

COSEWIC
Assessment and Status Report

on the

Sowerby's Beaked Whale
Mesoplodon bidens

in Canada



SPECIAL CONCERN
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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COSEWIC 2006. COSEWIC assessment and update status report on the Sowerby's beaked whale *Mesoplodon bidens* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 20 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

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Production note:

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Sowerby's Beaked Whale — Photos provided by the Whitehead lab, Dalhousie University.

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COSEWIC Assessment Summary

Assessment Summary – May 2019

Common name

Sowerby's Beaked Whale

Scientific name

Mesoplodon bidens

Status

Special Concern

Reason for designation

This small beaked whale is endemic to the North Atlantic Ocean where it is found mainly in deep, offshore waters. Little is known about its biology, fine-scale distribution, and abundance. Anthropogenic noise in the ocean has been increasing over the past several decades. It belongs to a family of beaked whales in which acute exposure to intense sounds (especially from military sonar, but also from seismic operations) has led to serious injury and mortality. Seismic operations are currently widespread and have increased over deeper shelf edge and slope waters that comprise the habitat of this species. Military activities involving the use of mid- and low-frequency sonar also occur occasionally in the habitat of this species off Canada's east coast. These whales are also vulnerable to vessel strikes and fishing gear entanglement.

Occurrence

Atlantic Ocean

Status history

Designated Special Concern in April 1989 and in November 2006. Status re-examined and confirmed in May 2019.



COSEWIC
Executive Summary

Sowerby's Beaked Whale
Mesoplodon bidens

Wildlife Species Description and Significance

Sowerby's Beaked Whale (*Mesoplodon bidens*) is a relatively small (4.5–5.5 m) beaked whale (Family Ziphiidae). It can vary from dark grey to light grey-white, often observed with long linear white scars, especially in males. Light speckling may also occur. Sowerby's Beaked Whale is a member of one of the least known groups of large mammals (the Ziphiidae) and, together with the Northern Bottlenose Whale (*Hyperoodon ampullatus*), likely has one of the largest ranges within Atlantic Canada of any ziphiid.

Distribution

Sowerby's Beaked Whales are found only in the North Atlantic and appear to be limited to deep offshore waters. Their distribution is relatively poorly known because at-sea sightings and acoustic detections remain limited. From these data, and stranding locations, they are considered to be the most northern North Atlantic species of the genus *Mesoplodon*. In the western Atlantic, this species ranges offshore from the Mid-Atlantic States of the US to Davis Strait, while in the eastern Atlantic the species has been sighted from the Canary Islands to the Norwegian Sea. Strandings in more southern waters (e.g., the Gulf of Mexico) may be extralimital.

Habitat

This species is most often sighted in deep water, along the continental shelf edge and slope.

Biology

Little is known about the biology of Sowerby's Beaked Whales. Their diet appears to be composed mainly of mid- and deep-water fish and squid. Although the data are inconclusive, length at sexual maturity for both sexes is approximately 4.7 m. They appear to be social, based upon sightings of groups composed of 2–6 animals and observations of mass strandings.

Population Sizes and Trends

Few population estimates for Sowerby's Beaked Whales have been generated and they do not cover all the species' range. Available population estimates are based on limited data and have very large confidence intervals. Therefore there are insufficient data to estimate total population size or to detect trends.

Threats and Limiting Factors

Sowerby's Beaked Whales, like other beaked whales, are likely threatened by intense underwater sounds, especially those associated with mid-frequency sonar and seismic surveys. They are also vulnerable to ship strikes and fishing interactions such as gear entanglement. Chemical and plastic pollution, including the ingestion of microplastics, likely impact this species.

Protection, Status and Ranks

Sowerby's Beaked Whale was assessed as Special Concern by COSEWIC in 2006 and May 2019, and was listed as a Species of Special Concern under the *Canadian Species at Risk Act* in 2011. This species was classified as Data Deficient by IUCN in 2008. NatureServe classifies the species globally as Vulnerable, meaning the species is at moderate risk of extinction. The species was ranked N3 (Vulnerable) nationally in Wild Species 2015 (CESCC 2016).

TECHNICAL SUMMARY

Mesoplodon bidens

Sowerby's Beaked Whale

Baleine à bec de Sowerby

Range of occurrence in Canada (province/territory/ocean): Atlantic ocean (off Nova Scotia, Newfoundland and Labrador)

Demographic Information

Generation time (Taylor <i>et al.</i> 2007)	15-30 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
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. not applicable b. not applicable c. not applicable
Are there extreme fluctuations in number of mature individuals?	unlikely

Extent and Occupancy Information

Estimated extent of occurrence (EEO)	> 20,000 km ²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	> 2,000 km ²
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. unknown but unlikely b. unknown but unlikely
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	unknown

* See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

Is there an [observed, inferred, or projected] decline in extent of occurrence?	unknown
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?	unknown
Is there an [observed, inferred, or projected] decline in number of "locations"??	unknown
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	unknown
Are there extreme fluctuations in number of subpopulations?	no
Are there extreme fluctuations in number of "locations"?	no
Are there extreme fluctuations in extent of occurrence?	unknown
Are there extreme fluctuations in index of area of occupancy?	unknown

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
<p>Based on survey estimates for Sowerby's Beaked Whale and imputation from Northern Bottlenose Whale (NBW).</p> <p><i>Imputation from NBW</i> 322 – 3432: (Detected Rate*Detectability Rate*Distribution Factor*n-NBW)</p> <ul style="list-style-type: none"> - Where lower limit is calculated as $(0.5 \cdot 3 \cdot 1.5 \cdot 143)$ and upper limit is calculated as $(0.8 \cdot 10 \cdot 3 \cdot 143)$ - For lower limit, Sowerby's Beaked Whales are likely detected on the Scotian Slope at 0.5–0.8 the rate of NBW. Sowerby's Beaked Whales are perhaps three to ten times less detectible than NBW, and one third to two thirds of their habitat is outside the Scotian Shelf. <p><i>Survey estimates</i> 3,518 (95% CI = 1,570 – 7,883, CV = 0.43) (Rogan et al. 2017) in Northeast Atlantic</p> <p>3,653 (CV = 0.69) (Palka 2012) in US Northwestern Atlantic</p>	Hundreds to low thousands
Total	Unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Unknown, calculation not undertaken
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Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? [Yes]
<p>The Calculated Overall Threat Impact was High to Medium, based upon the IUCN-CMP (World Conservation Union-Conservation Measures Partnership) unified threats classification system. Like other beaked Whales, Sowerby's Beaked Whale is likely vulnerable to noise pollution, fisheries interactions and vessel strikes, as well as the ingestion of macro- and microplastics and the same persistent organic pollutants that affect other cetaceans.</p> <ol style="list-style-type: none">i. Energy Production & Mining (Medium-Low)ii. Transportation and Service Corridors (Low)iii. Biological Resource Use (Low)iv. Human Intrusions & Disturbance (Low)v. Invasive & Other Problematic Species & Genes (Unknown)vi. Pollution (Unknown)vii. Climate Change & Severe Weather (Unknown)
What additional limiting factors are relevant? unknown

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	unknown
Is immigration known or possible?	unknown
Would immigrants be adapted to survive in Canada?	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?+	unknown
Is rescue from outside populations likely?	unknown

Data Sensitive Species

Is this a data sensitive species?	no
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Status History

COSEWIC: Designated Special Concern in April 1989 and in November 2006. Status re-examined and confirmed in May 2019.

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

Status and Reasons for Designation:

Status: Special Concern	Alpha-numeric codes: Not applicable
Reasons for designation: This small beaked whale is endemic to the North Atlantic Ocean where it is found mainly in deep, offshore waters. Little is known about its biology, fine-scale distribution, and abundance. Anthropogenic noise in the ocean has been increasing over the past several decades. It belongs to a family of beaked whales in which acute exposure to intense sounds (especially from military sonar, but also from seismic operations) has led to serious injury and mortality. Seismic operations are currently widespread and have increased over deeper shelf edge and slope waters that comprise the habitat of this species. Military activities involving the use of mid- and low-frequency sonar also occur occasionally in the habitat of this species off Canada's east coast. These whales are also vulnerable to vessel strikes and fishing gear entanglement.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable; no clear evidence of decline.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable; extent of occurrence and index of area of occupancy exceed thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable; no clear evidence of decline.
Criterion D (Very Small or Restricted Population): Not applicable; population may be very small.
Criterion E (Quantitative Analysis): Analysis not conducted.

PREFACE

Since the previous assessment of the Sowerby's Beaked Whale (*Mesoplodon bidens*; COSEWIC 2006) there has been greater interest in the ecology and biology of beaked whales in general. Much of the research has focused on the potential impacts of noise, especially military sonar, on Cuvier's (*Ziphius cavirostris*) and Blainville's Beaked Whales (*M. densirostris*; Parsons 2017). Some of this information is useful in assessing threats to Sowerby's Beaked Whales. Additionally there has also been a noticeable increase in the number of sightings of Sowerby's Beaked Whales, especially in Canadian waters. In most areas it is not possible to determine if the increase in the number of sightings represents an increase in sighting rate or an increase in survey effort. However, it is clear that there has been a dramatic increase in the number of sightings of Sowerby's Beaked Whales in the Gully (Whitehead 2013). A series of bottom mounted hydrophones have also been deployed along the east coast of North America which reveals the distribution of Sowerby's Beaked Whales along the shelf break (e.g., Stanistreet *et al.* 2017; Delarue *et al.* 2018). A management plan for Sowerby's Beaked Whales has been developed (Fisheries and Oceans 2017). The focus of the plan is to conduct research and enhance monitoring activities to improve understanding of the biology and threats to the species, as well as to inform management of the threats to the species, and educate the public through engagement and outreach.



