Proposed

Species at Risk Act
Management Plan Series

Management Plan for the Sowerby's Beaked Whale (*Mesoplodon bidens*) in Canada

Sowerby's Beaked Whale

2016

Canada

Recommended citation:

Fisheries and Oceans Canada. 2016. Management Plan for the Sowerby's Beaked Whale (*Mesoplodon bidens*) in Canada [Proposed]. *Species at Risk Act* Management Plan Series. Fisheries and Oceans Canada, Ottawa. iv + 48 pp.

Additional copies:

For copies of the management plan, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the SAR Public Registry[1].

Cover illustration: Sowerby's Beaked Whale. Illustration by Jeff Domm.

Également disponible en français sous le titre
« Plan de gestion de la baleine à bec de Sowerby (*Mesoplodon bidens*) au Canada »

ISBN ISBN to be included by SARA Responsible Agency
Catalogue no. Catalogue no. to be included by SARA Responsible Agency

[1] http://www.sararegistry.gc.ca/

Preface

Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed species of special concern and are required to report on progress within five years. The federal, provincial, and territorial government signatories under *The Accord for the Protection of Species at Risk* (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada.

The Minister of Fisheries and Oceans is the competent minister under SARA for the Sowerby's Beaked Whale and has prepared this Management Plan as per section 65 of SARA. It has been prepared in cooperation with: other federal government departments, provincial government departments, Aboriginal organizations, and stakeholders (Appendix A).

Success in the management of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Sowerby's Beaked Whale and Canadian society as a whole.

Implementation of this management plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

[2] http://www.sararegistry.gc.ca/default.asp?lang=En&n=92D90833-1

Acknowledgments

Fisheries and Oceans Canada wishes to acknowledge the many individuals who provided valuable input into the development of this Management Plan. A special thank you is extended to the Whitehead lab at Dalhousie University for generously sharing field data and photographs, and for playing such an integral role in advancing the knowledge of beaked whales on the Scotian Shelf.

Executive summary

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Sowerby's Beaked Whale (*Mesoplodon bidens*) as Special Concern in 2006. In 2011, the Sowerby's Beaked Whale was listed as Special Concern under the federal *Species at Risk Act* (SARA).

The Sowerby's Beaked Whale is endemic to the North Atlantic Ocean. Its distribution within Canadian waters is thought to include the offshore waters along the continental slope and within submarine canyons off of Nova Scotia and Newfoundland and Labrador. The Sowerby's Beaked Whale is difficult to observe and identify at sea due to its relatively small size and cryptic surface behaviour. As a result, little is known about specific habitat use, social structure, and population dynamics.

Several anthropogenic threats to the Sowerby's Beaked Whale have been identified, including acute and chronic noise exposure, entanglement, vessel strikes, and contaminant exposure. Of these threats, 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. In the absence of a population estimate for the Sowerby's Beaked Whale, and without knowledge of how the identified threats may have affected the population to date, population-level effects cannot be determined.

The objectives of this Management Plan are to: *1) Maintain a stable Sowerby's Beaked Whale population throughout its range in Atlantic Canadian waters* and *2) Quantify and mitigate the effects of identified threats on the population.* These objectives will be achieved through the implementation of several conservation measures falling under three broad strategies:

1) **Research and monitoring:** This broad strategy seeks to improve our understanding of Sowerby's Beaked Whale biology, behaviour, population size and trend, and distribution, as well as the threats posed to the species by human activities.
2) **Management:** This broad strategy seeks to appropriately monitor and mitigate known threats to the Sowerby's Beaked Whale and its habitat through the application of regulatory and non-regulatory measures.
3) **Engagement and public outreach:** This broad strategy seeks to increase stakeholder and public involvement in, and awareness of, the Sowerby's Beaked Whale and its threats by establishing regular communication, developing educational materials, and realizing collaborative stewardship opportunities.

Several actions have already been taken toward achieving these goals. Additional recommended actions are provided in the implementation schedule associated with this Management Plan. Progress made on the conservation measures outlined in the implementation schedule will be assessed five years following the publication of this document on the Species at Risk Public Registry.

Table of contents

1. COSEWIC[3] species assessment information

Date of Assessment: November 2006

Common Name (population): Sowerby's Beaked Whale

Scientific Name: *Mesoplodon bidens*

COSEWIC 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 temperate to subarctic waters. Little is known about its biology, fine-scaled distribution, and abundance. It belongs to a family of whales (Ziphiidae) 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 military activities involving the use of mid- and low-frequency sonar likely occur at least occasionally in the habitat of this species off Canada's East Coast. Although there is no direct evidence that such sound sources have affected this species, there is strong evidence for lethal effects on individuals of related species. Thus there is reasonable cause for concern about the potential effects on individuals of this species. The potential population-level impacts of this type of mortality are unknown.

Canadian Occurrence: Atlantic Ocean

COSEWIC Status History: Designated Special Concern in April 1989 and in November 2006. Last assessment based on an update status report.

2. Species status information

2.1. Canadian status

In April 1989, the Sowerby's Beaked Whale (*Mesoplodon bidens*) was assessed as Special Concern by COSEWIC. This status was reaffirmed in the most recent COSEWIC assessment of the species in November 2006 (COSEWIC 2006). In 2011, the Sowerby's Beaked Whale was listed as Special Concern[4] in Schedule 1 to the *Species at Risk Act* (SARA) (S.C. 2002, c.29). This Management Plan was prepared pursuant to section 65 of SARA, which requires the development of management plans for species listed as Special Concern. Implementation of the measures outlined in this plan will contribute to the conservation of the Sowerby's Beaked Whale and its habitat.

[3] COSEWIC stands for the Committee on the Status of Endangered Wildlife in Canada.
[4] A species of Special Concern is defined in subsection 2(1) of SARA as: "[...] a wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats."

Note that for species of Special Concern, the section 32 prohibition against killing, harming, harassing, capturing, or taking individuals does not apply, nor is there a requirement to identify and protect critical habitat (SARA section 58).

The Sowerby's Beaked Whale is also listed in Schedule I[5] 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 purpose of this Act is to protect certain species by regulating their international and interprovincial trade.

2.2. Global status

NatureServe, an international network of biological data inventories, has developed a species status assessment procedure in which at-risk species are assigned a global, national, and/or subnational "Conservation Status Rank" (NatureServe 2013). Under this system, Sowerby's Beaked Whale has been assigned a global ranking of G3-Vulnerable[6]. The national (Canadian) conservation status of the species has not been assessed using this system.

As part of their "Red List" program, the International Union for Conservation of Nature (IUCN) assessed Sowerby's Beaked Whale as Data Deficient in 2008 (Taylor et al. 2008). An assessment of extinction risk could not be made because adequate information on the global population and distribution of this species was not available.

Sowerby's Beaked Whale is included in Appendix II[7] of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) (1973). Accordingly, trade in specimens of this species is prohibited, unless it is in accordance with Article IV of the Convention.

3. Species information

3.1. Species description

3.1.1. Taxonomy

The Sowerby's Beaked Whale (also known as North Atlantic Beaked Whale and North Sea Beaked Whale) is one of 15 recognized species in the genus *Mesoplodon*, commonly referred to as the mesoplodont whales (Dalebout 2002; Pitman 2002; Dalebout et al. 2014). Mesoplodonts are part of the family Ziphiidae (beaked whales),

[5] Includes those species listed in the Appendices to CITES (refer to Section 2.2 of this document).
[6] A G3-Vulnerable ranking is defined as follows: "At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors" (NatureServe 2013).
[7] Article II of CITES states that Appendix II of the Convention "[...] shall include all species which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival [...]".

which includes over 20 recognized species across five genera (Mead 2002). Beaked whales are among the most poorly understood marine mammals (Cox et al. 2006). Table 1 describes the basic taxonomy of the Sowerby's Beaked Whale.

Table 1. The taxonomic classification of Sowerby's Beaked Whale. The most inclusive taxonomic rank is on the far left of the table, and the least inclusive taxonomic rank is on the far right. Non-scientific terminology is included where relevant for reference.

Kingdom	Phylum	Class	Order	Family	Genus	Species
Animalia	Chordata	Mammalia	Cetacea	Ziphiidae	Mesoplodon	*Mesoplodon bidens*
			Whales, dolphins, porpoises	Beaked whales	Mesoplodont whales	Sowerby's Beaked Whale

3.1.2. Physical description

The Sowerby's Beaked Whale is a small whale, with adults ranging in length from 4.5-5.5 m. It has a streamlined, spindle-shaped body, which is generally dark grey with light speckling (Pitman 2002; COSEWIC 2006) (Figure 1). Younger whales may have a comparatively paler ventral (bottom) surface and lack spots. The melon (forehead) is small, and tapers into a long and narrow rostrum (beak). There is a pair of external v-shaped grooves on the throat, between the lower jaw bones (Figure 2). The Sowerby's Beaked Whale has a small triangular dorsal fin located about two-thirds of the way down the back (Figure 1). The pectoral fins are relatively long (approximately one-eighth of the body length) and the tail fluke has no median notch (COSEWIC 2006).

Mesoplodont whales have three sexually dimorphic traits (Pitman 2002). These traits set males apart from females (and juveniles), and include the following:

1) Adult males have a single pair of fully erupted teeth in the lower jaw that protrude outside of the mouth (Pitman 2002 (Figures 1 and 3). The position, shape, and size of these teeth vary among species.
2) Adult males have extensive scarring on their bodies, which is presumed to result from male-male fighting between individuals of the same species to establish breeding hierarchies (e.g. Heyning 1984; Pitman 2002; O'Brien 2013) (Figures 1 and 4). White scar tissue forms over the tooth-rake injuries, making them visibly prominent on their dark bodies.
3) In adult males, the mesorostral canal, a narrow groove in the upper rostrum, is ossified, meaning the cartilage turns into bone (Pitman 2002). This generally does not occur in other cetaceans.

Distinguishing one mesoplodont species from another is challenging given their close anatomical similarities (Pitman 2002). Physical identification is aided by differences in rostrum length and the shape, size, and position of teeth; however, misidentification is common using these techniques. Genetic analysis of specimens is preferable when available. In addition to the Sowerby's Beaked Whale, three other mesoplodont species occur in the northwest Atlantic, including True's Beaked Whale (*M. mirus*), Gervais'

Beaked Whale (*M. europaeus*), and Blainville's Beaked Whale (*M. densirostris*) (MacLeod 2000). These other species have more southerly distributions and are rarely observed in Canadian waters.

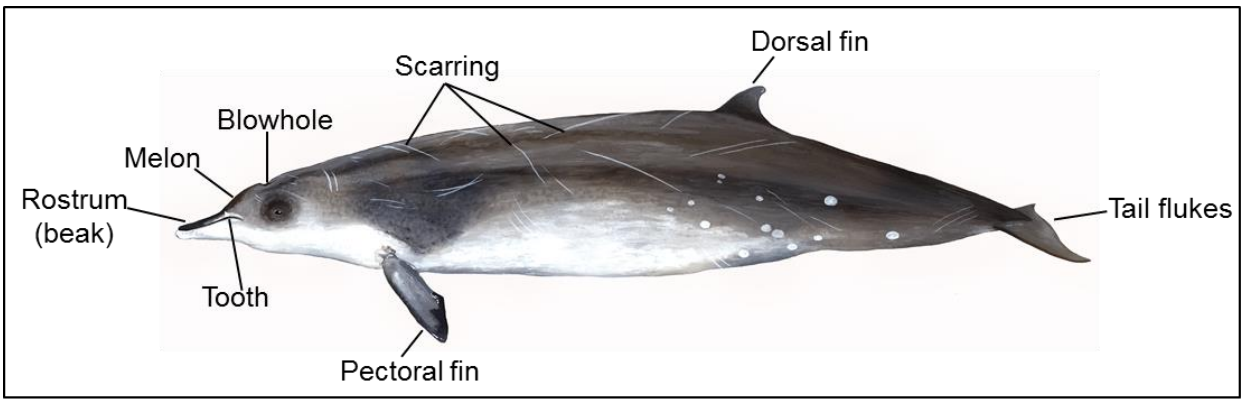

Figure 1. Side view of a male Sowerby's Beaked Whale with key physical features highlighted (adapted from cover illustration by J. Domm).

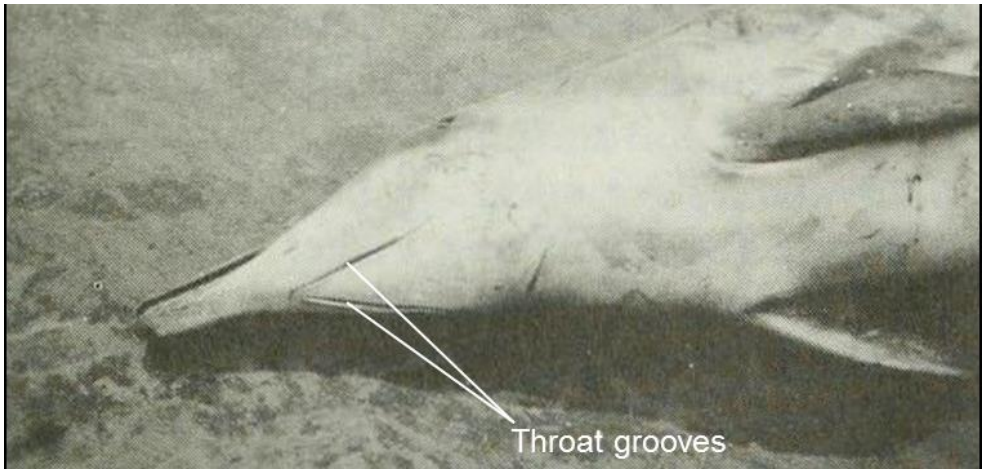

Figure 2. Ventral view of a beached female Sowerby's Beaked Whale, which shows the v-shaped throat grooves characteristic of the species (adapted from Lien and Barry 1990).

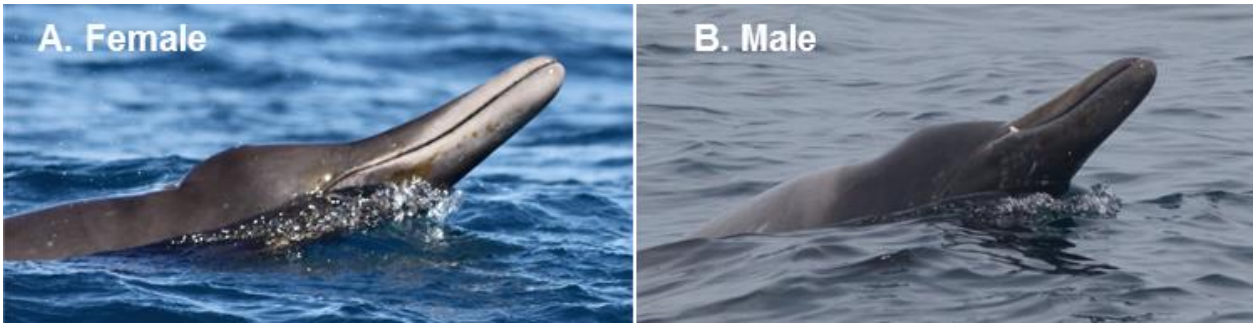

Figure 3. A. Female Sowerby's Beaked Whale observed in the Gully. B. Male Sowerby's Beaked Whale, with single tooth visible, observed in the Gully. Photo credits: Whitehead Lab, Dalhousie University.

