the Sei Whales' habitat off eastern Canada, and may develop in the species' habitat off northwest Africa and the eastern USA. The level of uncertainty regarding the severity of the impact is particularly high. While these activities are known to harm other baleen whales, very little is known about how oil and gas activities may impact Sei Whales.
3.2	Mining & quarrying						Deep sea mining may be increasing in the Sei Whales' putative wintering grounds off the coast of North Africa.
3.3	Renewable energy		Not Calculated (outside assessment timeframe)	Restricted - small	Unknown	Low (long-term)	Offshore windfarms may be developed in the Sei Whales' habitat, but there is little current interest.
4	Transportation & service corridors	D	Low	Pervasive (71-100%)	Slight or 1-10% pop. decline	High (continuing)	
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes	D	Low	Pervasive (71-100%)	Slight or 1-10% pop. decline	High (continuing)	Considered here is the potential risk of an encounter between a Sei Whale and a vessel anywhere within the home range of the species, not only in designated shipping lanes, in which the risks would be elevated. It also includes the exposure of vessel noise to the population. Ships produce low-frequency underwater noise that overlaps the hearing range of Sei Whales. Vessels occur everywhere within Canadian Sei Whale habitat and, thus, the entire population is exposed to noise and potential collisions.
4.4	Flight paths						
5	Biological resource use	D	Low	Large (31-70%)	Slight or 1-10% pop. decline	High (continuing)	
5.1	Hunting & collecting terrestrial animals						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	D	Low	Large (31-70%)	Slight or 1-10% pop. decline	High (continuing)	Potential for entanglement - but seems lower than other baleen whales. Likely little overlap between fisheries targets and Sei Whale diet. Could be indirect effects. Right Whale closure areas may help reduce the threat of entanglement but still lots of uncertainty about impact.
6	Human intrusions & disturbance	D	Low	Small (1-10%)	Slight or 1-10% pop. decline	High (continuing)	
6.1	Recreational activities		Negligible	Small (1-10%)	Negligible or <1% pop. decline	High (continuing)	Whale watching may be an issue especially in the Bay of Fundy, Azores and Madeira but unlikely to affect many animals.
6.2	War, civil unrest & military exercises	D	Low	Small (1-10%)	Slight or 1-10% pop. decline	High (continuing)	Military exercises may be an issue, no published data on effects.
6.3	Work & other activities						
7	Natural system modifications		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	Insignificant/negligible or past	
7.1	Fire & fire suppression						
7.2	Dams & water management/use						
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes		Unknown	Unknown	Unknown	High (continuing)	
8.1	Invasive non-native/alien species						May occur in the future but currently no data.
8.2	Problematic native species						
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						
8.6	Diseases of unknown cause		Unknown	Unknown	Unknown	High (continuing)	Anthropozoonotic parasites (*Entamoeba* sp., *Giardia* sp.), possibly acquired in contaminated coastal waters, were detected in Sei Whales in the Azores, while on their spring migration, but little known about the severity.
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (continuing)	
9.1	Household sewage & urban waste water		Unknown	Unknown	Unknown	High (continuing)	Discharges of household, industrial or agricultural effluents can cause eutrophication in (mostly) coastal waters, causing (toxic) algae blooms and deprive the water of oxygen. The effects could affect Sei Whales through the food-chain as shown by a mass die-off of Humpback Whales in the Gulf of Maine. Impact from microplastics from urban waste water included in 9.4. Nutrient runoff from sewage and waste water unlikely to lead to population level impacts.
9.2	Industrial & military effluents		Unknown	Unknown	Unknown	High (continuing)	Contaminants in blubber but effects unknown.
9.3	Agricultural & forestry effluents						See 9.1
9.4	Garbage & solid waste		Unknown	Pervasive (71-100%)	Unknown	High (continuing)	Plastic likely problematic, including microplastic pollution. Copepods are known to consume microplastics and may bio-accumulate.
9.5	Air-borne pollutants						
9.6	Excess energy						Noise pollution accounted for in sections: 3.1, 4.3 and 6.2.
10	Geological events		Negligible	Negligible (<1%)	Negligible or <1% pop. decline	Insignificant/negligible or past	
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
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 suitabilities will likely change across the species' range, but in ways that are currently unpredictable. Clear evidence that Right Whales have recently shifted distribution and Sei Whales may have also shifted.
11.2	Droughts						
11.3	Temperature extremes						Temperature fluctuations are likely to impact prey base and positive and negative changes are predicted for the future. Included in 11.1.
11.4	Storms & flooding						
Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).							