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



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

COSEWIC Status Report

on the

Sowerby's Beaked Whale *Mesoplodon bidens*

in Canada

2019

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Figure 4. Visual sightings of Sowerby’s Beaked Whales in the North Atlantic. Each circle represents a single sighting and may represent multiple individuals. Sighting data sources: NARWC (North Atlantic Right Whale Consortium 2017)¹; OBIS (OBIS 2017); DFO - Newfoundland (J. Lawson pers. comm. 2018); DFO - Maritimes (K. Hastings pers. comm. 2017), Whitehead Lab (H. Whitehead pers. comm. 2018). ¹Raw 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. 10

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Sowerby's Beaked Whale (Sowerby 1804), is a relatively small beaked whale (Family Ziphiidae) found only in the North Atlantic. It is also known as the North Atlantic or North Sea Beaked Whale and as Baleine à bec de Sowerby in French. No subspecies are recognized (COSEWIC 2006).

Morphological Description

Sowerby's Beaked Whales can reach 5.5 m in length, although most are smaller. They are difficult to identify, sharing many characteristics with other beaked whales such as Blainville's Beaked Whale and True's Beaked Whale (*M. mirus*). The ranges of these two species overlap that of Sowerby's Beaked Whale (MacLeod 2000). Diagnostic characteristics include the shape and position of teeth, rostrum length and ossification of the mesorostral canal. In mature males a single triangular tooth normally erupts through the gum line on each side of the lower jaw, about 35% of the distance along the mandible and midway along the gape in adults (Figure 1 B). The teeth are present but not erupted in females (Figure 1 C). Sowerby's Beaked Whales have a longer, narrower rostrum than Blainville's or Gervais' Beaked Whales (*M. europaeus*). The mesorostral canal in both Sowerby's and Blainville's Beaked Whales can be ossified, although only the posterior section is ossified in adult male Sowerby's Beaked Whales (MacLeod and Herman 2004).

Sowerby's Beaked Whales have streamlined bodies with small heads. They can vary from dark grey to light grey-whitish with long linear white scars, especially in males. Light speckling may also occur (Figure 1). Younger animals tend to be lighter ventrally and unspotted. A small triangular dorsal fin is located approximately two-thirds of the way back from the beak to flukes. The flukes generally have no median notch and the flippers are relatively long (approximately 1/8 body length). Like most beaked whales, they have a long narrow rostrum and a V-shaped groove on the throat. Apart from dentition differences, there is little sexual dimorphism (Mead 1989).

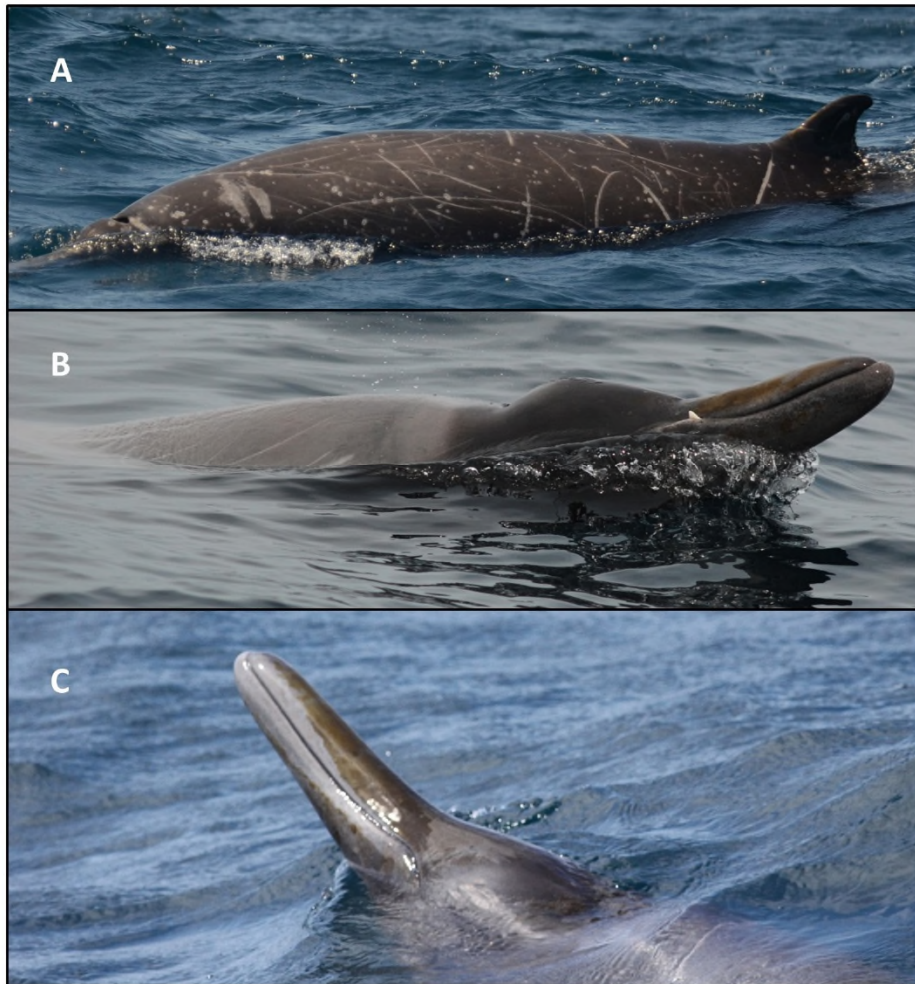


Figure 1. Sowerby's Beaked Whales. A) shows dark body colouration and long white linear scars. B) shows the erupted tooth in males and lighter body colouration as well a white linear scars. C) shows the beak of a female which is missing the erupted tooth found in males. Photos provided by the Whitehead lab, Dalhousie University.

Population Spatial Structure and Variability

There is no evidence available to suggest that Sowerby's Beaked Whales are migratory. While there have only been sightings of Sowerby's Beaked Whales during the warmer months in Canadian waters (May through September and a single sighting in November; Figure 2), search effort is low and sea conditions are rarely conducive to positive identifications of *Mesoplodon* whales in the winter. Acoustic detections of Sowerby's Beaked Whales from bottom-mounted hydrophones indicate year-round presence at most areas along the shelf edge (Stanistreet *et al.* 2017; D. Cholewiak pers. comm. 2018; Delarue *et al.* 2018).

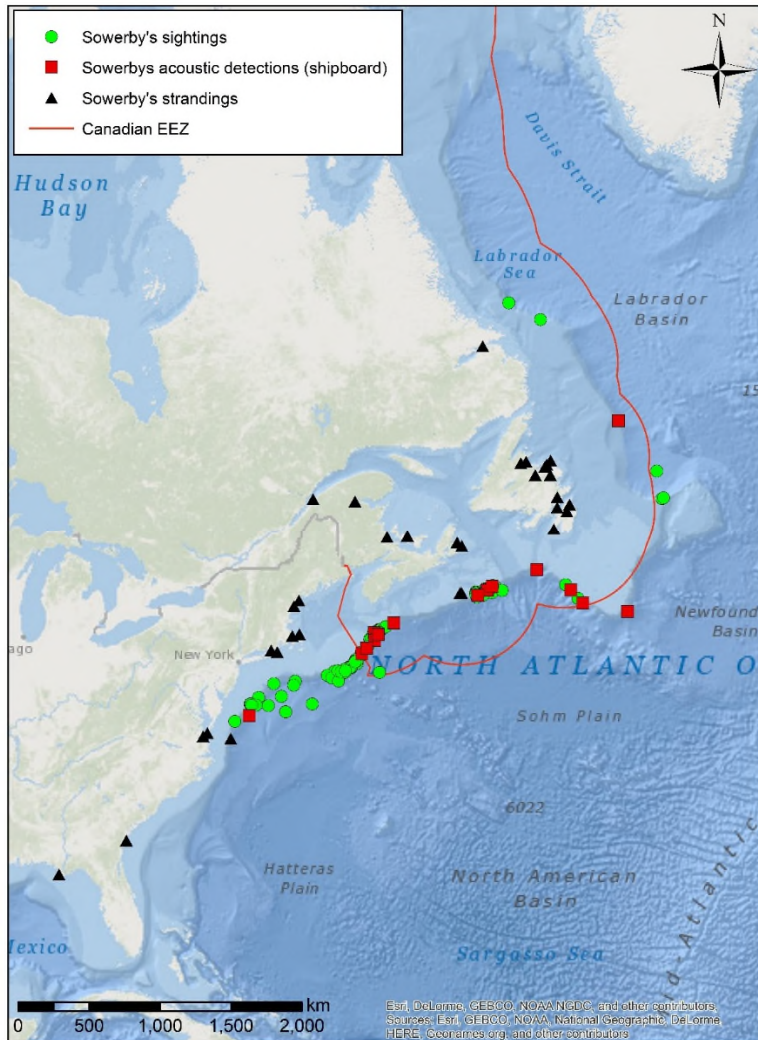


Figure 2. Visual sightings (circles), ship-board acoustic detections (squares) and strandings (triangles) of Sowerby's Beaked Whales in the western North Atlantic. Each circle represents a single sighting and may represent multiple individuals. Visual and acoustic detections and strandings are not corrected for differences in effort. Number of individuals vocalizing are not generally known with acoustic detections. Sighting data sources: NARWC database (North Atlantic Right Whale Consortium 2017)¹; OBIS (OBIS 2017); DFO - Newfoundland (J. Lawson pers. comm. 2018); DFO - Maritimes (K. Hastings pers. comm. 2017), Whitehead Lab (H. Whitehead pers. comm. 2018). Stranding data sources: Southeast US Marine Mammal Stranding Network (E. Stratton pers. comm. 2017); Northeast US Marine Mammal Stranding Network (M. Garron pers. comm. 2017); Fisheries and Oceans Canada - Maritimes (K. Hastings pers. comm. 2017); Marine Animal Response Society² (T. Wimmer pers. comm. 2018); DFO- Newfoundland (J. Lawson pers. comm. 2018). Note that data were collected using multiple methodologies and are not normalized for search effort. Additional notes from data sources: ¹Raw 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. ²Response to most species 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.