Figure 4. Male Sowerby's Beaked Whale, with extensive scarring evident, observed in the Gully. This scarring pattern resulted from male-male fighting. Photo credit: Whitehead Lab, Dalhousie University.

3.2. Population and distribution

The Sowerby's Beaked Whale is found exclusively in the North Atlantic (Figure 5), and is considered the most northerly of the mesoplodont species (MacLeod 2000). In the eastern North Atlantic, the range of the Sowerby's Beaked Whale includes the Norwegian Sea (Carlström et al. 1997), the North Sea, the waters off of Iceland and the British Isles (Sigurjónsson et al. 1989; Lien and Barry 1990; Weir et al. 2001), and the waters around Madeira and the Azores (MacLeod 2000). In the western North Atlantic, the species is thought to occur as far north as the Davis Strait (COSEWIC 2006; Waring et al. 2013); however, it is most frequently observed in the waters off of Newfoundland, Nova Scotia, and the northeastern United States (MacLeod 2000; MacLeod et al. 2006).

Much of the data on the distribution of the Sowerby's Beaked Whale has come from strandings and opportunistic sightings (COSEWIC 2006; MacLeod et al. 2006). These whales are difficult to observe at sea (e.g. Barlow et al. 2006) and their offshore habitat poses logistical difficulties for research scientists. Furthermore, because it is difficult to distinguish mesoplodont whales at sea, beaked whale observations recorded by aerial and shipboard surveys are often identified to the genus level only (e.g. Waring et al. 2013).

In Canada, the Sowerby's Beaked Whale is thought to occur primarily along the continental slope off of Nova Scotia and Newfoundland and Labrador (NL), in waters greater than 200 m depth (Figure 6). An unconfirmed sighting in the Davis Strait (COSEWIC 2006) and two recent strandings in the Gulf of St. Lawrence (Daoust 2013; Lair 2013) suggest that this species' range may also include these areas. However, in the absence of further data, their presence in these areas is assumed to be comparatively rare. Details on temporal and spatial habitat use within Canadian waters, including movement patterns and site fidelity, are not well known (COSEWIC 2006; O'Brien 2013; Whitehead 2013). However, O'Brien (2013) found evidence of site fidelity in the Gully, with resightings of certain individuals occurring across days and summer field seasons. Reported Sowerby's Beaked Whale sightings and incidents (e.g. strandings) in Atlantic Canadian waters are mapped in Figures 6 and 7, respectively.

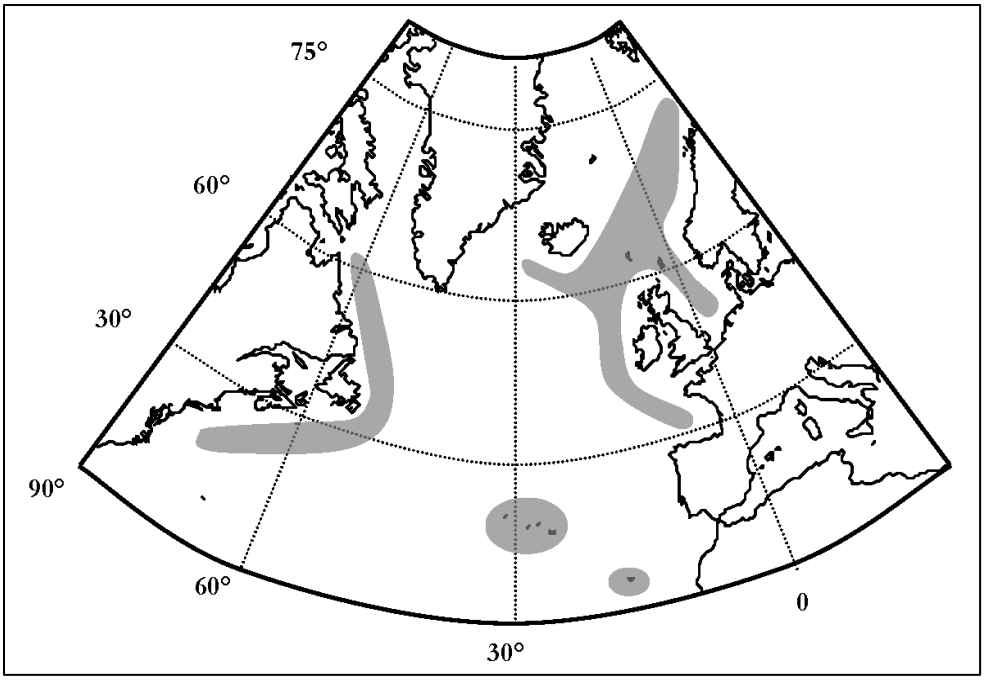

Figure 5. Distribution of the Sowerby's Beaked Whale in the North Atlantic Ocean (COSEWIC 2006). Shaded areas represent general locations of known sightings and strandings. To what extent the species may occur outside of these shaded areas is unknown. Shaded areas do not necessarily represent isolated populations.

No population estimate currently exists for the Sowerby's Beaked Whale in Canada. Survey effort has been limited and is largely biased toward specific areas of the offshore. These areas include the Gully, Shortland, and Haldimand submarine canyons (Figure 6), where Dalhousie University scientists have been conducting research on the endangered Northern Bottlenose Whale (*Hyperoodon ampullatus*) since the 1980s. There have been several incidental sightings of other cetacean species during these studies, including the Sowerby's Beaked Whale (e.g. Hooker and Baird 1999; O'Brien 2013; Whitehead 2013). Over a 23-year study period (i.e. 1988-2011), Whitehead (2013) calculated an annual increase of 21% in incidental sightings of Sowerby's Beaked Whales in the Gully (the first reported sighting was in 1994). The maximum potential rate of increase due to population growth was assumed by Whitehead (2013) to be 4%, which is in accordance with Wade (1998). Therefore, other factors must have contributed to the increasing observations of Sowerby's Beaked Whales in this canyon. Changes in prey abundance were cited as one potential driver of the trend (Whitehead 2013). However, because little is known about the diet of the Sowerby's Beaked Whale, and more generally about trends in mesopelagic biomass, it is unclear if and how this factor may have contributed. A decrease in anthropogenic noise over the period of study was also cited as a plausible explanation for the increased sightings of Sowerby's Beaked Whales in the Gully (Whitehead 2013). Fishing activities in and around the Gully have declined or ceased as a result of the 1993 groundfish moratorium and the establishment of the Gully Marine Protected Area (MPA) in 2004 (Whitehead 2013). Similarly, seismic exploration and commercial shipping have been voluntarily avoided or regulated in the Gully area since the mid-1990s.

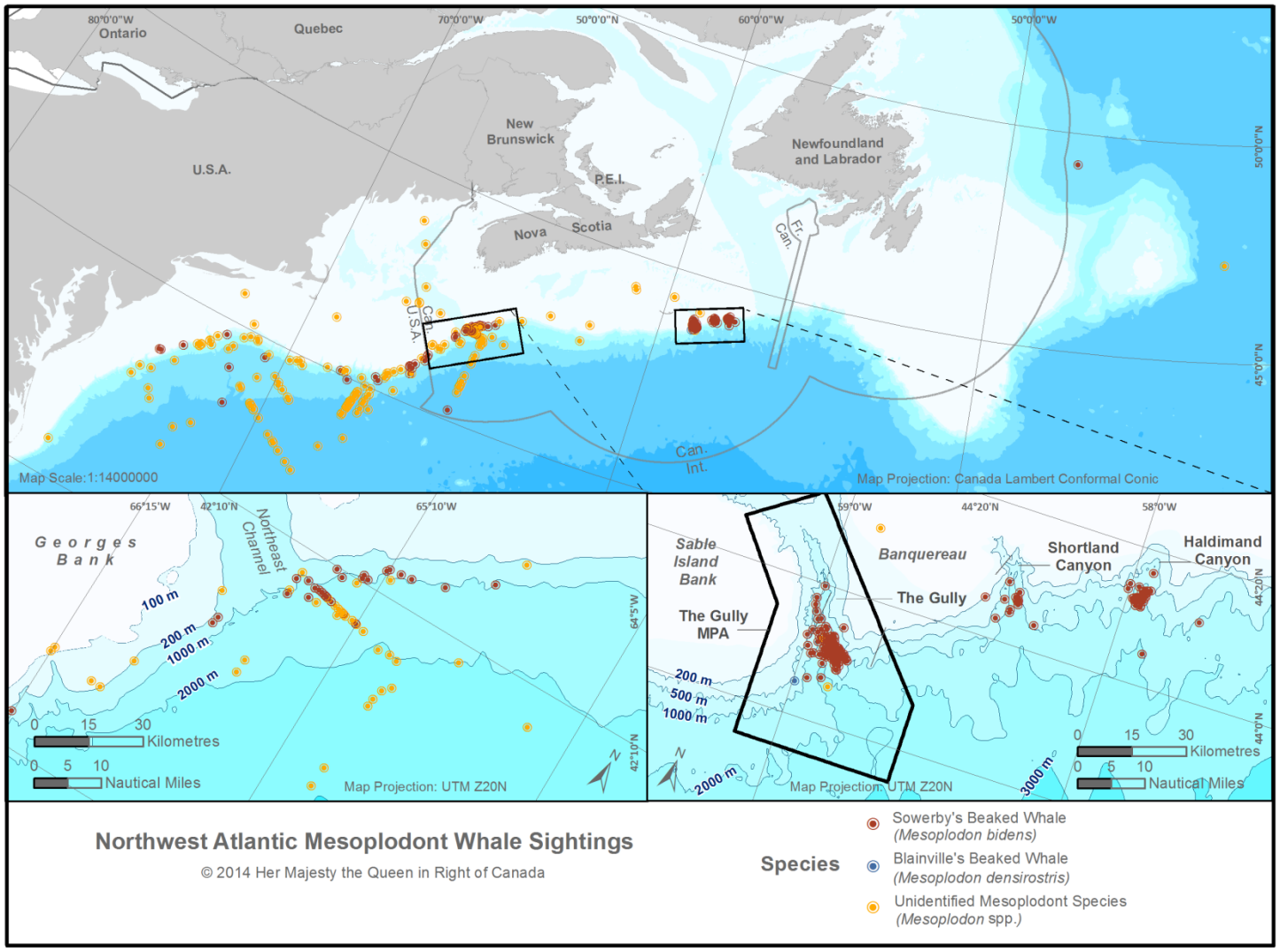

Figure 6. Reported Sowerby's Beaked Whale and other mesoplodont sightings in Atlantic Canadian waters and off of the northeastern U.S (the earliest record is from 1994, and the most recent records are from 2013). This map includes records obtained from Lawson and Gosselin (2009), H. Whitehead (pers. comm. 2013), J. Lawson (pers. comm. 2013), Narazaki (2013), NEFSC (2014), and the DFO Cetacean Sightings Database. Note that effort is not accounted for in this figure, nor is effort equally distributed throughout the area captured. Therefore, assumptions regarding areas of relatively greater or lesser importance for Sowerby's Beaked Whales cannot be made.

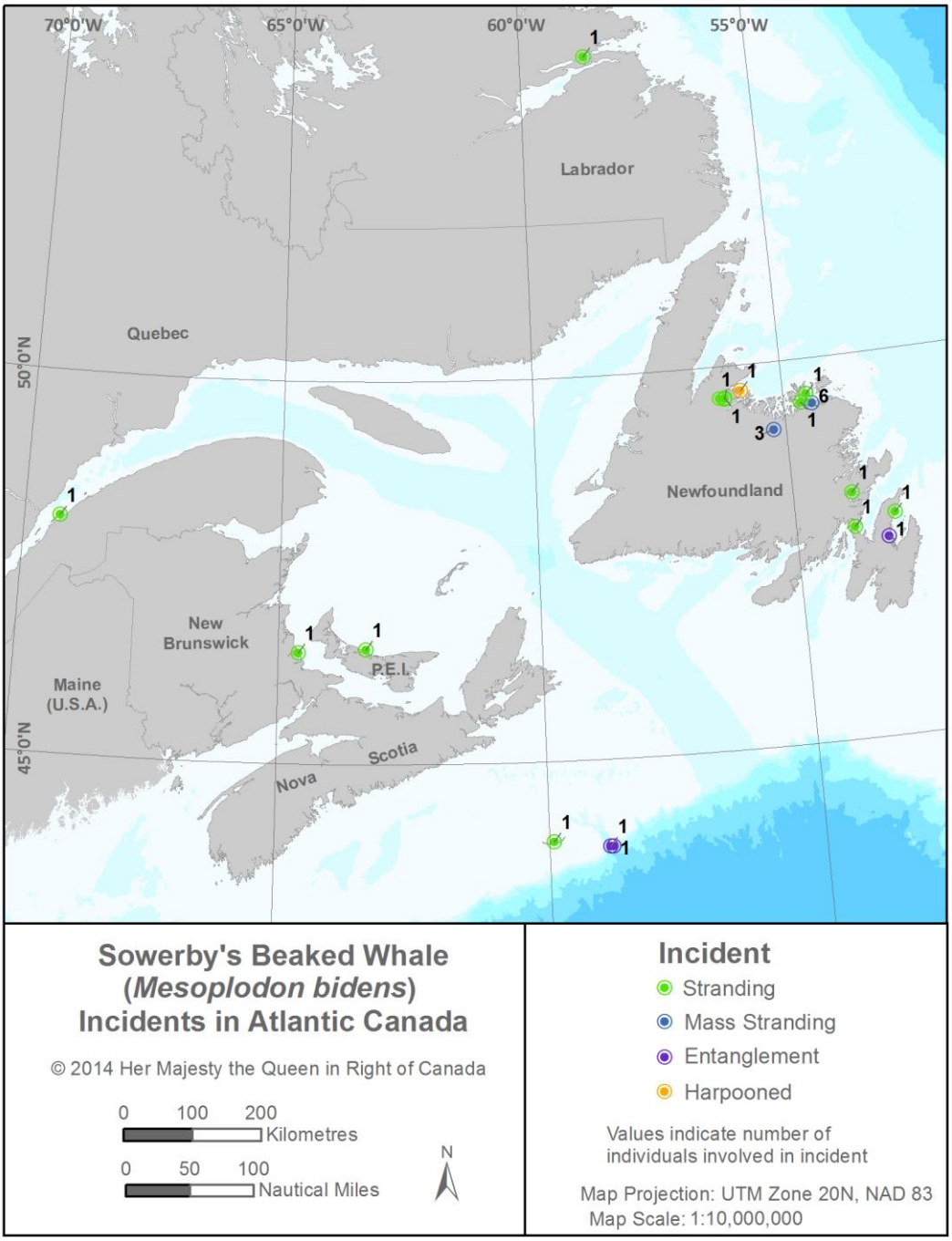

Figure 7. Distribution of reported Sowerby's Beaked Whale incidents in Atlantic Canada between 1952 and 2013. Incident data were derived from multiple sources, including: Sergeant and Fisher (1957); Lien and Barry (1990); Dix et al. (1986); Lien et al. (1990); McAlpine and Rae (1999); Lucas and Hooker (2000); J. Lawson (pers. comm. 2013); W. Ledwell (pers. comm. 2013); Daoust (2013); Lair (2013); and Narazaki (2013). A *stranding* refers to a single live or dead animal beached on the coastline. A *mass stranding* refers to a group (>1) of live or dead animals beached on the coastline. An *entanglement* refers to a sighting where fishing gear was present on the animal (animals with scarring suggesting past entanglement were not counted). There is also a single report of a *harpooned* Sowerby's Beaked Whale during the commercial whaling era. Note that although the data point representing the mass stranding of three whales appears to be inland, it does, in fact, coincide with a coastal location (Norris Arm, NL). The resolution of the base map is not fine enough to fully capture the Bay of Exploits.