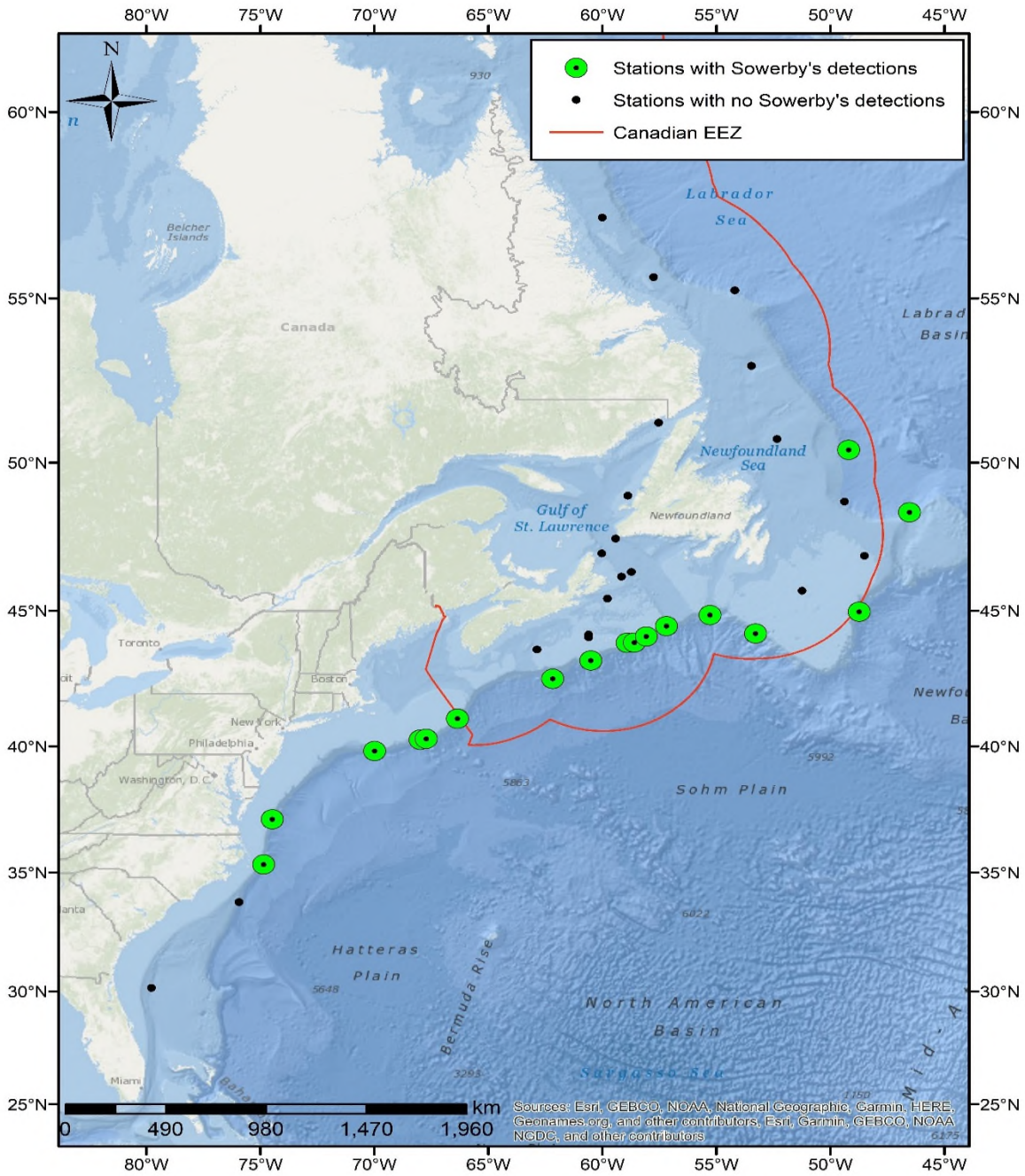


Figure 3 Locations of acoustic monitoring stations with and without Sowerby's Beaked Whale detections. Data sources: Stanistreet *et al.* 2017; JASCO Applied Sciences (J. Delarue pers. comm. 2018); NMFS (D. Cholewiak pers. comm. 2018). Note that this figure only indicates presence / absence of Sowerby's Beaked Whale as sounds recorded at each monitoring station, and does not reflect differences in methodology such as deployment period, duty cycle, sample rate and call identification criteria.

Site fidelity has been suggested for several beaked whale species including Cuvier's Beaked Whale (McSweeney *et al.* 2007; Baird *et al.* 2016), Blainville's Beaked Whale (McSweeney *et al.* 2007; Claridge 2013) and Northern Bottlenose Whale (Hooker *et al.* 2002; Wimmer and Whitehead 2004). A photo-identification study on Sowerby's Beaked Whale in the Gully (Scotian Shelf break, 43.8°N, 58.9°W) has been initiated. Based on photographs taken in 2010, 2011, 2015 and 2016, from 131 different encounters containing multiple individuals, there were only two resightings between the years 2010–2011 and none in the recent years. While this might suggest limited site fidelity, sample size was small and it was difficult to obtain high quality photographs. Mark change rates may also be high, limiting the ability to detect resightings of the same individual (Clarke 2017).

Designatable Units

In the absence of any data to suggest population structure within Canadian waters, a single designatable unit is recognized (COSEWIC 2006).

Special Significance

The beaked whales are among the least known groups of mammals. Of the five beaked whale species in Atlantic Canadian waters, Sowerby's Beaked Whale and the Northern Bottlenose Whale have the largest Canadian ranges. Sowerby's Beaked Whale is being sighted more frequently in Canadian waters since the mid-2000s (Whitehead 2013).

DISTRIBUTION

Global Range

The distribution of Sowerby's Beaked Whales is limited to the North Atlantic Ocean (Figure 4), where it is considered the most northerly of the *Mesoplodon* species (MacLeod 2000). Most of what is known of the range of this species is based upon strandings and opportunistic sightings (MacLeod *et al.* 2006), and more recently on acoustic detections (Stanistreet *et al.* 2017; Delarue *et al.* 2018; Kowarski *et al.* 2018). The use of stranding data to determine the range of offshore species has limitations; for example, a carcass may be transported over a great distance by wind and currents before it reaches a shoreline (Mead 1989).

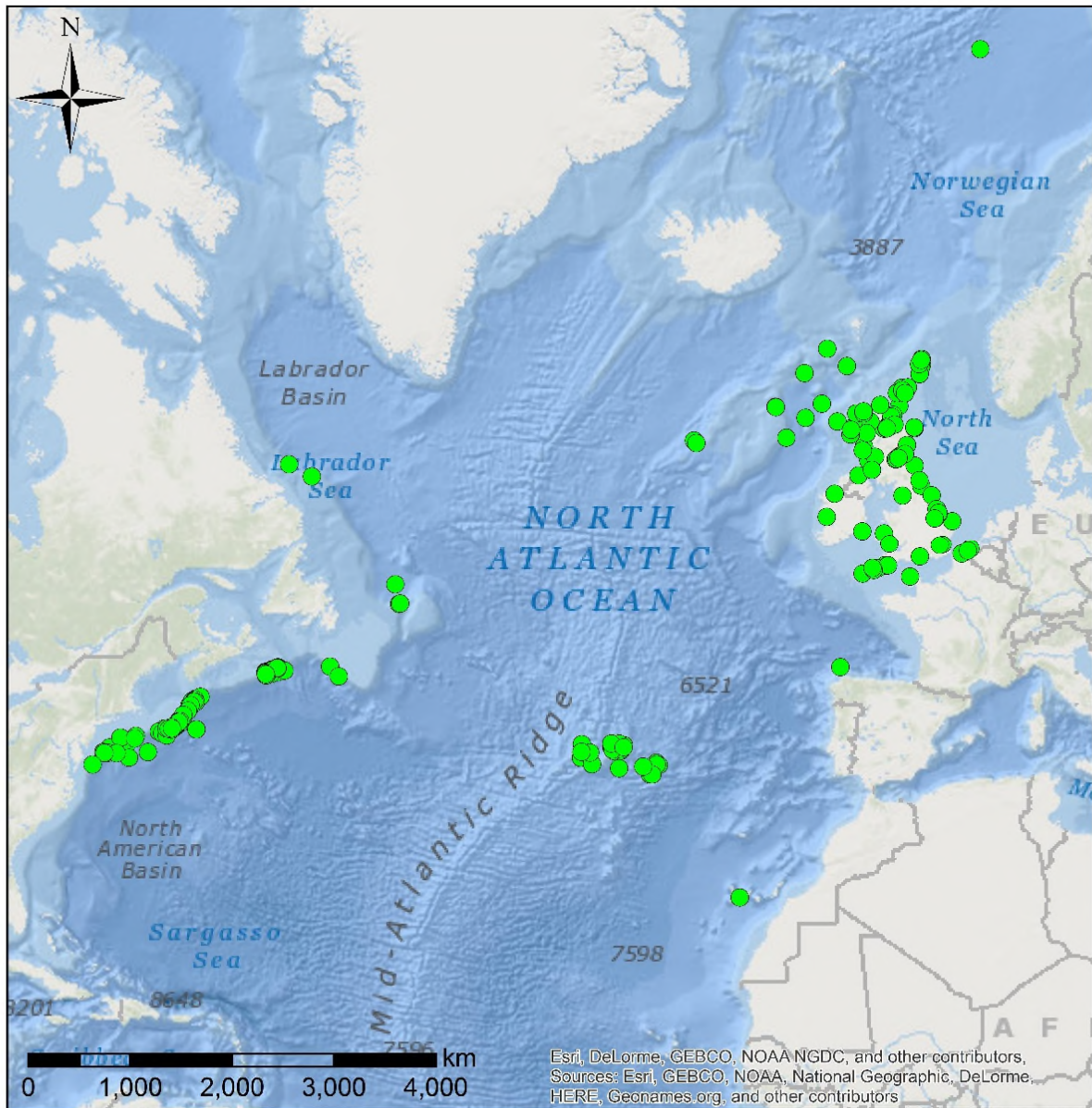


Figure 4. Visual sightings of Sowerby's Beaked Whales in the North Atlantic. Each circle represents a single sighting and may represent multiple individuals. Sighting data sources: NARWC (North Atlantic Right Whale Consortium 2017)¹; OBIS (OBIS 2017); DFO - Newfoundland (J. Lawson pers. comm. 2018); DFO - Maritimes (K. Hastings pers. comm. 2017), Whitehead Lab (H. Whitehead pers. comm. 2018). ¹Raw 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.