3.3. Needs of the Sowerby's Beaked Whale

3.3.1. Habitat and biological needs

Little is known about the specific habitat preferences and biological needs of the Sowerby's Beaked Whale. Mesoplodont whales, in general, appear to prefer deep water habitats (>200 m) characteristic of submarine canyons, continental slopes, and the open ocean (Pitman 2002). Sightings of Sowerby's Beaked Whales and undifferentiated mesoplodonts in U.S. and Canadian waters corroborate this observation (Figure 6). The unique depth profile and associated upwelling and downwelling processes of the continental slope and submarine canyons can boost primary productivity, prey concentration, and nutrient export to deeper waters (Moors-Murphy 2014). Enhanced prey density in these habitats is likely one of the primary reasons they tend to attract whales. Submarine canyons, in particular, appear to have special importance. Moors-Murphy (2014) reviewed cetacean associations with 21 submarine canyons worldwide, and found that beaked whale species associated with nine of the canyons studied, including three in Atlantic Canada (i.e. the Gully, Shortland, and Haldimand Canyons). Furthermore, beaked whales typically associate with these canyons year-round. The Sowerby's Beaked Whale appears to demonstrate a strong affinity for canyon habitats on the eastern Scotian Shelf (Figure 6); however, this could be an artifact of unequal survey effort across the region (Moors-Murphy 2014). Further research is required to better define the habitat preferences of this species in Canadian waters.

Reports of stranded (live or dead) Sowerby's Beaked Whales have been infrequent in Québec, Labrador, and the Maritime provinces (four incidents in total; five if Sable Island is included) (Figure 7). A comparatively higher number of strandings (10 incidents) have been reported along the northern coast of Newfoundland. It is unlikely that these strandings are indicative of regular use of coastal waters. It is more probable that the whales were stranded chasing prey or as a result of becoming disoriented (e.g. Lien et al. 1990). Their carcasses may also have washed up on the coast post-mortem.

Based on isotope and stomach content analyses, the diet of the Sowerby's Beaked Whale appears to consist of squid and fish occurring between 200 and 2000 m water depth (e.g. Ostrom et al. 1993; MacLeod et al. 2003). There is evidence to suggest, however, that this species may rely more heavily on fish than squid, principally codfishes, hakes, lanternfishes, and grenadiers (MacLeod et al. 2003; Pereira et al. 2011; Wenzel et al. 2013). It is unknown what species of squid the Sowerby's Beaked Whale may consume in Canadian waters; however, MacLeod et al. (2003) found that mesoplodonts tend to feed on smaller squid (<500 g) than other beaked whale genera (i.e. *Hyperoodon* and *Ziphius*), which typically feed on squid that are greater than 1 kg. Studies using digital acoustic recording tags (DTAGs) (Johnson and Tyack 2003) have enhanced the ability of research scientists to study the foraging behaviour of deep-diving species (Johnson et al. 2004; 2006). Of particular interest, is how beaked whales use click vocalizations to echolocate their prey and navigate the darkness of their deep-water feeding habitat. Still little is known about the characteristics of Sowerby's Beaked Whale vocalizations, although Choelwiak et al. (2013) provided some initial descriptions

of their clicks. It is believed that like other cetaceans, the Sowerby's Beaked Whale relies heavily on acoustic signals to carry out life functions.

The social structure of Sowerby's Beaked Whales is also not well known. They have been observed singly and in groups as large as 15; however, small groups of three to five individuals appear to be most common (Hooker and Baird 1999; O'Brien 2013). Individuals in groups tend to surface simultaneously and within a couple of body lengths of each other (Hooker and Baird 1999; Pitman 2002). Possible segregation by age or sex has been suggested (Lien et al. 1990); however, mixed groups have been observed at sea (e.g. Hooker and Baird 1999). O'Brien (2013) found evidence of stable associations between individuals of unknown age and sex over days and between years (i.e. summer of 2010 and summer of 2011).

3.3.2. Ecological role

The precise trophic level (i.e. position in the food chain) of the Sowerby's Beaked Whale is unknown. The Killer Whale (*Orcinus orca*) and large shark species are its only likely predators; however, predation events have not been observed (Pitman 2002).

Ten instances of polyspecific associations between Sowerby's Beaked Whales and Northern Bottlenose Whales were recorded on the Scotian Shelf between 2010 and 2011 (O'Brien 2013). Polyspecific associations occur when social groups of two or more species, sharing a common geographic area, aggregate (Lambert 2012). It is unclear whether these associations occur by chance, or whether they are purposeful.

3.3.3. Limiting factors

Data on length at sexual maturity have been recorded from Sowerby's Beaked Whale stranding records (e.g. Lien and Barry 1990); however, age at first reproduction, gestation time, lactation time, calving frequency, and other reproductive parameters are largely unknown (Mead 1984; Mead 1989). The species' reproductive rate is expected to be low, as is the case in other cetaceans (Evans and Stirling 2001). A low rate of reproduction limits the ability of a population to recover from disturbances, which increases its vulnerability to threats.

Cetaceans are susceptible to a group of nematode parasites belonging to the genus *Crassicauda* (e.g. Lambertsen 1992; Vlasman and Campbell 2004). Infection occurs in the kidney, and can ultimately cause urinary, respiratory, and digestive disease, with potentially lethal effects. A necropsy of a Sowerby's Beaked Whale recovered in Florida revealed a heavy *Crassicauda* infestation in the kidney (Mead 1989). *Crassicauda* species have also been recorded in other mesoplodont whales. Little is known about the rate of disease in the Sowerby's Beaked Whale; however, osteomyelitis (inflammation of the bone) has been recorded in the skull of at least three mesoplodont specimens (two *M. grayi* and one *M. europaeus*) (Mead 1989).

4. Threats

4.1. Threat assessment

Several known and potential anthropogenic threats to the Sowerby's Beaked Whale have been identified. These threats are summarized in Table 2, and described in more detail in Section 4.2. The table column headings are defined below.

Note: The purpose of the threat assessment is to inform management approaches by identifying significant threats to the species and its habitat at the population level. However, in the absence of a population estimate for the Sowerby's Beaked Whale, and without knowledge of how threats may have affected the population to date, population-level effects cannot be determined. Although evidence is lacking to support a rigorous threat assessment for this population, a precautionary approach is taken given the likelihood that the identified threats could result in a population-level impact. The threat assessment was thereby informed by knowledge of how these threats have affected individuals throughout the species' range, as well as how they have affected other beaked whale species.

Explanation of Table 2 headings

Threat: Refers to the specific activity or process that has caused, is causing, or may cause stress to the population, where stress is defined as changes to the ecological, demographic, or behavioural attributes of the population, leading to reduced viability. The threat may cause harm or death to individuals, or may result in the destruction or degradation of habitat to the extent that population-level effects occur.

Level of concern: Indicates that managing the threat is of *High*, *Medium*, or *Low* concern for the conservation of the species. Level of concern rankings are relative to each other, and reflect management priority based on the currently limited knowledge of the species and its threats. These rankings may change as more information becomes available.

Extent: Refers to whether the threat is *Localized*, meaning it relates to a specific site or a narrow portion of the species' range, or *Widespread*, meaning it relates to the species' whole distribution or a large portion of its range.

Occurrence: Indicates whether the threat is *Historic*, i.e. it contributed to a population decline but no longer affects the species; *Current*, i.e. it is affecting the species now; *Imminent*, i.e. it is expected to affect the species very soon; *Anticipated*, i.e. it may affect the species in the future; or *Unknown*, i.e. it may or may not be occurring currently, but it is a viable threat.

Frequency: Describes the temporal extent of the threat. The threat may be a *One-time Occurrence*, i.e. it occurred, or will occur, just once; *Seasonal*, i.e. it occurs at certain times of the year only, or else the species has a seasonal presence; *Recurrent*, i.e. it

occurs on an irregular or infrequent basis; *Continuous*, i.e. it occurs on an ongoing basis).

Severity: Describes the degree of impact (i.e. *High*, *Medium*, *Low*, or *Unknown*) the threat may have or is having on the population.

Causal certainty: Reflects the strength of the evidence linking the threat to a population-level impact. *High* causal certainty indicates that there is substantial scientific evidence of a causal link between the threat and stresses on the population. *Medium* causal certainty indicates that there is scientific evidence linking the threat to stresses on the population. *Low* causal certainty indicates that there is a plausible link with limited or no evidence that the threat has stressed the population.

Table 2. Threat classification for the Sowerby's Beaked Whale.

Threat	Level of Concern	Extent	Occurrence	Frequency	Severity	Causal Certainty
Threat category #1: Anthropogenic noise						
Exposure to acute noise	High	Widespread	Current	Recurrent	Unknown	Low
Exposure to chronic noise	Medium	Widespread	Current	Continuous	Unknown	Low
Threat category #2: Interactions with fishing gear						
Entanglements	Medium	Widespread	Current	Recurrent	Unknown	Low
Threat category #3: Interactions with vessels						
Vessel strikes	Low	Widespread	Current	Recurrent	Unknown	Low
Threat category #4: Exposure to contaminants						
Contaminants from industrial development, operations, and associated activities	Low	Localized	Unknown	Unknown	Unknown	Low

4.2. Description of threats

The four threat categories identified for the Sowerby's Beaked Whale (Table 2) were derived from the "COSEWIC Assessment and Update Status Report" (COSEWIC 2006), and are described in detail below. Assessing the population-level impact of these threats is not possible without a population estimate. Furthermore, species-threat interactions in their preferred offshore habitat are rarely observed and poorly understood. Williams et al. (2011) estimated that, on average, carcasses are recovered from just 2% of cetacean deaths. The impacts of threats on cetaceans are therefore prone to being underestimated (Weilgart 2007). In the absence of specific information regarding the Sowerby's Beaked Whale, much of the discussion below relates to what is known about other beaked whale species, such as the Northern Bottlenose Whale, or beaked whales in general.

4.2.1. Anthropogenic noise

Sound is of critical importance to whales. They use highly sensitive auditory systems and vocalizations (including echolocation in toothed whales) to navigate their environment, communicate, and locate prey (Richardson et al. 1995). Consequently, the introduction of human-made sounds into the ocean can result in both physiological and behavioural impacts of varying magnitudes. There are three main frequency bands within which different noise sources are grouped: low-frequency (10 Hz to 500 Hz), medium frequency (500 Hz to 25 kHz), and high frequency (>25 kHz) (Hildebrand 2009).

Mesoplodonts are categorized in the mid-frequency functional hearing group, which includes cetaceans that hear sound between 150 Hz and 160 kHz (Southall et al. 2007). Consequently, mesoplodonts may be vulnerable to disturbances or harm from anthropogenic sources that emit sounds in this frequency range. Deep-diving species may be especially susceptible to noise disturbances due to the concentrated and extended transmission of sound in the "SOFAR channel", or Sound Fixing and Ranging channel (Evans 2002). The SOFAR channel is a horizontal layer of water in the ocean that corresponds to the depth at which the speed of sound is lowest, typically falling between 600 and 1200 m depth in the low and mid-latitudes (Nieukirk 2013). The SOFAR channel acts as a waveguide for sound, allowing acoustic signals, particularly low-frequency ones, to travel many kilometres with minimal energy loss.

Anthropogenic noise can be broadly separated into two categories, acute (or impulsive) and chronic (or continuous) (CBD 2014), which are discussed further below. Comprehensive information on marine mammals and noise, including the typical characteristics of anthropogenic noise sources (e.g. sound pressure levels, frequencies, durations), are available in the following sources: Richardson et al. (1995), NRC (2003) and Hildebrand (2009).

Exposure to acute noise

There are several sources of acute (i.e. loud and of relatively short duration) anthropogenic noise in the marine environment that may affect Sowerby's Beaked Whales, including sonar, underwater explosions, and seismic exploration. Pile-driving, which may be used during the construction of offshore infrastructure, is another source of acute noise, but it mostly falls outside of the hearing and vocalization range of toothed whales (Hildebrand 2009).

(1) Active sonar

Active sonar is used in a variety of military (e.g. anti-submarine warfare), scientific (e.g. sub-bottom profiling), and civilian (e.g. fish finding) applications. Beaked whales are thought to be highly sensitive to active sonar in the mid-frequency (specifically, 2-10 kHz) band (Cox et al. 2006). Mid-frequency active sonar is most often used during military tactical exercises; however, research activities, particularly those that use sub-bottom profilers, may also be conducted within this frequency band (MMC 2007; Hildebrand 2009). Several mass strandings of beaked whales worldwide have been linked in time and space to the use of naval mid-frequency active sonar (Cox et al. 2006; Weilgart 2007; d'Amico et al. 2009). Necropsies of stranded whales from these events have revealed injuries consistent with acoustic trauma (e.g. Evans et al. 2001; Fernández et al. 2005). Cox et al. (2006) suggested several possible mechanisms through which beaked whales may strand or die from active sonar exposure, including:

- Behavioural responses:
    - Attempting to avoid the sound source by swimming into shallow waters where stranding may occur.
    - Altering normal dive patterns, resulting in secondary tissue damage due to hypoxia or gas bubble formation.
- Physiological changes:
    - Disorientation due to a vestibular response (i.e. sense of balance is affected).
    - Stress-induced hemorrhaging.
- Primary tissue damage resulting directly from the acoustic energy.

Of these potential mechanisms, Cox et al. (2006) found gas bubble formation to be the most plausible. Beaked whales tend to perform deeper dives, with slower ascent and descent rates, than other whales. They also spend less time at the surface. As a result, their tissues may experience up to 300% nitrogen supersaturation during a single dive sequence, which is among the highest levels modeled for cetaceans (Houser et al. 2001). Their deep-diving behaviour and physiology puts beaked whales at risk for decompression sickness, also referred to as "the bends" (e.g. Bernaldo de Quirós et al. 2012; Fahlman et al. 2014). When the normal dive sequence of a beaked whale is altered, as might happen during an avoidance reaction, the risk of developing gas bubble emboli is elevated (e.g. Fernández et al. 2005; Zimmer and Tyack 2007; Parsons et al. 2008). It has also been theorized that gas bubbles may form or grow in

supersaturated tissues as a direct result of intense sound exposure (Houser et al. 2001; Crum et al. 2005).

(2) Underwater explosions

Cetaceans can suffer acoustics-related blast injuries, including organ damage and rupture of gas-filled cavities, from underwater explosions (Weilgart 2007). Explosions generate both a shock wave and an acoustic wave, and may occur during naval exercises or the removal of structures such as offshore oil and gas platforms.

Naval weapons training is rarely conducted in Atlantic Canadian waters, and is restricted to specific exercise areas on the shelf off Halifax that do not overlap with known Sowerby's Beaked Whale habitat (Breeze and Horsman 2005; CCG 2014). To date, one oil and gas platform, located to the west of Sable Island, has been decommissioned on the Scotian Shelf (CNSOPB 2013a). In that case, explosives were not used to remove the fixed infrastructure (Jacques Whitford Environment Limited 2004). There have been no platforms decommissioned on the NL Shelf (CNLOPB 2014). Over the coming decades, decommissioning activities may become more frequent in Atlantic Canadian waters as the industry expands its offshore operations.

(3) Seismic surveys

Seismic surveys used for geophysical research and oil and gas exploration emit short, loud, low-frequency blasts of sound into the marine environment at regular intervals (Richardson et al. 1995). Madsen et al. (2006) found that seismic air-gun arrays also generate sound by-products in the sensitive hearing range of beaked whales (i.e. mid-frequencies). Seismic surveys are a source of both acute and chronic noise, as they can last several weeks or months. The sounds produced during seismic surveys are believed to have a number of primarily behavioural impacts on cetaceans, which are discussed further under "Exposure to chronic noise" (e.g. Gordon et al. 2002; DFO 2004a; Weilgart 2007). Acute injury and mortality in marine mammals have not been linked conclusively to seismic sound exposure (DFO 2004a). Circumstantial evidence exists for this linkage in the case of two beaked whales that were discovered freshly stranded in the Gulf of California in September 2002 coincident with a nearby seismic survey (Taylor et al. 2004). However, the research vessel conducting the survey was also using two active sonar systems at the time, including a sub-bottom profiler in the mid-frequency range, making it difficult to draw definitive conclusions about the cause of the stranding (Cox et al. 2006). Nonetheless, sounds produced by air gun arrays during seismic surveys are among the highest amplitude (i.e. loudest) anthropogenic sounds in the marine environment (Richardson et al. 1995), and have the potential to invoke temporary or permanent hearing loss in marine mammals (e.g. DFO 2004a; Weilgart 2007). Because of their strong reliance on sound, such a loss could have lethal consequences for cetaceans.

The CNSOPB and CNLOPB periodically announce a Call for Bids within their respective jurisdictions. Through these competitive bidding processes, licences may be awarded

for selected land parcels. There is currently renewed commercial interest in Scotian Shelf oil and gas reserves (CNSOPB 2013b), which could result in an increase in seismic surveys. Twelve exploration licenses for Scotian Shelf parcels were issued between March 2012 and January 2013. Exploration in the deeper waters off the Scotian Slope is expected to increase in coming years. CNSOPB's 2014 Call for Bids (CNSOPB 2014a) included parcels east of the Gully along the Scotian Slope that partially overlap with known Sowerby's Beaked Whale habitat, specifically, Shortland and Haldimand Canyons. In the NL Shelf region, 38 exploration licenses were active as of March 2013 (CNLOPB 2013).

Exposure to chronic noise

Sources of chronic (i.e. long in duration or frequently repeated) noise in the marine environment include commercial shipping, recreational boat traffic, drilling (e.g. for petroleum), construction (e.g. oil and gas platforms, coastal structures), and renewable energy turbines (of which there are currently none offshore in Atlantic Canada). Acute sources of noise disturbance, such as seismic surveys, can also be chronic if they continue for long periods of time or recur frequently. Anthropogenic noise levels in the ocean have been rising exponentially over several decades (Weilgart 2007), primarily due to increased commercial shipping activity (Frisk 2012). Vessel activity is moderate to high throughout the suspected Canadian range of the Sowerby's Beaked Whale, with the exception of the area north of St. John's, NL, where vessel activity is very low to low (Koropatnick et al. 2012). Noise disturbances generated by commercial vessels are principally in the lower frequencies, making them of greater concern for baleen whales, which communicate in the same range. However, there is evidence to suggest that large, fast-moving cargo ships may also introduce high-frequency noise disturbances that are within the sensitive hearing range of beaked whales (Aguilar Soto et al. 2006). This high-frequency noise is thought to result from increased cavitation from the ship's propellers, a phenomenon that increases with vessel speed. The contribution of high-frequency noise from commercial shipping may increase over time due to advances in technology that allow for the manufacture of faster ships (Southall 2005; Aguilar Soto et al. 2006).

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. Direct behavioural responses to noise disturbances have been documented, such as displacement or avoidance of habitat and changes in vocalization patterns (e.g. DFO 2004a; Weilgart 2007). Marine mammals also may be indirectly affected by noise-induced changes in prey availability. Physical and behavioural acoustic impacts on fish, squid, and crustacean species have been documented with varying levels of causal certainty (e.g. McCauley et al. 2003; DFO 2004b; Weilgart 2007). Chronic stress from exposure to persistent noise could have long-term health effects on individuals and the larger population; however, long-term impacts such as these are poorly understood in marine mammals (DFO 2004a; Weilgart 2007). Some sources of chronic noise are expected to increase offshore in Atlantic Canada, particularly those related to oil and gas activities, including seismic surveys, drilling,

construction, and operations. There are currently two active oil and gas projects on the Scotian Shelf (near Sable Island) and three projects active on the NL Shelf (near Grand Banks) (CNSOPB 2013a; CNLOPB 2013). As of March 2013, there were 33 significant discovery licenses issued for Scotian Shelf land parcels, and 52 issued for parcels on the NL Shelf, so further production projects may be expected in the future. Vessel traffic in support of oil and gas activities is also likely to increase.

4.2.2. Interactions with fishing gear

Entanglements

In 1984, a live Sowerby's Beaked Whale was observed entrapped in fishing gear in Conception Bay, Newfoundland (Dix et al.1986). It was freed, but stranded twice in the subsequent days, eventually dying. During the summer of 2013, two entangled Sowerby's Beaked Whales were observed in the Gully (Narazaki 2013). Both whales had injuries coinciding with the placement of the entangled rope (e.g. Figure 8). In each case, it is not known from which fishery the entangled gear originated. Scarring indicative of previous entanglement has been observed on several Sowerby's Beaked Whales in Atlantic Canadian waters. Lien et al. (2002) noted a scar that completely encircled the head of an animal that stranded in Boyd's Cove, Newfoundland, in October 2001. They suggested the scar was consistent with prior capture in a gill net. Suspected entanglement scarring has also been observed on animals in the Gully (e.g. Figure 9; O'Brien 2013). Due to the offshore distribution of this species, it is likely that entanglements are under-reported.

Prior to 1999, the Sowerby's Beaked Whale, along with other beaked whale species, was often reported as bycatch in the now-prohibited swordfish drift gillnet fishery in the U.S. (Waring et al. 2001; Waring et al. 2013). A total of 24 confirmed Sowerby's mortalities occurred in this fishery between 1989 and 1998. There is no similar fishery in Canada.

Given their similar habitat preferences and foraging behaviour, it may also be relevant to consider entanglement events involving Northern Bottlenose Whales. In Atlantic Canada, three instances of Northern Bottlenose Whale entanglement in longline gear have been reported through the At-Sea Observer Program (DFO 2010 & 2016a), and another instance was recorded in the Gully by Gowans et al. (2000). Five other Northern Bottlenose Whale entanglements in unspecified gear types have been reported through the At-Sea Observer Program since the 1980s (DFO 2010 & 2016a). There are currently no Sowerby's Beaked Whale records in the At-Sea Observer Program database.

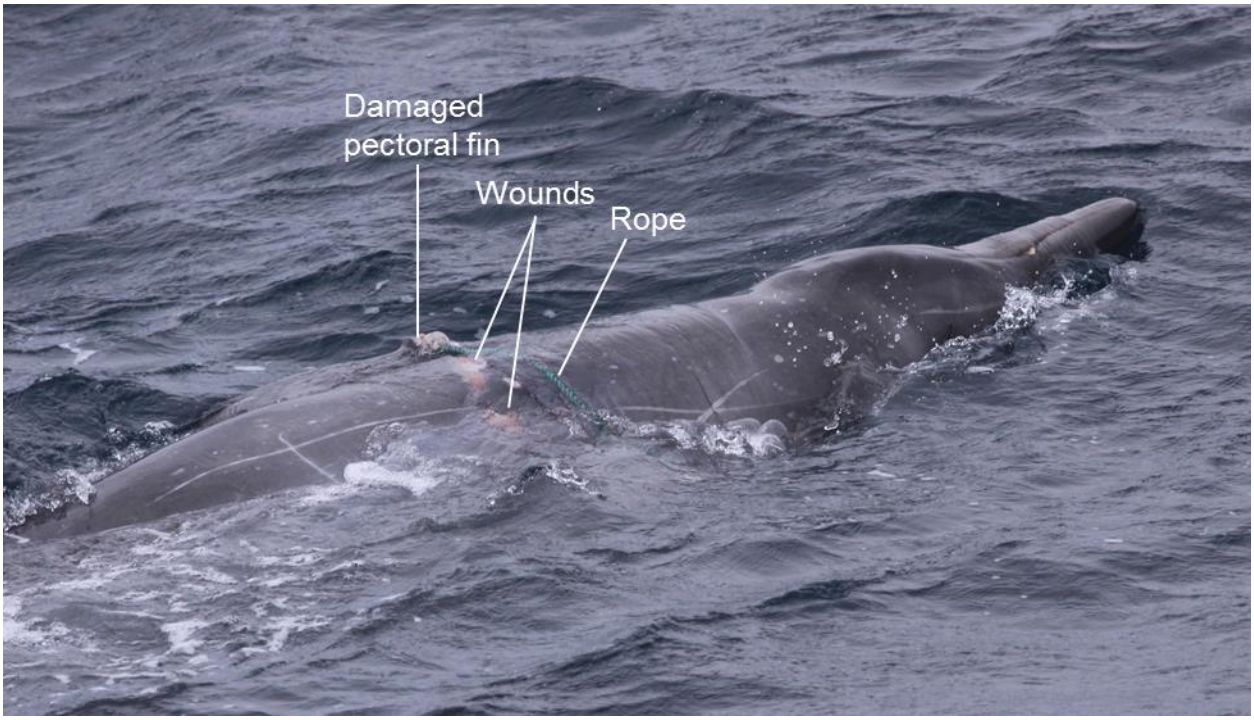

Figure 8. An entangled Sowerby's Beaked Whale floating on its side in the Gully, which was discovered and freed during the summer of 2013. Rope and fresh wounds are visible on the body and pectoral fin. Photo credit: K. O'Brien, Whitehead Lab, Dalhousie University.

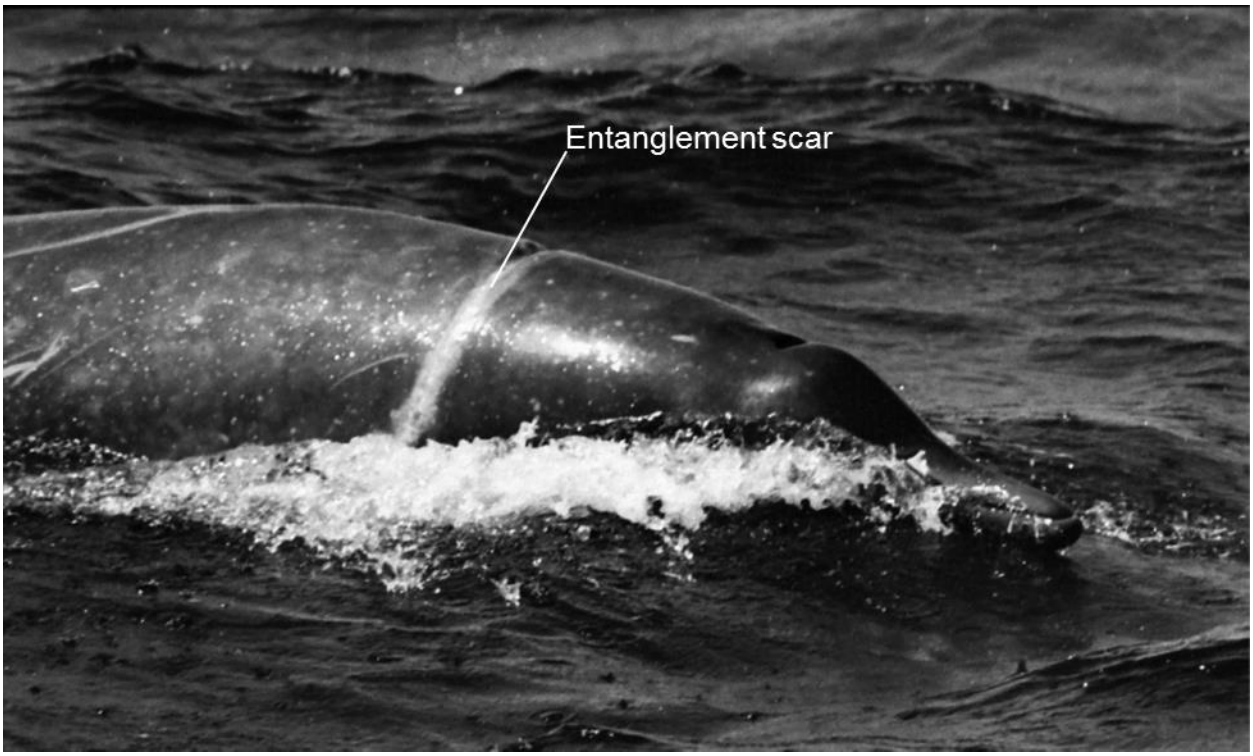

Figure 9. Scarring suggesting past entanglement on a Sowerby's Beaked Whale observed in the Gully in 2003. Photo credit: Whitehead Lab, Dalhousie University.