Sowerby's Beaked Whales, like other beaked whales, appear to prefer the deeper waters of the continental shelf breaks and open ocean, only occasionally being found in coastal waters (Kenney and Winn 1986, 1987; Lien and Barry 1990; Figure 2; Figure 4). In the eastern North Atlantic, Sowerby's Beaked Whales range from as far north as the Norwegian Sea (Carlström *et al.* 1997), the waters off Iceland and the British Isles (Sigurjónsson *et al.* 1989; Weir *et al.* 2001), and south to Madeira and the Azores (MacLeod 2000). Strandings have been recorded as far south as the Canary Islands (Martin *et al.* 2011). Live sightings and strandings of Sowerby's Beaked Whale have been reported in the Mediterranean; however, it does not appear that this species is commonly found in the Mediterranean Sea (Bittau *et al.* 2017).

In the western Atlantic, Sowerby's Beaked Whales have been sighted as far north as 56°N, and south to 38°N (Figure 2). There have been sightings of unidentified beaked whales in Davis Strait north of 60°N (unidentified *Mesoplodon*: COSEWIC 2006; H. Whitehead pers. comm. 2018; unidentified beaked whale: Hiede-Jørgenson *et al.* 2007). Given the northern range of Sowerby's Beaked Whale in relation to other mesoplodont beaked whale species, these observations were likely Sowerby's Beaked Whales (H. Whitehead pers. comm. 2018). Extensive aerial surveys to document beaked whales off Cape Hatteras, North Carolina did not identify any Sowerby's Beaked Whales, although several other mesoplodonts were identified to species level (McLellan *et al.* 2018). There have been strandings as far south as Georgia (COSEWIC 2006) and in the Gulf of Mexico (Bonde and O'Shea 1989). However, these are likely extralimital (see Figure 2). Strandings have also been reported but not confirmed in Brazil and the Dominican Republic (Wotjek *et al.* 2014). If verified, these are also likely extralimital.

In the Atlantic, a network of hydrophones has been placed along the continental shelf edge in US waters and over the continental shelf and shelf edge in Canadian waters north to Labrador. Sowerby's Beaked Whale echolocation clicks were recorded along the shelf break from ~50°N to ~35°N (from Labrador to Cape Hatteras: Stanistreet *et al.* 2017; D. Cholewiak pers. comm. 2018; Delarue *et al.* 2018). However, only a single detection was made off Cape Hatteras over the 734 days hydrophones were deployed in this location. Further north at Norfolk Canyon (~37°N), Sowerby's Beaked Whales were recorded on 36% of the 289 days of deployment (Stanistreet *et al.* 2017). Vocalizations from Sowerby's Beaked Whales were not detected from on-shelf hydrophones deployed on the Scotian Shelf, the Gulf of St. Lawrence or off the coast of Labrador (Delarue *et al.* 2018;). Further review of these data is currently underway to examine how this species is using these areas over different time scales. Details on the individual studies (e.g., types of recorders, duty cycle, sample rate, deployment dates) can be found in the studies referenced. While additional acoustic datasets exist that are not discussed in this report, some of these do not record at the frequency to capture Sowerby's Beaked Whale clicks (as is the case for AURAL recorders deployed in the Gulf of St. Lawrence; Fisheries and Oceans Canada, Newfoundland, Fisheries and Oceans Canada, Québec), or have not yet been analyzed for the presence of beaked whales.

Canadian Range

The northern limit of confirmed sightings of Sowerby's Beaked Whale in Canadian waters is at ~56°N (off Labrador, Figure 2) although it is likely that this species occurs further north. The southern limit of distribution in Canadian waters is approximately the international boundary between Canada and the United States along the shelf break, as there are numerous sightings of Sowerby's Beaked Whales along the shelf edge from Canadian waters south to Virginia. Given the apparent preference of this species for deeper, offshore waters, Sowerby's Beaked Whales likely range to the seaward limit of the 200 nautical mile Exclusive Economic Zone (EEZ) and beyond. Two sightings occurred just outside the EEZ near the Flemish Cap ~ 47°N (Figure 2). Sightings have predominantly occurred in summer months, when survey effort is greatest. Although there was an increase in detections of the echolocation clicks of Sowerby's Beaked Whale in June through August in the Gully (Stanistreet *et. al* 2017), Sowerby's Beaked Whale clicks have been recorded year-round at hydrophones located along the Scotian Shelf and shelf break along the Labrador Sea (Delarue *et al.* 2018).

Visual sightings of Sowerby's Beaked Whales in Canadian waters are concentrated just north of the international boundary between Canada and the United States, along the shelf break, the Gully, as well as Shortland and Haldimand Canyons (Scotian Shelf break, 44.1°N, 58.4°W; 44.2°N, 58.0°W respectively; Figure 2). However, these are also the best surveyed areas along the Canadian shelf edge and the lack of sightings in other areas does not necessarily indicate lack of presence. Visual sighting data were obtained from a variety of different sources (OBIS - Ocean Biogeographic Information System, NARWC - North Atlantic Right Whale Consortium, DFO - Fisheries and Oceans Canada) and represent hundreds of different cruises from numerous different platforms. The vast majority of these cruises were not targeting beaked whales, and thus these represent incidental sightings. Many of these sightings cannot be corrected for effort. Sightings from dedicated surveys which can be corrected for effort are relatively few in the offshore area, and therefore all sightings are included in this report. Two large-scale aerial surveys of marine megafauna have been conducted in Canadian waters, Trans North Atlantic Sightings Surveys (TNASS) in 2007 and Northwest Atlantic International Sightings Survey (NAISS) in 2016. From the TNASS survey in 2007, nine sightings of *Mesoplodon* whales were made representing thirty-five individuals (Lawson and Gosselin 2009); however, none of these sightings were identified to the species level. From the 2016 survey, there were eleven "beaked whales" and twelve "Sowerby's beaked whales" sighted off southern Newfoundland, and six "*Mesoplodon* sp." and twelve "unidentified beaked whales" off the Scotian Shelf (Lawson, J., and J.-F. Gosselin 2018).

Strandings (Figure 2; Table 1) have been reported in Newfoundland (mostly on the east coast) and Labrador (J. Lawson pers. comm. 2018) and along the Atlantic coast of Nova Scotia, including Sable Island (Lucas and Hooker 2000; COSEWIC 2006; P-Y. Daoust pers. comm. 2017; J. Lawson pers. comm. 2018, T. Wimmer pers. comm. 2018). Strandings have also occurred in the Gulf of St. Lawrence (COSEWIC 2003; P-Y. Daoust pers. comm. 2017; S. Lair pers. comm. 2017; T. Wimmer pers. comm. 2018). However the lack of suitable habitat in the Gulf of St. Lawrence (Truchon *et al.* 2013), and the lack of visual sightings and acoustic detections suggest these may be extralimital.

Table 1. Strandings of Sowerby’s Beaked Whales on the east coast of North America since 2005. For a list of older strandings in Canadian waters please see COSEWIC 2006. Stranding data sources: Southeast US Marine Mammal Stranding Network (SE MMSN; E. Stratton pers. comm. 2017); Northeast US Marine Mammal Stranding Network (NE MMSN; M. Garron pers. comm. 2017); Marine Animal Response Society (MARS; T. Wimmer pers. comm. 2018); Fisheries and Oceans Canada, Newfoundland (DFO NL; J. Lawson pers. comm. 2018). CBD: could not be determined. Note: Not all incidents are reported and many incidents cannot be investigated nor can assessments of human interaction and complete necropsies always be performed to determine cause of death. Additionally, the offshore and northerly distribution of this species, and the fact that many carcasses will never wash ashore, means that 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
Sep 4 2006	Kings Point NL (49.60°N, 56.16°W)	No predation, gear entanglement or external wounds	DFO NL
May 21 2008	Trinity Bay NL (48.20°N, 53.86°W)	First reported alive then stranded	DFO NL
Jan 22 2009	Cape Charles VA (37.22°N, 76.01°W)	Full necropsy, CBD Human Interaction	NE MMSN
Nov 8 2009	Hampton VA (37.06°N, 76.28°W)	Full necropsy, CBD Human Interaction	NE MMSN
Jan 22 2011	Georgetown SC (°33.24N, 79.18°W)	Limited necropsy, CBD Human Interaction	SE MMSN
Jun 5 2013	Cavendish Beach National Park PEI (46.50°N, 63.35°W)	Full necropsy, CBD Human interaction; however, several healed rib fractures could suggest previous vessel strike	MARS; P-Y. Daoust pers. comm. 2017
Jul 3 2013	Trois Pistoles QC (48.11°N, 69.32°W)	Full necropsy no indication Human Interaction	MARS; S. Lair pers. comm. 2018
Sep 3 2013	EEZ offshore NS (43.82°N, 58.86°W)	Live entangled	MARS
Jul 14 2014	Cape Elizabeth ME (43.60°N, 70.22°W)	No necropsy conducted	NE MMSN
Jun 21 2015	Fogo Island NL (49.72°N, 54.28°W)	First reported alive then stranded	DFO NL
Apr 21 2016	Mira Gut, NS (46.05°N, 59.90°W)	No necropsy conducted	MARS
Jun 13 2016	Baie des Chaleurs QC (48.01°N, 66.67°W)	No indication of Human Interaction	MARS; P-Y. Daoust pers. comm. 2017
Oct 23 2016	North Sydney NS (46.21°N, 60.20°W)	First reported alive then stranded, jaw fractured in several places, Pneumonia	MARS; P-Y. Daoust pers. comm. 2017
Apr 6 2017	Sable Island NS (43.93°N, 60.02°W)	No necropsy conducted	MARS
May 13 2017	Sable Island NS (43.94°N, 59.94°W)	Necropsy conducted but could not determine cause of death – advanced decomposition	MARS
Jun 27 2017	EEZ US off VA (36.84°N, 74.53°W)	No necropsy, floating at sea, CBD for Human Interaction	NE MMSN

Extent of Occurrence and Area of Occupancy

Given the widespread distribution of this species (Figure 2), the extent of occurrence (EOO) for Sowerby's Beaked Whales exceeds the COSEWIC threshold for EOO of 20,000 km² to trigger a status of Threatened. Similarly, the index of area of occupancy (IAO) for Sowerby's Beaked Whales also exceeds the COSEWIC threshold for IAO of 2,000 km².