4.2.3. Interactions with vessels

Vessel strikes

As mentioned previously, vessel activity is generally moderate to high throughout the Canadian range of the Sowerby's Beaked Whale, with the exception of the most northerly extent (Koropatnick et al. 2012). In Canada, two instances of Sowerby's Beaked Whale mortality presumed to be caused by vessel strikes have been documented. In 1997, a stranded Sowerby's Beaked Whale on Sable Island, Nova Scotia had long, deep, fresh wounds and a series of apparent dents on its mid-flank, beneath which were eight broken ribs (Lucas and Hooker 2000). A vessel strike was suggested by the authors as the cause of death. In 2004, a Sowerby's Beaked Whale was found stranded in Conception Bay, Newfoundland with a fractured jaw, five fractured ribs, and a fractured rostrum (Ledwell et al. 2005). Once again, the authors concluded that a vessel strike was the likely cause of death. Evidence of recovery from a vessel strike was found in a stranded Sowerby's Beaked Whale on the north shore of Prince Edward Island in 2013 (Daoust 2013). The necropsy revealed a number of healed rib and possible vertebral fractures. Vessel-related fatalities and injuries have also been recorded in several other beaked whale species worldwide (Van Waerebeek et al. 2007; Carrillo and Ritter 2010).

Little is known about vessel interactions with small cetaceans (Van Waerebeek et al. 2007). The threat posed by vessel interactions is likely lessened for beaked whales because of their extended dive times and limited surface time. Furthermore, mesoplodont whales have been mostly observed travelling away from vessels, and may even dive to avoid them (Pitman 2002; Barlow et al. 2006). Nonetheless, when these whales are at the surface they are difficult to detect (Barlow and Gisiner 2006), making it more challenging for vessels to avoid them if necessary (Van Waerebeek et al. 2007). Due to the offshore distribution of the Sowerby's Beaked Whale, ship strike injuries are likely under-reported.

4.2.4. Exposure to contaminants

Contaminants from industrial development, operations, and associated activities

Marine mammals, like other wildlife, are susceptible to the toxic effects of persistent contaminants (e.g. Fox 2001). Top predators, such as whales, are especially vulnerable due to the biomagnification of pollutants in the food chain (Ross et al. 2007). The high trophic level of whales, coupled with their longevity and extensive fat stores, can result in tissue contamination levels unparalleled in other species (Reijnders et al. 1999). Bioaccumulation of chemicals in the tissues of whales can have adverse effects on general physiology, reproduction, immunity, genetics, and development, with possible long-term impacts at the population level (e.g. Reijnders et al. 1999; Tanabe 2002; DFO 2007a; Ross et al. 2007).

Offshore pollution typically originates from shipping and industrial activity (e.g. oil and gas development, mineral extraction) (Kachel 2008). Accidental or operational discharges from these activities can lead to elevated levels of hydrocarbon compounds (e.g. polycyclic aromatic hydrocarbons [PAHs]), persistent toxic substances (e.g. DDT), heavy metals (e.g. lead, mercury), and/or radioactive materials in the marine environment. A vessel collision, grounding, sinking, or loss of cargo can introduce large amounts of contaminants to the marine environment.

Information on contaminant levels in Sowerby's Beaked Whales is limited. Analyses of liver tissue samples from 11 stranded cetacean species in England and Wales revealed high mercury concentrations in the two beaked whale specimens, one of which was a Sowerby's Beaked Whale (Law et al. 2001). Law et al. (2001) suggested that these results could be explained by the hypothesis of Monteiro et al. (1996) whereby organic mercury bioaccumulation is enhanced in deep (>200 m) waters.

Hooker et al. (2008) analyzed Northern Bottlenose Whale skin and blubber samples from the Gully for organochlorine contaminants. They found several classes of contaminants in the samples, including DDTs, PCBs, and chlordanes, among others. A statistically significant increase in persistent DDE (a breakdown product of DDT) and chlordanes between 1996-97 and 2002-03 was noted. The authors reasoned that oil and gas activity in the area could have caused an increase in contaminant levels in local water and/or prey by disturbing sediment and remobilizing contaminants. The observed contaminant concentrations were not inconsistent with other North Atlantic toothed whales, and were not high enough to cause serious health problems. Nonetheless, Hooker et al. (2008) found the results concerning since offshore oil and gas development is expected to continue to increase on the Scotian Shelf. These findings may also warrant concern for the Sowerby's Beaked Whale which appears to share much of the same habitat.

5. Management objectives

The objectives of this Management Plan are to:

1) Maintain a stable Sowerby's Beaked Whale population throughout its range in Atlantic Canadian waters.
2) Quantify and mitigate the effects of identified threats on the population.

It is believed that these objectives can be achieved through the continued application of the actions described in Section 6.2, and the timely implementation of the conservation measures outlined in Sections 6.3 and 6.4. Because uncertainty around population size and species biology is high, addressing knowledge gaps is of crucial importance to meeting the management objectives. A growing knowledgebase will contribute to more effective threat mitigation over time. Currently, in the absence of conclusive data on the population-level impacts of identified threats (Section 4.2), a precautionary approach to management must be adopted to ensure the Sowerby's Beaked Whale does not become threatened or endangered.

6. Broad strategies and conservation measures

6.1. Broad strategies

The conservation measures proposed for the Sowerby's Beaked Whale are organized under three broad strategies:

1) **Research and monitoring:** This broad strategy seeks to improve our understanding of Sowerby's Beaked Whale biology, behaviour, population size and trend, and distribution, as well as the threats posed to the species by human activities.
2) **Management:** This broad strategy seeks to appropriately monitor and mitigate known threats to the Sowerby's Beaked Whale and its habitat through the application of regulatory and non-regulatory measures.
3) **Engagement and public outreach:** This broad strategy seeks to increase stakeholder and public involvement in, and awareness of, the Sowerby's Beaked Whale and its threats by establishing regular communication, developing educational materials, and realizing collaborative stewardship opportunities.

The above broad strategies and their associated conservation measures support the management objective discussed in Section 5. Several conservation measures are already in progress, and are discussed in Section 6.2. Further recommended measures are outlined in the prioritized implementation schedule (Section 6.3) and associated narrative (Section 6.4).

6.2. Actions already completed or currently underway

6.2.1. Research and monitoring

To date, there have been no targeted field studies or surveys of the Sowerby's Beaked Whale in Canada. The information currently available for this population has been collected either opportunistically or as part of broad cetacean surveys. Specifically, Sowerby's Beaked Whale sightings and photographs for photo-identification purposes have been collected during studies focused on the Northern Bottlenose Whale (e.g. Hooker and Baird 1999; Narazaki 2013; O'Brien 2013; Whitehead 2013). In the summer of 2007, DFO conducted its first systematic, large-scale aerial survey of cetaceans in Atlantic Canadian waters as part of the multinational Trans North Atlantic Sightings Survey (Lawson and Gosselin 2009). A total of 35 whales belonging to the genus *Mesoplodon* were observed in nine sighting events on the Scotian Shelf during the survey. No mesoplodonts were detected in the survey strata outside of the Scotian Shelf. Wimmer and Whitehead (2004) surveyed Scotian Shelf waters along the 1000 m depth contour between 54° and 72°W. During that survey, Sowerby's Beaked Whales were observed near Georges Bank/Browns Bank and in the Gully, Shortland, and Haldimand Canyons. In addition, the Northeast Fisheries Science Center (NEFSC) of the National Oceanic and Atmospheric Administration (NOAA) has conducted aerial and

shipboard surveys of cetacean abundance every 1-3 years since 1995 (NEFSC 2013). Several undifferentiated mesoplodont sightings have been recorded during these surveys, which have included line-transects on the Scotian Shelf[8] (e.g. Waring et al. 2013; NEFSC 2013).

A Sowerby's Beaked Whale photo-identification project was completed recently in which photographs taken on the Scotian Shelf between 1997 and 2012 were compiled and analyzed (O'Brien 2013). DFO, in cooperation with the Whitehead Lab at Dalhousie University, is currently developing a digital photo-identification catalogue as a next step to this work. The catalogue will help standardize how Sowerby's Beaked Whale photographs are collected and analyzed, and could eventually help answer important questions regarding social structure, population dynamics, and site fidelity. DFO is also developing a beaked whale multimedia database for storing photographs, videos, and audio files.

Passive acoustic monitoring of cetaceans and ambient noise is currently being conducted by DFO Science at sites in and around the eastern Scotian Shelf canyons (Cochrane and Moors-Murphy 2013). Between October 2012 and October 2014, acoustic recorders were deployed at three sites for 5-7 month periods with 1-2 month breaks between deployments: 1) in the Gully, 2) between the Gully and Shortland Canyon, and 3) between Shortland and Haldimand Canyons. An acoustic recorder was again deployed in May 2015 in the Gully. This unit is expected to be in place until 2017. The recordings collected are being analyzed for potential Sowerby's Beaked Whale echolocation clicks. Beaked whale vocalizations that have been recorded in the frequency range of 70-90 kHz are suspected to be associated with Sowerby's Beaked Whales, as they are higher frequency than those typically associated with Northern Bottlenose Whales. Once Sowerby's vocalizations have been fully characterized and confirmed, these acoustic data will help contribute to our understanding of habitat use over various temporal scales (i.e. daily, monthly, seasonally, annually). Cholewiak et al. (2013) described the echolocation clicks associated with several small groups of Sowerby's Beaked Whales encountered along the continental slope off of Georges Bank (40.8°N and 66.5°W). This work will help guide the analysis of Scotian Shelf recordings.

In March 2014, DFO's Canadian Science Advisory Secretariat (CSAS) hosted a National Science Advisory Process on seismic sound mitigation and monitoring in habitat areas frequented by at-risk cetacean species, including beaked whales. The objective of this meeting was to obtain peer-reviewed science advice and information on sound exposure thresholds and mitigation guidelines for seismic surveys. The Science Advisory Report (DFO 2015) provides recommendations for enhanced mitigation measures to be considered for seismic survey operations occurring in areas overlapping SARA-listed cetacean habitat. The report also identifies research needs relevant for establishing seismic sound exposure thresholds and assessing how effective mitigation measures are in avoiding SARA-prohibited impacts on species at risk.

[8] Up to the Laurentian Channel, with progressively fewer transects with distance north of the U.S.-Canada border (NEFSC 2013).

Several post-mortem studies of stranded Sowerby's Beaked Whales in Canada have been completed (e.g. Lucas and Hooker 2000; Lien et al. 2002; Ledwell et al. 2005; Daoust 2013; Lair 2013). This research has helped advance our knowledge of species biology and anthropogenic threats.

6.2.2. Management

There are several regulatory and non-regulatory mechanisms through which threats to the Sowerby's Beaked Whale and its habitat are currently managed and mitigated.

General prohibition on marine mammal disturbance

All marine mammals are protected from human disturbance under section 7 of the *Marine Mammal Regulations* (SOR/93-56) made pursuant to the federal *Fisheries Act* (R.S.C. 1985, c.F-14), except when being fished under the authority of those regulations (e.g. a licence to fish for scientific or experimental purposes).

DFO operational guidelines for cetacean management

In April 2012, DFO finalized its "Operational Guidelines for the Conservation of Cetaceans" and the associated decision tool (DFO 2012). These guidelines are national in scope and provide a framework for consistent and transparent decision-making in cetacean management. The goal of the policy is "…to encourage resilient cetacean populations through the application of sustainable management practices…" (p. 3). A decision tree was developed based on five categories of human activities that impact cetaceans.

Area-based management measures

On 7 May 2004, the *Gully Marine Protected Area Regulations* (SOR/2004-112) came into force. The Gully Marine Protected Area (MPA) was designated pursuant to subsection 35(3) of the *Oceans Act* (S.C. 1996, c.31), and consists of three management zones, each of which is afforded a different level of protection (DFO 2008). Zone 1, where many Sowerby's Beaked Whale sightings have occurred, is strictly protected, with general prohibitions on the disturbance, damage, destruction, or removal of any living marine organism or its habitat. Depositing, discharging, or dumping any substance that could result in any of the aforementioned effects is also prohibited, regardless of whether the activity occurs inside or outside the Gully MPA. Exceptions to the general prohibitions are made in Zones 2 and 3. Vessels are permitted to transit the Gully MPA provided they are fully compliant with the *Canada Shipping Act, 2001* and its associated regulations. A management plan for the Gully MPA was finalized by DFO in 2008. The plan identifies priority conservation issues and actions, including protecting cetaceans, such as the Sowerby's Beaked Whale, from the impacts of human activities (DFO 2008).

The Gully, Shortland, and Haldimand Canyons have been identified as critical habitat in the Recovery Strategy for the endangered Northern Bottlenose Whale (DFO 2010 & 2016a). The SARA subsection 58(1) prohibition on the destruction of critical habitat already applies in the Gully MPA (Government of Canada 2010). The remaining two critical habitat areas will be protected from destruction by a Critical Habitat Order made pursuant to paragraph (a) of subsection 58(5) of SARA. The protection afforded to these areas will also benefit the Sowerby's Beaked Whales known to occur in these canyons.

Oil and gas exploration and development

The Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) and the Canada-Newfoundland and Labrador Offshore Petroleum Board (CNLOPB), formed pursuant to section 9 in the *Canada-Nova Scotia Offshore Petroleum Resources Accord Implementation Act* (S.C. 1988, c.28) and the *Canada-Newfoundland Atlantic Accord Implementation Act* (S.C. 1987, c.3), respectively, regulate the offshore oil and gas industry. Ensuring environmental protection is a mandate of the Accord Act legislation, and each Board has adopted a series of policies and guidelines to achieve that end. Oil and gas operators must adhere to these environmental standards as a condition of authorization. For example, the "Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment" (DFO 2007b) applies to all seismic surveys in Canadian waters. Operators complying with this Statement must plan and conduct their seismic survey in such a way that the amount of sound energy used is minimized, and that any potential adverse effects on marine mammals and sea turtles are avoided. Depending on the nature of the activity to be undertaken, the Boards also require operators to submit an Environmental Protection Plan with their authorization application, as per the "Environmental Protection Plan Guidelines" (NEB 2011). The Plan further commits the operator to following the "Offshore Waste Treatment Guidelines" (NEB 2009) and the "Offshore Chemical Selection Guidelines" (NEB 2010). Drilling and production projects must undergo regular scientific monitoring of environmental effects (CNSOPB 2013b; CNLOPB 2013). The Boards each have compliance monitoring and enforcement programs in place, which include on-site audits and inspections.

The CNSOPB has excluded all petroleum activities from the Gully since 1998, and have stated that any future activity near the area could be subject to mitigation requirements beyond the standard (CNSOPB 2014b). Similarly, the Board included the following statement in the 2014 Call for Bids, which includes land parcels near Northern Bottlenose Whale critical habitat areas (which are also known to host Sowerby's Beaked Whales): "Any approved activity within or near these areas may require enhanced mitigation and may include certain limitations to avoid the destruction of critical habitat" (CNSOPB 2014c). Although there is no critical habitat identified under SARA for Special Concern species, the Sowerby's Beaked Whale is likely benefitting from the SARA prohibitions that apply to Northern Bottlenose Whale critical habitat.

In each of the Accord Acts, section 46 calls for coordination among government agencies on a series of items including environmental regulation. This coordination has

been accomplished through the establishment of Memoranda of Understanding (MOU). Both the CNSOPB and C-NLOPB have entered into MOUs with DFO and Environment and Climate Change Canada for the purposes of strengthening protection of the marine environment.