Search Effort

Little survey effort has been expended in deep waters off Atlantic Canada, especially with respect to systematic aerial surveys. In addition, *Mesoplodon* beaked whales are difficult to sight and identify, and they may avoid boats. The Whitehead Lab (Dalhousie University) has conducted extensive visual surveys during summer months in the Gully (1988-2017) and expanded their work in recent years (2002-2017) to Shortland and Haldimand Canyons (e.g., Whitehead 2013) and other areas of the shelf break along Nova Scotia, Newfoundland, and Labrador, focusing on Northern Bottlenose Whales and Sperm Whales (*Physeter microcephalus*); however, incidental sighting records were kept for all cetacean species. They have also conducted visual surveys along the shelf break as far north as Labrador (in 2001 from New Jersey to the Grand Banks and in 2003 north to Labrador). The Whitehead Lab has been responsible for the majority of sightings of Sowerby's Beaked Whale in Canadian waters (H. Whitehead pers. comm. 2018). Two large-scale aerial surveys have been conducted by DFO in 2007 (TNASS) and in 2016 (NAISS). The US National Marine Fisheries Service (NMFS) has conducted numerous cetacean surveys (using both visual and acoustic methods) along the Eastern Seaboard including southern Canadian waters. They have been increasingly documenting Sowerby's Beaked Whale in their surveys (D. Cholewiak pers. comm. 2018).

A series of bottom mounted hydrophones along the east coast of North America has created a valuable dataset for examining the distribution of vocalizing Sowerby's Beaked Whale. As echolocation clicks are the predominant vocalizations made by the species, and these animals forage (and echolocate) year-round, it is not expected that there would be a strong seasonal pattern in their vocalization behaviour. Cholewiak *et al.* (2017) have recently documented that beaked whales including Sowerby's Beaked Whale frequently stop producing echolocation clicks in the presence of commercial echosounders, which can frequently be employed along the shelf break.

Stranding networks in Atlantic Canada have become more active since the late 1970s and the number of strandings reported has increased (Table 1). However, it is difficult to determine if this increase is due to increased outreach and reporting efforts or an increased number of carcasses ashore (Lien and Barry 1990; COSEWIC 2006; T. Wimmer pers. comm. 2018).

Raw sighting data from the North Atlantic Right Whale Consortium (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.

HABITAT

Habitat Requirements

Mesoplodont whales, in general, appear to prefer deep water habitats (>200 m) (Pitman 2002). Sowerby's Beaked Whale are generally found in deep waters (generally 1000 m or deeper – although they have occasionally been seen in shallower waters), including continental shelf edges and continental slopes (Mead 1989; Lien and Barry 1990; MacLeod 2000; Figure 4). They have been observed in waters deeper than 3000 m (COSEWIC 2006; Figure 4). Moors-Murphy (2014) found that beaked whale species were associated with nine of the 21 worldwide canyons studied, including three in Atlantic Canada (i.e., the Gully, Shortland, and Haldimand Canyons).

Habitat Trends

Whitehead (2013) indicated a 21% per year increase in the occurrence of Sowerby's Beaked Whales between 1988 and 2011, with no sightings occurring before 1994, a slow increase in sightings between 2006 and 2011 and a rapid rise in sightings between 2011 and 2012 in the Gully. A total of 284 sightings of Sowerby's Beaked Whale have been compiled in Canadian waters; 235 (83%) since the last COSEWIC status report and 125 (44%) since 2011 (not effort corrected; Figure 2). The majority of the sightings have come from the Gully, Shortland and Haldimand canyons through work by the Whitehead Lab. However, a number of sightings have been made along the shelf break near the US border in conjunction with NMFS surveys. While there have been fewer aerial surveys in the past decade and a reluctance to identify Mesoplodonts to species, the number of recent sightings may suggest an increased use of submarine canyons in Canadian waters as well as a more widespread increase in the use of Canadian waters by Sowerby's Beaked Whale (Figure 2). Anthropogenic noise levels in the ocean have been increasing over the past several decades (Weilgart 2007), primarily due to increased commercial shipping activity (Frisk 2012).

BIOLOGY

Life Cycle and Reproduction

Although the timing and age of breeding are unknown, investigation of three stranded females indicated that the females 4.83 m and 5.05 m long were sexually mature while a 4.62 m female was not. Data concerning male sexual maturity are even sparser. Males less than 5.00 m long are considered immature based on necropsy data (Lien and Barry 1990). However, a study of skull morphology indicated that in the eastern Atlantic, 4.70 m males had attributes of sexual maturity (MacLeod and Herman 2004). A one-year gestation and one-year lactation period has been suggested for the species, based largely on data from other beaked whales. This would likely lead to at least a 2-3 year inter-birth interval (New *et al.* 2013). The generation time for assessment purposes is 15–30 years based upon other beaked whale species (Taylor *et al.* 2007).

Physiology and Adaptability

Little is known about the physiology and adaptability of Sowerby's Beaked Whale. Studies using digital acoustic recording tags (DTAGs) (Johnson and Tyack 2003) have enhanced the study of deep-diving species (Johnson *et al.* 2004, 2006). Beaked whales use click vocalizations to echolocate their prey and navigate in the deep-water feeding habitat. Cholewiak *et al.* (2013) provided some initial descriptions of their clicks. Similar to other cetaceans, Sowerby's Beaked Whales rely on acoustic signals for primary biological functions such as foraging.

Dispersal and Migration

Little is known about the dispersal and migration of Sowerby's Beaked Whale. Site fidelity has been suggested for several beaked whale species.

Interspecific Interactions

Based on stomach contents and stable isotope analysis of stranded animals, mid- to deep-water fish and offshore squid appear to comprise the bulk of the diet of Sowerby's Beaked Whales (Ostrom *et al.* 1993; MacLeod *et al.* 2003; Spitz *et al.* 2011). Recent analysis of individuals stranded in the Azores (Pereira *et al.* 2011) and by-caught in the now closed pelagic drift gillnet fishery (Wenzel *et al.* 2013) suggests that Sowerby's Beaked Whales prey frequently on midwater fish (including Family Moridae, Myctophidae, Macrouridae, Phycidae, Diremidae and Opisthoproctidae) and less frequently on squid. They also appear to feed opportunistically on the most available species at the time, rapidly changing prey species in response to prey abundance (Pereira *et al.* 2011; Wenzel *et al.* 2013).

There are no data on predation on Sowerby's Beaked Whales. Killer Whale (*Orcinus orca*) and large sharks are likely their only predators (COSEWIC 2006). The distribution of Killer Whales (Lawson *et al.* 2007; Lawson and Stevens 2014) overlaps the distribution of Sowerby's Beaked Whales in eastern Canada, and Killer Whales in the Northwest Atlantic are known to feed on cetaceans (Lawson *et al.* 2007) and it is possible that they would prey on Sowerby's Beaked Whale.

Relatively few Sowerby's Beaked Whales have been tested for parasitic infections. Four individuals stranded in Scotland were examined for the presence of *Toxoplasma gondii* and two tested positive (van de Velde *et al.* 2016).

Sowerby's Beaked Whales have been observed in polyspecific aggregations with Northern Bottlenose Whales, where social groups of both species were aggregated, although the function of these aggregations is unknown (Fisheries and Oceans Canada 2017).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Recent cetacean aerial sighting surveys in Eastern Canadian waters have tried to target all whale species. However, aerial surveys, which are efficient for covering large areas, have a lower probability of detecting deep-diving whales such as Sowerby's Beaked Whales because of less time spent at the surface. Sightings of Sowerby's Beaked Whale have also occurred opportunistically during cruises for other purposes.

Abundance

Most surveys designed to assess cetacean populations have identified relatively few Sowerby's Beaked Whales. Frequently, due to difficulties in distinguishing beaked whale species at the species level, sightings are only recorded as *Mesoplodon* sp. The 2007 TNASS survey in Canadian waters did document nine sightings of *Mesoplodon* whales, but none of these sightings were identified to the species level. No attempt was made to estimate the population of *Mesoplodon* whales; however, the density of beaked whales appears to be lower than that of White-beaked (*Lagenorhynchus albirostris*), Atlantic White-sided (*L. acutus*) or Short-beaked Common Dolphins (*Delphinus delphis*), which were sighted much more frequently (Lawson and Gosselin 2009). The 2016 NAISS survey in Canadian waters documented eleven sightings of "beaked whales" and twelve sightings of "Sowerby's Beaked Whales" sighted off southern Newfoundland, and six "*Mesoplodon* sp." and twelve "unidentified beaked whales" off the Scotian Shelf (Lawson, J., and J.-F. Gosselin 2018).

Several population estimates have been made for undifferentiated *Mesoplodon* species; however, these estimates were often not corrected for the probability of detecting an animal that is directly on the trackline. Estimates may be negatively biased, especially when considering the behaviour of mesoplodonts including deep dives without fluking, elusive behaviour and their low profile at the surface. Additionally as each survey covered a different portion of the habitat considered suitable for mesoplodonts and occurred at a different time of the year, the estimates are not directly comparable. However, aerial and shipboard surveys from 1978 to 1994 indicated that there were several hundred mesoplodonts in the area from Cape Hatteras to Nova Scotia during the summer months, and that the Georges Bank region may be an area of relatively high density (Blaylock *et al.* 1995).

Even when *Mesoplodon* whales are identified to species, low sighting numbers typically yield imprecise population estimates. However, as they are often the only population estimates available, they are reported here. In the eastern Atlantic, Rogan *et al.* (2017) combined aerial and shipboard survey data from several surveys that occurred between 2005 and 2007. These surveys focused on continental shelf, slope and deep canyon systems likely preferred by beaked whales. They estimated a population size of 3,518 Sowerby's Beaked Whales (95% CI = 1,570–7,883, CV = 0.43), that covered the oceanic and shelf waters of the northeastern Atlantic using Distance sampling methods. This technique likely underestimated the population size but the inclusion of some unidentified beaked whales may have overestimated the population size. This estimate was based on six observations of Sowerby's Beaked Whales such that the low number of observations prevented the authors from conducting species-specific habitat modelling (Rogan *et al.* 2017).

The most recent comprehensive survey in the western Atlantic was conducted in June – August 2011 in waters from North Carolina to the Bay of Fundy, from shore to the Gulf Stream using both aerial and shipboard surveys (Palka 2012). Mark-recapture Distance sampling generated a total population of 3,653 (CV = 0.69), with most individuals associated with shelf features (N = 2,007 CV = 0.99) and the remainder associated with offshore waters (N = 1,646 CV = 0.93). It is important to note that all Sowerby's Beaked Whale sightings were made from the shipboard survey along the shelf break and offshore waters in the Massachusetts and Mid-Atlantic Region, and consisted of only about six sightings (Palka 2012).

Mark-recapture population estimates based on photo-identification of individual animals can often produce population estimates with greater precision. However, they typically require considerably more effort both in the field and in the lab. A photo-identification catalogue has been established for sightings of Sowerby's Beaked Whale in the Gully, Shortland and Haldimand canyons (Clarke 2017). There were two resightings of individuals between 2010 and 2011. However, these resightings included photographs of poor quality which would bias mark-recapture estimates. Therefore estimates of minimum population size with zero recaptures were applied and indicated a minimum of 23 individuals (based on 17 unique individuals from right-side identification photographs) and 74 (based on 32 unique individual left-side identification photographs). While these estimates are much smaller than the Distance sampling estimates, they cover a much smaller geographic range and are only minimum estimates; the maximum is infinity (Clarke 2017). Additionally as there were no resightings with the later years it suggests a larger, perhaps mobile population, although photographic quality and mark change likely restricted the ability to detect resightings. Further photo-identification work could yield important information about Sowerby's Beaked Whale population sizes, movements and habitat use (Clarke 2017).

Order-of-magnitude estimates for the number of Sowerby's Beaked Whales using Canadian waters can be obtained by comparison with the Northern Bottlenose Whale, which uses similar habitat (Macleod 2000; Whitehead and Hooker 2012). Off the Scotian Shelf Northern Bottlenose Whales and Sowerby's Beaked Whales are sighted and heard at somewhat similar rates, although Northern Bottlenose are encountered and heard rather more often than Sowerby's Beaked Whales, but are more easily detectable both visually and aurally (H. Moors-Murphy pers. comm. 2018, H. Whitehead pers. comm. 2018). The Scotian Shelf population size of Northern Bottlenose Whales is estimated at 143 animals (95% CI: 129-156) using mark-recapture methods (O'Brien and Whitehead 2013). Off Newfoundland and Labrador, Sowerby's Beaked Whales are detected aurally and visually less often than off the Scotian Shelf, and less often than Northern Bottlenose Whales in the same region (L. Feyrer pers. comm. 2018). This suggests that the Canadian population of Sowerby's Beaked Whales numbers in the hundreds or low thousands.

Fluctuations and Trends

There are insufficient data to determine population fluctuations or trends in population size of Sowerby's Beaked Whale. Since the mid-1990s, there has been an increased sighting rate of Sowerby's Beaked Whales in the Gully (Whitehead 2013). But it is not clear if this relates to an increase in the actual numbers of Sowerby's Beaked Whales in the North Atlantic. If this is an increase in the population size, the rate of increase is higher than could be produced by natural reproduction rates and likely represents a shift in habitat use by this species (Whitehead 2013).

Rescue Effect

Sowerby's Beaked Whales are found near the continental slope off the Atlantic coast of the United States and are likely part of the same population as those found in Canadian waters. However, there are no data indicating the frequency of movement between Canadian and American waters. No confirmed sightings or strandings of Sowerby's Beaked Whales have been reported from western Greenland. Search effort in this area is low so the lack of records does not necessarily mean lack of presence. Sowerby's Beaked Whales have been observed off Iceland (Sigurjónsson *et al.* 1989), but it is unknown if individuals move between the eastern and western Atlantic. A rescue effect is at least plausible if animals were to move into Canadian waters from adjacent areas (COSEWIC 2006).

THREATS AND LIMITING FACTORS

Threats

Direct threats faced by Sowerby's Beaked Whales assessed in this report were organized and evaluated based on the IUCN-CMP (World Conservation Union-Conservation Measures Partnership) unified threats classification system (Master *et al.* 2012). Threats were defined as proximate activities or processes that directly and negatively impact Sowerby's Beaked Whales. The impact, scope, severity, and timing of threat are presented in tabular form in the Appendix I.

The calculated overall threat impact was High to Medium. There have been relatively few observations of injured Sowerby's Beaked Whales. It is likely that most carcasses do not end up on shore where they could be examined. Many stranded carcasses are not detected in time to determine cause of death. Therefore, there is limited information to assess the threats to Sowerby's Beaked Whales (see Table 1). It is becoming clear that many beaked whale species are vulnerable to noise pollution. However, no study has been conducted to investigate the impact on Sowerby's Beaked Whales. It is also clear that fisheries interactions can be harmful to beaked whales. Beaked whales are also vulnerable to the same persistent organic pollutants as other long-lived cetaceans and are likely vulnerable to ingestion of macro- and microplastics.

An unprecedented number of strandings which included six groups of Sowerby's Beaked Whales, as well as a number of other deep diving cetaceans, occurred in the United Kingdom, Ireland and France in 2008 (Dolman *et al.* 2010). Although the cause of death could not be determined, it remained a possibility that a currently unidentified anthropogenic or natural factor may have been responsible for the mortalities.

Category 3: Energy Production & Mining (medium to low threat)

Sowerby's Beaked Whales may also be vulnerable to other sources of acoustic pollution. Drilling can cause underwater noise for sustained periods of time, and noise produced by thrusters on dynamic positions vehicles for deep offshore drilling can be quite loud and continuous over long periods of time (weeks to months). Exposure to acute noise is currently of highest concern due to the potential severity of the physiological harm and behavioural disturbances that may be experienced as a result of the exposure. Seismic surveys have been shown to influence the behaviour and distribution of other cetaceans (e.g., Gordon *et al.* 2003). Although there have been no direct studies of the effects of seismic activities on any species of beaked whale, fatal strandings of Cuvier's Beaked Whales in the Gulf of California have been linked to seismic activities (Hildebrand 2005; Cox *et al.* 2006). Seismic surveys are common in the offshore waters of Atlantic Canada where licensing and prospecting for oil and gas is being pursued extensively (e.g., see CNSOPB 2018 for the Scotian Shelf and CNLOPB 2018 for Newfoundland and Labrador). Such surveys have been increasing over deeper shelf edge and slope waters that comprise the habitat of Sowerby's Beaked Whales and other beaked whales (Figure 5). It is also likely that the decommissioning of rigs in the future will contribute to increased noise levels in Sowerby's Beaked Whale habitat (Fisheries and Oceans Canada 2017). Disturbance and displacement may occur not only because of seismic exploration activities, but also because of drilling activities.

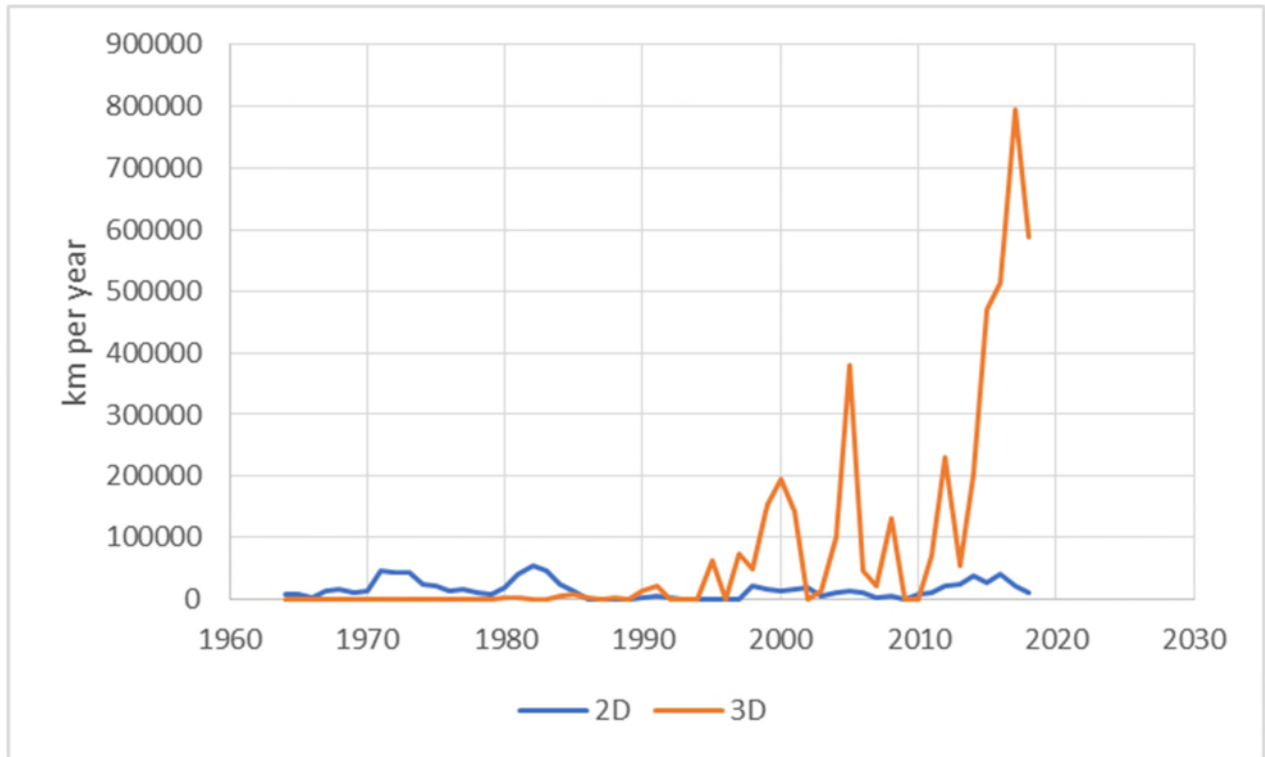


Figure 5. Seismic activity off Newfoundland and Labrador 1960 – 2018. Data from Canada Newfoundland & Labrador Offshore Petroleum Board.