Offshore oil and gas drilling and production activities, and some decommissioning activities, are listed in the *Regulations Designating Physical Activities* (SOR/2012-147) made pursuant to section 84 of the *Canadian Environmental Assessment Act, 2012* (CEAA, 2012) (S.C. 2012, c.19, s.52). These activities are subject to the applicable requirements of that Act. Furthermore, pursuant to section 79 of SARA, whenever an environmental assessment is required by an Act of Parliament, the appropriate minister(s) must be immediately notified if the designated activity is likely to affect a listed wildlife species, including species of Special Concern. Any adverse effects the activity may have on the species must be avoided or mitigated and monitored. The CNSOPB and CNLOPB conduct environmental assessments on all oil and gas-related activities within their respective jurisdictions that do not fall under CEAA, 2012 (e.g. seismic surveys and some decommissioning activities) (CNSOPB 2013b; CNLOPB 2013). The approach to these environmental assessments is very similar to the pre-2012 CEAA screening process, and is equally thorough.

Naval activities

The North Atlantic Treaty Organization (NATO) has rules and procedures in place to mitigate the threat of active sonar and other naval activities on marine mammals, and in particular, beaked whales (Ryan 2009). The Royal Canadian Navy (RCN) has adopted marine mammal mitigation procedures that are consistent with NATO practices, as directed in MARCORD 46-13 "Marine Mammal Mitigation Procedures" (DND 2008) and described in the Ship Class Safety and Environmental Management Systems (SEMS) Manuals. The Department of National Defence and the Canadian Forces are committed to exercising environmental stewardship as described in Defence Administrative Order and Directive 4003-0 "Environmental Protection and Stewardship" (DND 2004). The RCN have several mechanisms in place to manage their operating areas such that threats to the marine environment and marine mammals are minimized. In Atlantic Canada, MARLANTORD 44-4 ensures that environmental considerations are taken into account during the planning and execution of naval activities in the region. The order's overarching environmental directives include avoiding known high-use marine mammal habitat, using the Maritime Operating Area Management Plan, and adhering to MARCORD 46-13. The RCN also has an environmental assessment program in place. Together, these mechanisms contribute to ensuring that military activities are conducted in a responsible and environmentally sustainable manner, and in compliance with the *Fisheries Act*, SARA, and other federal legislation.

Shipping

Vessel conduct in Canadian waters is governed by the *Canada Shipping Act, 2001* (S.C. 2001, c.26). Parts 8 and 9 of the Act address pollution prevention exclusively.

There are two sets of associated regulations that are intended to reduce the risk of harmful contamination of Canadian waters. Specifically, the *Ballast Water Control and Management Regulations* (SOR/2011-237) protect against the introduction of non-indigenous organisms and pathogens, while the *Vessel Pollution and Dangerous Chemicals Regulations* (SOR/2012-69) seek to prevent or minimize pollution caused by oil, chemicals, noxious liquids, sewage, garbage, and air emissions.

Each year, the Canadian Coast Guard issues a series of Notices to Mariners (e.g. CCG 2014). Notices 5 and 5A are dedicated to vessel conduct around marine mammals, as well as in and around MPAs (e.g. the Gully) and critical habitat areas. These Notices highlight relevant legislation and regulations, and provide guidelines on speed reductions, the use of echo sounders to indicate vessel presence, and incident reporting, among other items. The coordinates of MPAs and critical habitat areas are provided in the Notices with a recommendation to avoid them if possible.

In July 2009, the International Maritime Organization (IMO) approved the "Guidance Document for Minimizing the Risk of Ship Strikes with Cetaceans" (IMO 2009). This document was subsequently circulated to Member Governments, including Canada, for consideration and wider distribution to relevant industry stakeholders.

Disposal at sea

Division 3, Part 7 of the *Canadian Environmental Protection Act, 1999* (S.C. 1999, c.33) prohibits the disposal of substances at sea from a vessel, aircraft, platform, or other structure. Similarly, subsection 36(3) of the *Fisheries Act* prohibits the unauthorized deposition of deleterious substances in waters frequented by fish, including marine mammals.

Incident reporting and response

Under the umbrella of the Marine Mammal Response Program, DFO supports marine mammal incident response networks across the country that deal with deceased, stranded, entangled, or otherwise injured animals. In addition to providing expert care and assistance to distressed animals, these networks provide valuable data that can be used to help quantify threats to species at risk (e.g. DFO 2013). The Maritime Marine Animal Response Network (MMARN) is composed of a number of animal rescue and research organizations (MMARN 2014). These organizations coordinate responses to distressed or dead marine animals in the Maritimes. They also coordinate the collection of data and samples from incidents. The Marine Animal Response Society (MARS) is a member of MMARN, and is the primary responder to marine mammal incidents in the Maritimes. In NL, the primary responder to marine mammal incidents is an organization called Whale Release and Strandings-Newfoundland and Labrador (WRS-NL) (also known as Tangly Whales). MARS and WRS-NL each maintain incident and mortality records.

In the Annual Notices to Mariners (e.g. CCG 2014), all vessels are encouraged to report observations of dead or distressed marine mammals to the appropriate regional response network (e.g. MARS) via the emergency hotline or marine VHF radio. Marine Mammal Observers (MMOs), who are stationed on vessels conducting seismic surveys, for example, will also ensure that any observed incidents are reported in accordance with the training they receive.

6.2.3. Engagement and public outreach

To date, DFO has not conducted any directed stakeholder engagement or public outreach on the Sowerby's Beaked Whale outside of the SARA listing consultation process (as summarized in Government of Canada 2011). There has, however, been extensive engagement and outreach on the Northern Bottlenose Whale, a species that shares many of the same threats and which appears to have similar habitat preferences. There has also been extensive engagement on the Gully MPA. The Sowerby's Beaked Whale is featured in DFO's YouTube video entitled "The Gully Marine Protected Area: A Diversity of Life and a Sanctuary for Whales". It has also been highlighted in public/school presentations on the Gully given by regional DFO cetacean scientists. When applicable, Sowerby's-related research findings are discussed at the meetings of the multi-stakeholder Gully Advisory Committee. Overall, the Sowerby's Beaked Whale population has likely benefitted from the awareness generated around the Northern Bottlenose Whale and the Gully MPA.

DFO recently created an informational poster that outlines marine mammal emergency response protocol for sea-going audiences. The poster highlights how to identify an entangled or dead whale, what information to record, and who to call. The purpose of these posters is to increase awareness and reporting of marine mammal incidents, particularly offshore. An entangled Sowerby's Beaked Whale is featured on the poster, which may also help to make the species more recognizable to mariners.

6.3. Conservation measures

Table 3 summarizes the conservation measures recommended to attain the objective of this Management Plan as outlined in Section 5. Each measure is prioritized based on the degree to which it is expected to contribute directly to the conservation of the species or is an essential precursor to an action that will contribute to the conservation of the species. Estimated timelines for completion of the conservation measures are also provided. These timelines may refer to a specific time interval or may be ongoing, meaning the activity is expected to occur regularly throughout an indefinite time period. While DFO has already commenced efforts to implement the Management Plan, the performance of activities that have been included in Table 3, but which have not yet been implemented, will be subject to available funding and other resources. Where appropriate, partnerships with other government departments, First Nations and other Aboriginal organizations, non-governmental organizations, academia, and stakeholders may provide the necessary expertise and/or capacity to complete an activity. Effective management of this species requires the commitment and collaboration of multiple

groups and individuals. Should you or your organization wish to become involved in implementing any of the conservation measures outlined in this Management Plan, please contact the Species at Risk Management Division by email (xmarsara@mar.dfo-mpo.gc.ca) or by phone (1-866-891-0771) for more information.

The Sowerby's Beaked Whale and the Northern Bottlenose Whale share similar biological characteristics, habitat areas, and threat sensitivities. Consequently, several of the recovery measures outlined in the "Action Plan for the Northern Bottlenose Whale (*Hyperoodon ampullatus*), Scotian Shelf population, in Atlantic Canadian waters" (DFO 2016b) are also expected to benefit the Sowerby's Beaked Whale. Opportunities to implement this Management Plan synergistically with the Northern Bottlenose Whale Action Plan will be explored wherever appropriate (Appendix B). This will help to maximize efficiencies as well as benefits to the species.

Table 3. Conservation measures and implementation schedule organized by broad strategy. Abbreviations used in this table: SBW = Sowerby's Beaked Whale; DFO = Fisheries and Oceans Canada; MMARN = Maritime Marine Animal Response Network; MARS = Marine Animal Rescue Society; WRS-NL = Whale Release and Strandings-Newfoundland and Labrador; OGDs = Other government departments; NGOs = Non-government organizations.

BROAD STRATEGY 1: RESEARCH AND MONITORING

#	Conservation measure	Priority	Leads	Partners	Threats or concerns addressed	Timeline
1.1	Estimate population size, trend, and distribution.	High	Academia	DFO	• Knowledge gaps	>5 years
1.2	Continue to build and maintain a beaked whale digital photo- identification catalogue and multimedia database.	High	DFO	Academia	• Knowledge gaps • Need for effective data stewardship	Ongoing
1.3	Maintain database entries for reported SBW sightings and incidents.	High	DFO MARS WRS-NL	Academia Industry OGDs	• Knowledge gaps • Need for effective data stewardship	Ongoing
1.4	Explore ways to improve SBW detection rates for survey, monitoring, and threat mitigation purposes.	Medium	Academia	Industry DFO	• Knowledge gaps	2-5 years
1.5	Conduct scientific studies on SBW biology, behaviour, threat response, and vocalizations.	High	Academia	DFO MMARN	• Knowledge gaps	Ongoing
1.6	Conduct necropsies on deceased SBW and explore opportunities for sharing samples and data with cetacean/SBW specialists.	Medium	MMARN MARS WRS-NL	DFO Academia	• Knowledge gaps	Ongoing
1.7	Develop a SBW tissue bank for cataloguing and storing biopsy samples.	Low	Academia	DFO	• Knowledge gaps • Need for effective data management	2-5 years
1.8	Conduct acoustic studies to determine the source, frequency, and amplitude of noise in SBW habitat, and continue to monitor regularly.	High	DFO	Academia Industry	• Noise exposure	Ongoing

#	Conservation measure	Priority	Leads	Partners	Threats or concerns addressed	Timeline
1.9	Attempt to identify gear types implicated in SBW entanglements.	Medium	DFO	MMARN	• Entanglement	Ongoing
1.10	Evaluate entanglement risk by gear type and area.	Medium	DFO	N/A	• Entanglement	Ongoing
1.11	Evaluate the risk posed by vessel traffic.	Low	DFO	OGDs Industry	• Vessel strikes • Noise exposure • Contaminant exposure	Ongoing
1.12	Analyze contaminant levels in SBW and its prey, as opportunities arise.	Low	Academia	DFO	• Contaminant exposure	>5 years

BROAD STRATEGY 2: MANAGEMENT

#	Conservation measure	Priority	Leads	Partners	Threats or concerns addressed	Timeline
2.1	Continue to review and enhance noise mitigation and monitoring measures.	High	DFO Academia	Industry OGDs	• Noise exposure	Ongoing
2.2	Assess the need for mitigation measures to reduce SBW interactions with fishing gear, and implement as necessary (to be informed by the results of Measures 1.9 and 1.10).	Medium	DFO	Industry	• Entanglement	>5 years
2.3	Assess the need for additional mitigation measures to reduce the threat of ship strikes and harmful contaminant levels, and implement as necessary (to be informed by the results of Measures 1.11 and 1.12).	Low	DFO	OGDs Industry	• Vessel strikes • Contaminant exposure	>5 years
2.4	Continue to support and expand the work of regional marine mammal response networks through the Marine Mammal Response Program.	High	DFO	OGDs NGOs	• Vessel strikes • Noise exposure • Contaminant exposure • Entanglement	Ongoing
2.5	Ensure the best available knowledge on the Sowerby's Beaked Whale is used in decision-making processes across government departments.	High	DFO	OGDs	• Vessel strikes • Noise exposure • Contaminant exposure • Entanglement	Ongoing

BROAD STRATEGY 3: ENGAGEMENT AND PUBLIC OUTREACH

#	Conservation measure	Priority	Leads	Partners	Threats or concerns addressed	Timeline
3.1	Regularly communicate with relevant First Nations, other Aboriginal organizations, and stakeholders regarding the SBW, its threats, and the mitigation measures in place	High	DFO	N/A	• Vessel strikes • Noise exposure • Contaminant exposure • Entanglement	Ongoing

#	Conservation measure	Priority	Leads	Partners	Threats or concerns addressed	Timeline
	to address these threats.					
3.2	Widely publicize offshore cetacean incident reporting procedures.	High	DFO	MMARN MARS WRS-NL	• Vessel strikes • Noise exposure • Contaminant exposure • Entanglement	Ongoing
3.3	Seek and encourage collaborative SBW stewardship and management opportunities within Canada and abroad.	Medium	DFO	OGDs NGOs Industry	• Vessel strikes • Noise exposure • Contaminant exposure • Entanglement	2-5 years
3.4	Include SBW information in public outreach materials (e.g. school presentations, brochures, websites).	Low	DFO	NGOs	• Lack of public awareness	2-5 years

6.4. Narrative to support implementation schedule

6.4.1. Research and monitoring

The conservation of Sowerby's Beaked Whales in Canada relies in part on enhancing our knowledge of where they occur and in what numbers, and whether the population is increasing, decreasing, or remaining the same over time. Increased survey and other dedicated field research efforts throughout the species' range are needed to make these determinations. Such efforts may include visual and acoustic surveys, photo-identification studies, tagging studies, biopsy sampling, and long-term acoustic monitoring of known habitat areas. The small size and inconspicuous surface behaviour[9] of small beaked whales makes them more difficult to visually detect than most other cetaceans, and therefore challenging subjects for field studies. Barlow and Gisiner (2006) estimated that ship-based visual detection rates for *Mesoplodon* species were less than 50% in the best survey conditions (i.e. highly experienced observers, low sea state, excellent visibility). Furthermore, small beaked whales spend the majority of their time diving (15-40 minutes per dive), and typically surface for an interval of less than three minutes (Barlow et al. 2006). They have been characterized as shy, and may actively avoid vessels (Barlow et al. 2006). This is in contrast to the Northern Bottlenose Whale which has been described as curious and often approaches vessels (DFO 2010 & 2016a). To overcome visual detection challenges to the extent possible, survey designs and techniques must be optimized. This may include new and improved training opportunities for at-sea observers and research scientists, which could increase detection rates and the accuracy of opportunistically collected data. Passive acoustic monitoring can be used to complement or enhance visual detection of beaked whales (Barlow and Gisiner 2006), and to monitor behaviour and ecology over longer time scales (Moors 2012). Yack et al. (2013) found the use of a towed hydrophone array

[9] Barlow et al. (2006) described the surface behaviour of small beaked whales as follows: "They typically surface inconspicuously, usually without a splash or visible blow and seldom breach or display other aerial activities. In addition, small beaked whales rarely display their flukes when they dive […]" (p. 264).

platform to be a highly effective survey method for detecting and tracking beaked whales. Sowerby's Beaked Whale vocalizations have yet to be fully described (MacLeod and D'Amico 2006; Moors 2012; Cholewiak et al. 2013), so such real-time acoustic surveys will only be practical once the characteristics of their vocalizations are better understood. Analysis of the in situ Scotian Shelf acoustic recordings described in Section 6.2.1 will contribute to this understanding, as will concurrent acoustic and visual observations of Sowerby's Beaked Whales (such as those made by Cholewiak et al. 2013). Other detection techniques may also warrant investigation, such as remote sensing technologies (e.g. satellite imagery, LIDAR, radar imagery) (Barlow and Gisiner 2006). Overall, an integrated approach to studying Sowerby's Beaked Whales, one that uses both visual and acoustic detection techniques, will likely be the most successful (e.g. Yack et al. 2013).