Category 4: Transportation & service corridors (low threat)

Although vessel traffic is high throughout the southern portions of the suitable habitat for Sowerby’s Beaked Whales in Canada (south of the Grand Banks) (Figure 6), there are few documented vessel strikes. Lucas and Hooker (2000) documented a Sowerby’s Beaked Whale stranded on Sable Island with injuries consistent with a ship strike. Similar evidence was found on a stranded whale in Conception Bay, Newfoundland (Ledwell *et al.* 2005). Healed fractures were found on an individual that stranded in Prince Edward Island, suggesting a previous, non-lethal ship strike (Daoust 2013; P-Y. Daoust pers. comm. 2017). Again, as this species is only found offshore, it is likely that vessel strikes on Sowerby’s Beaked Whales are underreported.

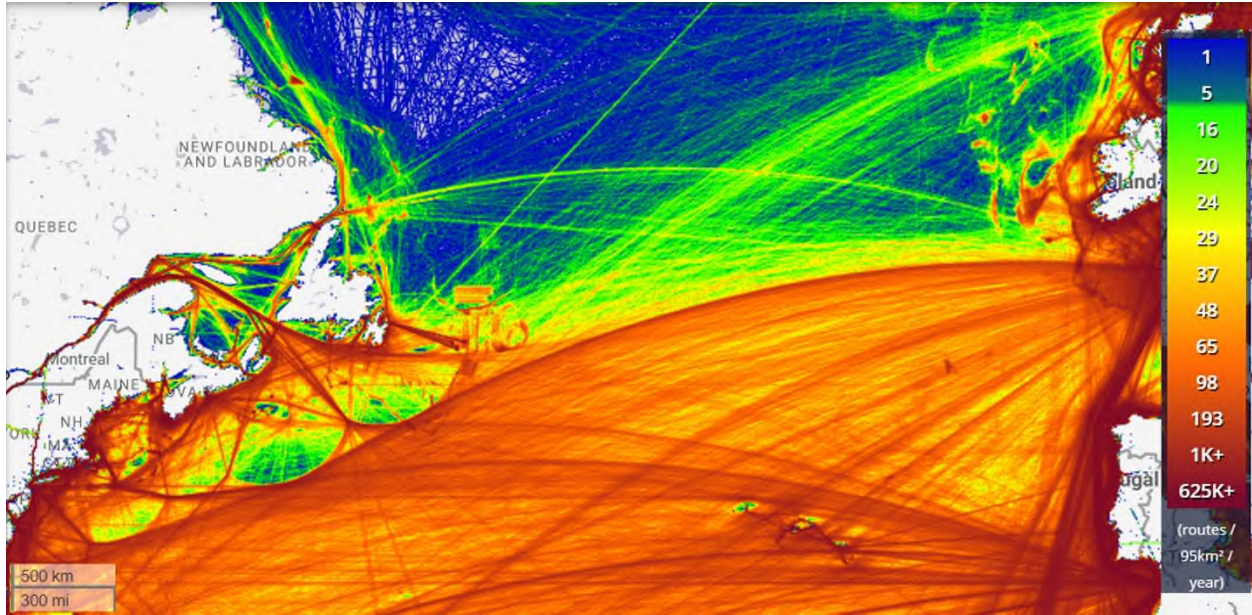


Figure 6. Density of marine vessel traffic in the North Atlantic 2016—2017. Map source from MarineTraffic (www.marinetraffic.com).

Category 5: Biological resource use (low threat)

At least 24 Sowerby's Beaked Whales were taken as bycatch in the pelagic drift gillnet fishery for swordfish in the United States between 1989 and 1998. This fishery was closed in 1998 due to the high rate of cetacean bycatch (Wenzel *et al.* 2013). No current fishery along the east coast of North America is known to have a high rate of bycatch of Sowerby's Beaked Whales. However, Sowerby's Beaked Whales may be susceptible to at least occasional entanglement in longline gear (COSEWIC 2006).

Sowerby's Beaked Whales have stranded along the east coast with signs of fisheries entanglement (Table 1). In 1984, a single Sowerby's Beaked Whale was found entangled in fishing gear in Manuels Cove, Newfoundland and Labrador. The live whale was successfully disentangled; however, it stranded two days later in the same area (Dix *et al.* 1986). Two Sowerby's Beaked Whales were observed in the Gully entangled in fishing gear in 2013, but the fate of these whales is unknown (Fisheries and Oceans Canada 2017). Scars from previous entanglements have also been observed on free swimming whales, as well as on stranded individuals (Fisheries and Oceans Canada 2017). As this species is only found offshore, it is likely that entanglement rates of Sowerby's Beaked Whales are underreported.

Category 9: Pollution (unknown impact)

Many chemical pollutants bioaccumulate in the blubber and other tissues of cetaceans, especially odontocetes. A mature male Sowerby's Beaked Whale that stranded in eastern England contained higher levels of chromium, nickel, copper, zinc, arsenic, selenium, cadmium and mercury than many other stranded cetaceans in the UK, although most of these levels were within previously established ranges for marine mammals (Law *et al.* 2001; COSEWIC 2006). Chemical contaminants have not been assessed in any Sowerby's Beaked Whales in the Western Atlantic, but analysis by Hooker *et al.* (2008) of biopsy samples from Northern Bottlenose Whales may be relevant for Sowerby's Beaked Whales. Cytochrome P450 1A1 is a protein encoded by the CYP1A1 gene that is induced by exposure to polycyclic aromatic hydrocarbons (PAH) and planar halogenated aromatic hydrocarbons (PHAHS) such as non-ortho polychlorinated biphenyls (PCBs). In general the expression of CYP1A1 was low for bottlenose whales in Canadian waters. Expression was elevated after oil and gas development occurred in the areas surrounding the Gully. Additionally CYP1A1 expression was relatively high in samples from Labrador. Levels of PCBs and other organochlorines were similar to other North Atlantic odontocetes. However, concentrations in Labrador samples were lower than those from the Gully (Hooker *et al.* 2008).

Plastic ingestion has been well documented in cetaceans including several beaked whales. There have been at least two reports of Sowerby's Beaked Whales ingesting plastic, including one in Massachusetts (Baulch and Perry 2014; M. 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 Sowerby's Beaked Whales, they have been found in True's Beaked Whales (Lusher *et al.* 2015) and high levels of contamination have recently been documented in several species of myctophid fish off the Flemish Cap (Wieczorek *et al.* 2018) where Sowerby's Beaked Whales have been sighted. The potential effects of microplastic ingestion in Sowerby's Beaked Whales remain unknown.

Persistent anthropogenic noise can mask important acoustic signals produced by marine mammals, which may affect their ability to communicate, navigate, capture prey, and avoid threats. Noise disturbances generated by commercial vessels are principally in the lower frequencies, making them of greater concern for baleen whales, which communicate in this frequency range. However, there is evidence to suggest that large, fast-moving cargo ships may also introduce high-frequency noise disturbances that are within the acoustic range of beaked whales (Aguilar Soto *et al.* 2006). There is increasing evidence that mass strandings of beaked whales can be caused by military sonar (Frantzis 1998; Balcomb and Claridge 2001; Jepson *et al.* 2003; Fernández *et al.* 2005; Cox *et al.* 2006; Parsons 2017). The susceptibility of beaked whales in general suggests that whales from all species in the family Ziphiidae can be harmed by exposure to high-energy, mid-frequency sonar. When mass strandings of beaked whales have occurred in association with military sonar deployments, they seem to have involved most or all of the ziphiid genera that inhabit the area (cf. Brownell *et al.* 2005). The deep-diving behaviour of these whales makes them especially vulnerable to acute noise exposure (Bernaldo de Quirós *et al.* 2012; Fahlman *et al.* 2014).

While much of the initial concern regarding beaked whales and underwater noise focused on lethal effects, recent work has focused on sub-lethal (often behavioural) effects. Blainville's Beaked Whales appear to alter their dive behaviour, typically surfacing away from the source, and reducing foraging clicks when exposed to military sonar (Moretti *et al.* 2014). It has been suggested that a risk-disturbance model can be used to explain many of these responses; individuals are responding to these sonar sounds in a similar way to a predatory attack (Harris *et al.* 2017). More work is required to determine the sensitivity of each species as well as individual variability in response. Even more work is required to determine the likelihood that these sub-lethal effects can have population-level effects (Harris *et al.* 2017); however, Blainville's Beaked Whales in the Bahamas exposed to routine navy sounds appear to have fewer calves than other groups (Claridge 2013). There is no reason to believe that the effects are specific to a single species or species group within the Ziphiidae, and therefore it is reasonable (and prudent) to infer that mid-frequency sonars such as those deployed by many modern naval vessels can have lethal effects on all species of *Mesoplodon*, including Sowerby's Beaked Whales (COSEWIC 2006).

Cholewiak *et al.* (2017) indicate that beaked whales, including Sowerby's Beaked Whales, are likely detecting commercial echosounders (similar to those found on many research vessels and commercial fishery vessels) and reducing the number of vocalizations. As beaked whales likely rely on echolocation to find prey, this may result in reduced foraging opportunities. While a single transit of a research vessel through an area is unlikely to cause long-term disruption to foraging, Cholewiak *et al.* (2017) also noted that shipboard echosounders were detected by a bottom-mounted hydrophone near Georges Bank on approximately 25% of the days deployed (44 days out of a six-month deployment).

Limiting Factors

Like most cetaceans, Sowerby's Beaked Whales are thought to have a low reproductive rate (Mead 1984; Evans and Stirling 2001), which will limit a population's ability to adapt to or recover from disturbance (COSEWIC 2006). An examination of the vulnerability of beaked whale reproduction and survival in relation to energetic demands suggested that beaked whale reproduction requires energy-dense prey, and that poor resource availability would lead to an extension of the inter-calving interval (New *et al.* 2013). Little is known about the rate of disease in the Sowerby's Beaked Whale.

Number of Locations

Sowerby's Beaked Whales are distributed widely in the deeper waters off eastern Canada. Although Sowerby's Beaked Whales occupying areas of intense seismic, fishing or shipping activity could face elevated risk, these areas are not sufficiently well defined to designate locations.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Sowerby's Beaked Whale is listed by the IUCN as Data Deficient (Taylor *et al.* 2008). It is listed in Appendix II of the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora; CITES 2018). It is included under Cetacea spp. in Schedule I of the *Wild Animal and Plant Trade Regulations* (SOR/96-263), made pursuant to section 21 of the *Wild Animal and Plant Protection and Regulation of the International and Interprovincial Trade Act* (WAPPRIITA) (S.C. 1992, c.52). The species is not listed as Endangered or Threatened under the US *Endangered Species Act*, nor is it considered a strategic stock under the US *Marine Mammal Protection Act* (Waring *et al.* 2015).

Within Canada the species was originally assessed in 1989 by COSEWIC as Special Concern (originally Vulnerable; Lien and Barry 1990), reassessed in 2006 as Special Concern (COSEWIC 2006), and reassessed in May 2019 as Special Concern. Since 2011 the species has been listed as Special Concern under the Canadian *Species at Risk Act* (Species at Risk Public Registry 2018). Additionally Fisheries and Oceans Canada (2017) has developed a management plan for Sowerby's Beaked Whales (DFO 2017). The focus of this plan is to conduct research and monitoring to better understand the biology of these whales as well as to research the threats this species faces. Management actions as well as public engagement and outreach are also highlighted in order to ensure a stable population of Sowerby's Beaked Whales in Canadian waters.

Non-Legal Status and Ranks

According to NatureServe the global status is listed as G3 – Vulnerable (meaning that the species is at moderate risk of extinction; last reviewed in 1997). It was ranked N3 (Vulnerable) nationally (CESCC 2016). The species has not been ranked nationally in the US by NatureServe and the only sub-region listed is Newfoundland and Labrador where the species is not ranked (NatureServe 2018).

Habitat Protection and Ownership

There is no habitat protected specifically for Sowerby's Beaked Whales in the eastern North Atlantic. However, protection measures enacted for other species may provide some protection. The Gully has been designated as a Marine Protected Area, in part to protect Northern Bottlenose Whales. However, this area is also known Sowerby's Whale habitat. The Gully, Shortland and Haldimand canyons have also been identified as critical habitat for Northern Bottlenose Whales, which may also provide some protection for Sowerby's Beaked Whales. Fisheries and Oceans Canada has also established a number of marine refuges along the east coast, some of which may provide some protection to Sowerby's Beaked Whales from fishing gear entanglement (DFO 2018).

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Shannon Gowans has been researching cetaceans since 1993. She first worked on the distribution of small cetaceans in the offshore waters of Nova Scotia. Her Ph.D. focused on the social organization and population size of northern bottlenose whales in the Gully. During this time she 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 she 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, she has been working at Eckerd College, where she is currently an Associate Professor of Marine Science and Biology. Her current research focuses on local Bottlenose Dolphins where she coordinates the Eckerd College Dolphin Project (ECDP), the longest running undergraduate marine mammal research program.

Peter Simard began his 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, he established Blind Bay Cetacean Studies to investigate distribution patterns and population structure of coastal cetaceans in Nova Scotia. His Ph.D. work at the University of South Florida investigated 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. His 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. He currently studies an inshore population of Bottlenose Dolphins with the Eckerd College Dolphin Project.

COLLECTIONS EXAMINED

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

Appendix 1. Threats Assessment for Sowerby's Beaked Whale.

Species or Ecosystem Scientific Name	<i>Mesoplodon bidens</i>	Element ID	Sowerby's Beaked Whale
Version Date:	03/01/2018 modified by D. Lee on April 29, 2019 based on discussion at COSEWIC Species Assessment Meeting.		
Version Author(s):	Peter Simard, Shannon Gowans, David Lee, Hal Whitehead, Kim Parsons, Steve Ferguson, Hillary Moors-Murphy		
References:			
Generation Time:			
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:		
	Impact Adjustment Reasons:		
	Overall Threat Comments		

Threat	Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1 Residential & commercial development					
1.1 Housing & urban areas					
1.2 Commercial & industrial areas					
1.3 Tourism & recreation areas					
2 Agriculture & aquaculture					
2.1 Annual & perennial non-timber crops					
2.2 Wood & pulp plantations					
2.3 Livestock farming & ranching					
2.4 Marine & freshwater aquaculture					
3 Energy production & mining	CD Medium - Low	Pervasive - large	Moderate - slight	High (continuing)	
3.1 Oil & gas drilling	CD Medium - Low	Pervasive - large	Moderate - slight	High (continuing)	Beaked whales vulnerable to noise produced during seismic surveys as well as during exploitation and the commissioning/decommissioning of offshore rigs. Potential for contaminants as well.
3.2 Mining & quarrying					

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.3	Renewable energy		Not Calculated (outside assessment timeframe)	Restricted - small	Unknown	Low (long-term)	Effects of potential development of offshore windfarms along shelf (as per Atlantic Fin Whale (<i>Balaenoptera physalus</i>) threats calculator)
4	Transportation & service corridors	D	Low	Pervasive - large	Slight or 1-10% pop. decline	High (continuing)	
4.1	Roads & railroads						
4.2	Utility & service lines						
4.3	Shipping lanes	D	Low	Pervasive - large	Slight or 1-10% pop. decline	High (continuing)	Several major shipping lanes between Eastern North America and Europe pass through suitable habitat. Documented ship strike injury or mortality is low; however, it is likely that most ship strike injuries are undocumented.
4.4	Flight paths						
5	Biological resource use	D	Low	Pervasive - large	Slight or 1-10% pop. decline	High (continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources	D	Low	Pervasive - large	Slight or 1-10% pop. decline	High (continuing)	Fisheries bycatch has occurred in the past, although the pelagic drift net fishery is now closed. An entangled Sowerby's Beaked Whale was observed live in the Gully; however, its fate is unknown. Fishing activity occurs throughout much of the suitable habitat and it is likely that many fisheries interactions are undocumented.
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)	
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, but no published data.
6.3	Work & other activities						
7	Natural system modifications						
7.1	Fire & fire suppression						
7.2	Dams & water management/use						
7.3	Other ecosystem modifications						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8	Invasive & other problematic species & genes		Unknown	Unknown	Unknown	Unknown	
8.1	Invasive non-native/alien species		Unknown	Unknown	Unknown	Unknown	No data available.
8.2	Problematic native species						
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause		Unknown	Unknown	Unknown	High (continuing)	
9	Pollution		Unknown	Pervasive - large	Unknown	High (continuing)	
9.1	Household sewage & urban waste water		Unknown	Unknown	Unknown	High (continuing)	No data available.
9.2	Industrial & military effluents		Unknown	Unknown	Unknown	High (continuing)	Contaminants in blubber but effects unknown.
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste		Unknown	Pervasive - large	Unknown	High (continuing)	Plastics, including microplastics likely problematic.
9.5	Air-borne pollutants		Unknown	Pervasive - large	Unknown	High (continuing)	
9.6	Excess energy		Unknown	Pervasive - large	Unknown	High (continuing)	Seismic exploration for oil and gas, as well as the drilling of oil/gas wells, is common in much of Sowerby's habitat off eastern Canada, and may develop in the species' habitat off the eastern USA. The level of uncertainty regarding the severity of the impact is particularly high. Noise from shipping is likely a threat but severity remains unknown. Drilling can cause underwater noise for sustained periods of time, and noise produced by thrusters on dynamic positions vehicles for deep offshore drilling can be quite loud and continuous over long periods of time (weeks to months). No published data on SBW specifically but there are data on SONAR impacts on mesoplodonts and on beaked whales. Mid-frequency active (MFA) sonar overlaps expected hearing and vocalization range of beaked whales. Cuvier's Beaked Whales responded strongly to playbacks at low received levels after ceasing normal fluking and echolocation (DeRuiter <i>et al.</i> 2013).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Unknown	Pervasive - large	Unknown	High (continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive - large	Unknown	High (continuing)	Habitat suitabilities will likely change across the species' range, but in ways that are currently unpredictable.
11.2	Droughts						
11.3	Temperature extremes		Unknown	Pervasive - large	Unknown	High (continuing)	Temperature fluctuations may impact prey base.
11.4	Storms & flooding						
Classification of Threats adopted from IUCN-CMP, Salafsky <i>et al.</i> (2008).							