As the volume of Sowerby's Beaked Whale data rises, there is an increasing need for a means to store, organize, and manage these data efficiently. The existing DFO Cetacean Sightings Databases in the Maritimes and NL Regions were designed to keep a record of cetacean sightings collected from a wide variety of sources (e.g. research scientists, MMOs, fisheries observers, etc.). Marine animal incident and mortality records are maintained by MARS (Maritimes) and WRS-NL (NL). Continued growth and maintenance of the Beaked Whale Digital Photo-identification Catalogue and associated DFO Beaked Whale Multimedia Database is of particular importance for estimating population abundance. The development of a tissue bank for biopsy samples will help address other information management needs. Regular communication and coordination between DFO, the various marine animal response networks, and regional cetacean research labs will be necessary to ensure that the Sowerby's Beaked Whale information in these databases is consistent, organized, comprehensive, current, and readily accessible.

In addition to furthering our scientific knowledge of the basic biology (e.g. diet, growth, reproduction, range) and behaviour (e.g. foraging, social) of the Sowerby's Beaked Whale, a better understanding of the threats posed to this species in Canadian waters is required. This will involve monitoring ambient noise levels in known habitat areas, spatially mapping fishing activities and vessel transits in known habitat areas, examining fishing gear removed from entangled animals, and analyzing contaminant levels in the tissues of Sowerby's Beaked Whales and/or in the tissues of their prey. Examination of the photo-identification catalogue for evidence of gear entanglement or other injuries may complement these activities. In addition, conducting necropsies on deceased whales will help identify and quantify causes of mortality, thereby advancing our understanding of the frequency and severity of threats, while providing opportunities to study the biology of the species. Identifying cetacean specialists with an interest in analyzing tissue samples or obtaining other information from necropsies will play an important role in maximizing knowledge development. Scientific observation and monitoring of the behavioural and physiological effects of identified threats are also needed to better understand how individuals and the population may be impacted.

6.4.2. Management

Optimizing noise mitigation measures is of particular importance, given the potential for this threat to adversely affect the Sowerby's Beaked Whale population. Progress continues to be made toward better understanding how to minimize the threat of acute noise to marine animals (e.g. Nowacek et al. 2013); however, there is still considerable progress to be made. Furthermore, the effectiveness of existing noise mitigation techniques is largely unproven (e.g. Weilgart 2007). Emerging technologies could provide quieter alternatives to those currently used in noise producing marine activities (e.g. regarding seismic air gun alternatives, see Weilgart [2012]). As these technologies are proven effective and become commercially available, their use should be encouraged to reduce noise-related threats.

Once more is known about the potential threat posed by entanglement, further management measures may be considered to help reduce the risk from fishery interactions (e.g. temporal or spatial fisheries closures, changes in gear configurations, reducing the amount of gear or line in the water). Similarly, when more is known about the threat posed by vessel strikes and contaminant levels, further management measures may be investigated and implemented if deemed necessary.

Continued support for regional marine mammal response networks (e.g. MARS, WRS-NL) through the DFO Marine Mammal Response Program and other funding sources will maintain the current capacity to respond to animals in distress and learn more about threat interactions. Opportunities to expand the capacity for offshore response will also be explored. A specific protocol for handling and disentangling beaked whales is needed. Once this protocol is developed, the feasibility of providing training and disentanglement kits to deep-water fishermen, research scientists, and other groups conducting work offshore will be considered.

Regulatory and policy decisions (e.g. environmental assessments) regarding activities that may affect the Sowerby's Beaked Whale or its habitat should be informed by the current state of knowledge on this species, its habitat, and how it reacts to threats. DFO will continue to keep abreast of study results related to the Sowerby's Beaked Whale. Effective internal coordination and communication are necessary to ensure these results are incorporated and considered appropriately in decision-making processes across government departments.

6.4.3. Engagement and public outreach

As a rarely observed offshore species, the Sowerby's Beaked Whale is not well known among stakeholders and the general public. Enhanced communications regarding this species, its habitat, and its threats are necessary to address this lack of awareness and to ensure a cooperative effort is made to conserve this species. Existing engagement mechanisms could be used to share and discuss information pertaining to the Sowerby's Beaked Whale. For example, the Gully Advisory Committee, which provides input into the management of the Gully MPA, meets annually and is composed of

representatives from the federal and Nova Scotia government, First Nations and other Aboriginal organizations, the fishing industry, the oil and gas industry, environmental non-government organizations, and academia. There are also several fisheries working groups, species advisory committees, and other representative bodies such as the Shipping Federation of Canada, the Canadian Marine Advisory Council, and the Canadian Association of Petroleum Producers, through which information sharing could take place. Stakeholder recognition of the Sowerby's Beaked Whale could be improved with the creation and distribution of an offshore whale species identification key (i.e. a visual depiction of each species' distinguishing features). A profile page for the Sowerby's Beaked Whale could also be developed for inclusion on the websites of marine animal response networks (e.g. MARS 2013; WRS-NL 2013).

Offshore cetacean incident reporting procedures need to be highly visible to ocean users. The whale emergency hotline is provided in the Annual Notices to Mariners, as is a DFO email address for providing information on the location and date of whale sightings. The poster recently created by DFO to advertise marine mammal incident reporting procedures (Section 6.2.3) will be widely distributed through existing networks (e.g. MARS, Canadian Whale Institute), DFO field offices, and fishing licence mail-outs.

The nature of the connection between the Canadian and U.S. Sowerby's Beaked Whale populations is unknown. However, based on survey efforts to date, there appears to be continuity in the distribution of the species across the international border (Figure 6). As such, embarking on collaborative stewardship and/or management initiatives with U.S. partners could benefit the Canadian Sowerby's Beaked Whale population. There may also be opportunities for new partnerships to be formed among government, NGOs, and stakeholders in Canada to achieve the conservation objectives outlined in this Management Plan.

Education and outreach materials, including posters, brochures, temporary tattoos, postcards, website profiles, and colouring books, have been developed by DFO over the past decade to raise awareness of the Gully MPA and aquatic species at risk. Future updates to these materials could include information on the Sowerby's Beaked Whale.

7. Measuring progress

In accordance with section 72 of SARA, progress on the implementation of this Management Plan will be assessed every five years following its publication on the Species at Risk Public Registry. The measures outlined in Table 4 will be used to evaluate progress made toward achieving the management objective for this species.

Table 4. Progress measures organized according to the three broad strategies.

Broad strategy	Progress measures
1. Research and monitoring	• Databases have been kept up-to-date and organized. • The beaked whale photo-identification catalogue has been advanced. • Range-wide survey effort has increased. • A preliminary estimate of population size and distribution has been determined. • Scientific studies on species biology and behaviour have been conducted and the results have been published or otherwise made available for the purposes of implementing conservation measures. • Opportunities to observe SBW responses to threats, particularly noise, have been sought out and taken when possible. • SBW vocalizations have been identified and described. • Ambient noise levels have been evaluated in known habitat areas. • Threats have been better quantified. • Visual detection methodologies have been optimized to address species-specific detection challenges. • Training modules for at-sea observers have been expanded and updated to include more SBW information. • Necropsies have been conducted when applicable, and tissue samples have been collected and stored.
2. Management	• Noise mitigation measures have been reviewed and enhanced as needed in response to new scientific information. • A needs assessment has been conducted to determine whether additional management action is necessary to mitigate the other identified threats to SBW. • The regional marine mammal response networks are able to successfully carry out their mandates. • Inter-departmental government coordination and communication on SBW conservation has occurred.
3. Engagement and public outreach	• SBW and threat mitigation information has been communicated to relevant First Nations, other Aboriginal organizations, and stakeholders regularly. • Offshore cetacean incident reporting procedures have been widely distributed. • Collaborative stewardship opportunities have been sought out and pursued as appropriate. • SBW information has been included in outreach materials.

8. References

Aguilar Soto, N., M. Johnson, P.T. Madsen, P.L. Tyack, A. Bocconcelli, J.F. Borsani. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? Marine Mammal Science 22(3): 690-699.

Barlow, J., and R. Gisiner. 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7(3): 239-249.

Barlow, J., M.C. Ferguson, W.F. Perrin, L. Ballance, T. Gerrodette, G. Joyce, C.D. MacLeod, K. Mullin, D.L. Palka, and G. Waring. 2006. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). Journal of Cetacean Research and Management 7(3): 263-270.

Bernaldo de Quirós, Y., O. González-Diaz, M. Arbelo, E. Sierra, S. Sacchini, and A. Fernández. 2012. Decompression vs. decomposition: distribution, amount, and gas composition of bubbles in stranded marine mammals. Frontiers in Physiology 3 (Article 177). 19 pp.

Breeze, H., and T. Horsman (eds.). 2005. The Scotian Shelf: An Atlas of Human Activities. Oceans and Coastal Management Division, Fisheries and Oceans Canada, Dartmouth, NS.

Carrillo, M., and F. Ritter. 2010. Increasing numbers of ship strikes in the Canary Islands: Proposals for immediate action to reduce risk of vessel-whale collisions. Journal of Cetacean Research and Management 11(2): 131-138.

Carlström, J., J. Denkinger, P. Feddersen, and N. Øien. 1997. Record of a new northern range of Sowerby's beaked whale (*Mesoplodon bidens*). Polar Biology 17: 459-461.

CBD (Convention on Biological Diversity). 2014. Background document on the development of practical guidance and toolkits to minimize and mitigate the significant adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity. Subsidiary Body on Scientific, Technical and Technological Advice, eighteenth meeting, Montreal, 23-28 June 2014. UNEP/CBD/SBSTTA/18/INF/11. 81 pp.

CCG (Canadian Coast Guard). 2014. Annual edition: notices to mariners 1-46. April 2014-March 2015. Canadian Coast Guard Programs, Aids to Navigation and Waterways, Fisheries and Oceans Canada, Ottawa, ON.

Cholewiak, D., S. Baumann-Pickering, and S. Van Parijs. 2013. Description of sounds associated with Sowerby's beaked whales (*Mesoplodon bidens*) in the western

North Atlantic Ocean. Journal of the Acoustical Society of America 134(5): 3905-3912.

CNLOPB (Canada-Newfoundland and Labrador Offshore Petroleum Board). 2013. Annual report 2012-13 . Canada-Newfoundland and Labrador Offshore Petroleum Board, St. John's, NL. 54 pp.

CNLOPB. 2014. Regulated projects. Website: http://www.cnlopb.nl.ca/abt_projects.shtml [accessed 4 July 2014].

CNSOPB (Canada-Nova Scotia Offshore Petroleum Board). 2013a. Offshore Activity. Website: http://www.cnsopb.ns.ca/offshore-activity [accessed 13 December 2013].

CNSOPB. 2013b. 2012-2013 annual report. Canada-Nova Scotia Offshore Petroleum Board, Halifax, NS. 54 pp.

CNSOPB. 2014a. Call for bids. Website: http://www.cnsopb.ns.ca/lands-management/call-for-bids [accessed 5 August 2014].

CNSOPB. 2014b. Marine protected area. Website: http://www.cnsopb.ns.ca/environment/marine-protected-area [accessed 15 May 2014].

CNSOPB. 2014c. Environment. Website: http://www.callforbids.ca/content/environment [accessed 15 May 2014].

Cochrane, N., and Moors-Murphy, H. 2013 Passive acoustic monitoring of cetaceans and ocean noise in the Gully Marine Protected Area (MPA) and adjacent areas of the Scotian Shelf. Project proposal for the Strategic Program for Ecosystem-based Research and Advice (SPERA). Fisheries and Oceans Canada, Dartmouth, NS.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 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, ON. vi + 20 pp.

Cox, T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernández, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T. Hullar, P.D. Jepson, K. Ketten, C.D. MacLeod, P. Miller, S. Moore, D.C. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, and L. Benner. 2006. Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7(3): 177-187.

Crum, L.A., M.R. Bailey, J. Guan, P.R. Hilmo, S.G. Kargl, T.J. Matula, and O.A. Sapozhnikov. 2005. Monitoring bubble growth in supersaturated blood and tissue *ex vivo* and the relevance to marine mammal bioeffects. Acoustics Research Letters Online 6(3): 214-220.

Dalebout, M.L. 2002. Species identity, genetic diversity and molecular systematic relationships among the Ziphiidae (beaked whales). Ph.D. dissertation, University of Auckland, New Zealand.

Dalebout, M.L., C.S. Baker, D. Steel, K. Thompson, K.M. Robertson, S.J. Chivers, W.F. Perrin, M. Goonatilake, R.C. Anderson, J.G. Mead, C.W. Potter, L. Thompson, D. Jupiter, and T.K. Yamada. 2014. Resurrection of *Mesoplodon hotaula* Deraniyagala 1963: A new species of beaked whale in the tropical Indo-Pacific. Marine Mammal Science 30(3): 1081-1108.

D'Amico, A., R.C. Gisiner, D.R. Ketten, J.A. Hammock, C. Johnson, P.L. Tyack, and J. Mead. 2009. Beaked whale strandings and naval exercises. Aquatic Mammals 35(4): 452-472.

Daoust, P-V. 2013. Wildlife Diagnostic Report, Canadian Cooperative Wildlife Health Centre, Necropsy #X13631-13. Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PEI.

DFO. 2004a.Review of the scientific information on impacts of seismic sound on fish, invertebrates, marine turtles and marine mammals. DFO Canadian Science Advisory Secretariat Habitat Status Report 2004/002.15 pp.

DFO. 2004b.Potential impacts of seismic energy on snow crab. DFO Canadian Science Advisory Secretariat Habitat Status Report 2004/003.5 pp.

DFO. 2007a. Proceedings of the workshop on the St. Lawrence Estuary beluga-review of carcass program. DFO Canadian Science Advisory Secretariat Proceedings Series 2007/005. vii + 88 pp.

DFO. 2007b. Statement of Canadian practice with respect to the mitigation of seismic sound in the marine environment. Fisheries and Oceans Canada. 5 pp.

DFO. 2008. The Gully marine protected area management plan. Oceans and Coastal Management Division, Fisheries and Oceans Canada, Dartmouth, NS. 75 pp.

DFO. 2010. Recovery Strategy for the Northern Bottlenose Whale (*Hyperoodon ampullatus*), Scotian Shelf population, in Atlantic Canadian waters. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada. vi + 61 p.

DFO. 2012. Operational guidelines for the conservation of cetaceans. Fisheries and Oceans Canada. 7 pp.

DFO. 2013. Marine Mammal Response Program annual report 2011-2012. Website: http://www.dfo-mpo.gc.ca/fm-gp/mammals-mammiferes/publications/6-eng.htm [accessed 9 January 2014].

DFO. 2015. Review of Mitigation and Monitoring Measures for Seismic Survey Activities in and near the Habitat of Cetacean Species at Risk. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/005.

DFO. 2016a. Recovery Strategy for the Northern Bottlenose Whale, (Hyperoodon ampullatus), Scotian Shelf population, in Atlantic Canadian waters. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. vii + 71 pp.

DFO. 2016b. Action plan for the Northern Bottlenose Whale (*Hyperoodon ampullatus*), Scotian Shelf population, in Atlantic Canadian waters. *Species at Risk Act* Action Plan Series. Fisheries and Oceans Canada, Ottawa. v + 40 pp.

Dix, L., J. Lien, and D.E. Sergeant. 1986. A north sea beaked whale, *Mesoplodon bidens*, in Conception Bay, Newfoundland. Canadian Field-Naturalist 100(3):389-391.

DND (Department of National Defence). 2004. DAOD 4003-0, environmental protection and stewardship. Website: http://www.forces.gc.ca/en/about-policies-standards-defence-admin-orders-directives-4000/4003-0.page [accessed 18 December 2013].

DND. 2008. Maritime Command Order: Marine Mammal Mitigation Procedures (MMMP). MARCORD 46-13, Volume 3A. 10 pp.

Evans, D.L., G.R. England, C.C. Lautenbacher, Jr., S.M. Livingstone, W.T. Hogarth, and H.T. Johnson. 2001. Joint interim report: Bahamas marine mammal stranding event of 15-16 March 2000. National Oceanic and Atmospheric Administration, and Department of the Navy, Washington. vi + 59 pp.

Evans, P.G.H., and I. Stirling. 2001. Life history strategies of marine mammals. Pp. 7-62, in P.G.H. Evans and J.A. Raga (eds.). Marine Mammals: Conservation and Biology, Kluwer Academic/Plenum Publishers, New York.

Evans, P.G.H. 2002. Biology of cetaceans of the north-east Atlantic (in relation to seismic energy). Chapter 5 in M.L. Tasker and C. Weir (eds.). Proceedings of the seismic and marine mammals workshop, London, 23-25 June 1998.

Fahlman, A., P.L. Tyack, P.J.O.Miller, and P.H. Kvadsheim. 2014. How man-made interference might cause gas bubble emboli in deep diving whales. Frontiers in Physiology 5 (Article 13). 6 pp.

Fernández, A., J.F. Edwards, F. Rodríguez, A. Espinosa de los Monteros, P. Herráez, P. Castro, J.R. Jaber, V. Martín, and M. Arbelo. 2005. "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (family *Ziphiidae*) exposed to anthropogenic sonar signals. Veterinary Pathology 42: 446-457.

Fox, G.A. 2001. Wildlife as sentinels of human health effects in the Great Lakes-St. Lawrence basin. Environmental Health Perspectives 109 (Suppl.6): 853-861.

Frisk, G.V. 2012. Noiseonomics: The relationship between ambient noise levels in the sea and global economic trends. Scientific Reports 2: 437. 4 pp.

Gordon, J.C.D., D. Gillespie, J. Potter, A. Franzis, M.P. Simmonds, and R. Swift. 2002. The effects of seismic surveys on marine mammals. Chapter 6 in M.L. Tasker and C. Weir (eds.). Proceedings of the seismic and marine mammals workshop, London, 23-25 June 1998.

Government of Canada. 2010. Description of critical habitat of the northern bottlenose whale (*Hyperoodon ampullatus*), Scotian Shelf population, in the Gully Marine Protected Area. Canada Gazette Part I, vol. 140, no. 33, pp. 2192-2193, August 14, 2010.

Government of Canada. 2011. Order amending Schedule 1 to the Species at Risk Act. P.C. 2011-728, June 23, 2011, SOR/2011-128. Canada Gazette Part II, vol.145, no. 14, pp. 1227-1253, July 6, 2011.

Gowans, S., H. Whitehead, J.K. Arch, and S.K. Hooker. 2000. Population size and residency patterns of northern bottlenose whales (*Hyperoodon ampullatus*) using the Gully, Nova Scotia. Journal of Cetacean Research and Management 2(3): 201-210.

Heyning, J.E. 1984. Functional morphology involved in intraspecific fighting of the beaked whale, *Mesoplodon carlhubbsi*. Canadian Journal of Zoology 62:1645-1654.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395: 5-20.

Hooker, S.K., and R.W. Baird. 1999. Observations of Sowerby's beaked whale (*Mesoplodon bidens*) in the Gully, Nova Scotia. Canadian Field-Naturalist 113: 273-277.

Hooker, S.K., T.L. Metcalfe, C.D. Metcalfe, C.M. Angell, J.Y. Wilson, M.J. Moore, and H. Whitehead. 2008. Changes in persistent contaminant concentration and CYP1A1 protein expression in biopsy samples from northern bottlenose whales, *Hyperoodon ampullatus*, following the onset of nearby oil and gas development. Environmental Pollution 152: 205-216.

Houser, D.S., R. Howard, and S. Ridgway. 2001. Can diving-induced tissue nitrogen supersaturation increase the chance of acoustically driven bubble growth in marine mammals? Journal of Theoretical Biology 213: 183-195.

IMO (International Maritime Organization). 2009. Guidance document for minimizing the risk of ship strikes with cetaceans. MEPC.1/Circ. 674.

Jacques Whitford Environmental Incorporated. 2004. CEAA screening environmental assessment: Cohasset Project: Phase II decommissioning. x + 172 pp.

Johnson, M.P., and Tyack, P.L. 2003. A digital acoustic recording tag for measuring the response of wild marine mammals to sound. IEEE Journal of Oceanic Engineering 28(1): 3-12.

Johnson, M., P.T. Madsen, W.M.X. Zimmer, N. Aguilar de Soto, and P.L. Tyack. 2004. Beaked whales echolocate on prey. Proceedings of the Royal Society of London B (Suppl.) 271: S383-S386.

Johnson, M., P.T. Madsen, W.M.X. Zimmer, N. Aguilar de Soto, and P.L. Tyack. 2006. Foraging Blainville's beaked whales (*Mesoplodon densirostris*) produce distinct click types matched to different phases of echolocation. The Journal of Experimental Biology 209: 5038-5050.

Kachel, M.J. 2008. Particularly Sensitive Sea Areas: The IMO's Role in Protecting Vulnerable Marine Areas. Springer, Berlin. 376 pp.

Koropatnick, T., S.K. Johnston, S. Coffen-Smout, P. Macnab, and A. Szeto. 2012. Development and applications of vessel traffic maps based on long range identification and tracking (LRIT) data in Atlantic Canada. Canadian Technical Report of Fisheries and Aquatic Sciences 2966: 27 pp.

Lair, S. 2013. Rapport de nécropsie, Centre canadien coopératif de la santé de la faune, No. de pathologie: P1633-13. Centre québécois sur la santé des animaux sauvages, Université de Montréal, Saint-Hyacinthe, QC.

Lambert, J. E. 2012. Primates in communities: The ecology of competitive, predatory, parasitic, and mutualistic interactions between primates and other species. Nature Education Knowledge 3(10): 85.

Lambertsen, R.H. 1992. Crassicaudosis: a parasitic disease threatening the health and population recovery of large baleen whales. Revue scientifique et technique / Office international des épizooties 11(4): 1131-1141.

Law, R.J., M.E. Bennett, S.J. Blake, C.R. Allchin, B.R. Jones, and C.J.H. Spurrier. 2001. Metals and organochlorines in pelagic cetaceans stranded on the coasts of England and Wales. Marine Pollution Bulletin 42(6): 522-526.

Lawson, J., pers. comm. 2013. *Email correspondence to Hilary Moors-Murphy*. December 2013. Research Scientist, Fisheries and Oceans Canada, Newfoundland and Labrador Region, St. John's, NL.

Lawson, J.W., and J.-F. Gosselin. 2009. Distribution and preliminary abundance estimates for cetaceans seen during Canada's marine megafauna survey – A component of the 2007 TNASS. DFO Canadian Science Advisory Secretariat Science Research Document 2009/031. vi +28 pp.

Ledwell, W., J. Lien, and D. Wareham. 2005. A possible ship collision with a Sowerby's beaked whale (*Mesoplodon bidens*) that stranded in Conception Bay, Newfoundland. The Osprey 36(4): 95-97.

Ledwell, W., pers. comm. 2013. *Email correspondence to Ree Brennin*. September 2013. Director, Whale Release and Strandings, Portugal Cove-St. Philip's, NL.

Lien, J., and F. Barry. 1990. Status of Sowerby's beaked whale, *Mesoplodon bidens*, in Canada. Canadian Field-Naturalist 104: 125-130.

Lien, J., F. Barry, K. Breeck, and U. Zuschlag. 1990. Multiple strandings of Sowerby's beaked whales, *Mesoplodon bidens*, in Newfoundland. Canadian Field-Naturalist 104(3): 414-420.

Lien, J., C. Hood, W. Ledwell, and C. Corbelli. 2002. New records of Sowerby's beaked whales in Newfoundland. The Osprey 33(1): 18-20.

Lucas, Z.N., and S.K. Hooker. 2000. Cetacean strandings on Sable Island, Nova Scotia, 1970-1998. Canadian Field-Naturalist 114: 45-61.

MacLeod, C.D. 2000. Review of the distribution of *Mesoplodon* species (order Cetacea, family Ziphiidae) in the North Atlantic. Mammal Review 30: 1-8.

MacLeod, C.D., M.B. Santos, and G.J. Pierce. 2003. Review of data on diets of beaked whales: evidence of niche separation and geographic segregation. Journal of the Marine Biological Association of the United Kingdom 83: 651-665.

MacLeod, C.D. and A. D'Amico. 2006. A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. Journal of Cetacean Research and Management 7: 211-221.

MacLeod, C.D., W.F. Perrin, R. Pitman, J. Barlow, L. Ballance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D.L. Palka, and G.T. Waring. 2006. Known and

inferred distributions of beaked whale species (Cetacea: Ziphiidae). Journal of Cetacean Research and Management 7:271-286.

MARS (Marine Animal Response Society). 2013. Home page. Website: http://www.marineanimals.ca/ [accessed 2 September 2013].

McAlpine, D.F., and M. Rae. 1999. First confirmed reports of beaked whales, cf. *Mesoplodon bidens* and *M. densirostris* (Ziphiidae), from New Brunswick. Canadian Field-Naturalist 113: 293-295.

McCauley, R.D., J. Fewtrell, and A.N. Popper. 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113: 638-642.

Madsen, P.T., M. Johnson, P.J.O. Miller, N. Aguilar Soto, J. Lynch, and P. Tyack. 2006. Quantitative measures of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. Journal of the Acoustical Society of America 120(4): 2366-2379.

Mead, J.G. 1984. Survey of reproductive data for beaked whales (Ziphiidae). Pp. 91-96, in W.F. Perrin, R.L. Brownell, and D.P. DeMaster (eds.). Reproduction in whales, dolphins and porpoises. Reports of the International Whaling Commission, Special Issue 6.

Mead, J.G. 1989. Beaked whales of the genus *Mesoplodon*. Pp. 349-430, in S.H. Ridgway and R. Harrison (eds.). Handbook of Marine Mammals Volume 4: River Dolphins and the Larger Toothed Whales, Academic Press, San Diego.

Mead, J.G. 2002. Beaked whales, overview. Pp. 81-84, in W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.). Encyclopedia of Marine Mammals, Academic Press, San Diego.

MMARN (Maritime Marine Animal Response Network). 2014. Home page. Website: http://mmarn.ca/ [accessed 27 March 2014].

MMC (Marine Mammal Commission). 2007. Marine mammals and noise: A sound approach to research and management. A report to Congress from the Marine Mammal Commission. Marine Mammal Commission. Bethesda, Maryland. vii + 50 pp. + appendices.

Monteiro, L.R., V. Costa, R.W. Furness, and R.S. Santos. 1996. Mercury concentrations in prey fish indicate enhanced bioaccumulation in mesopelagic environments. Marine Ecology Progress Series 141: 21-25.

Moors, H.B. 2012. Acoustic monitoring of Scotian Shelf northern bottlenose whales (*Hyperoodon ampullatus*). PhD dissertation, Dalhousie University, Halifax, Nova Scotia, Canada. xx + 213 pp.

Moors-Murphy, H.B. 2014. Submarine canyons as important habitat for cetaceans, with special reference to the Gully: A review. Deep-Sea Research II 104: 6-19.

Narazaki, T. 2013. Cruise report: body condition project 2013 – *Hyperoodon* Gully trial. Unpublished report. Sea Mammal Research Unit, University of St. Andrews, UK. 26 pp.

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. Website: http://www.natureserve.org/explorer [accessed 18 October 2013].

NEB (National Energy Board). 2009. Offshore chemical selection guidelines for drilling & production activities on frontier lands. National Energy Board, Calgary, AB. iii + 13 pp.

NEB. 2010. Offshore waste treatment guidelines. National Energy Board, Calgary, AB. vi + 28 pp.

NEB. 2011. Environmental protection plan guidelines. National Energy Board, Calgary, AB. vii + 20 pp.

NEFSC (Northeast Fisheries Science Center). 2014. Unpublished data. Northeast Fisheries Science Center, Woods Hole, MA, USA 02543.

Nieukirk, S. 2013. Understanding ocean acoustics. Website: http://oceanexplorer.noaa.gov/explorations/sound01/background/acoustics/acoustics.html [accessed 16 December 2013].

Nowacek, D.P., K. Bröker, G. Donovan, G. Gailey, R. Racca, R.R. Reeves, A.I. Vedenev, D.W. Weller, and B.L. Southall. 2013. Responsible practices for minimizing and monitoring environmental impacts of marine seismic surveys with an emphasis on marine mammals. Aquatic Mammals 39(4): 356-377.

NRC (National Research Council). 2003. Ocean Noise and Marine Mammals. The National Academies Press, Washington, DC. 204 pp.

O'Brien, K. 2013. Photo-identification of Sowerby's beaked whales (*Mesoplodon bidens*) on the Scotian Shelf, Nova Scotia. Unpublished report to Fisheries and Oceans Canada, Dartmouth, Nova Scotia.

Ostrom, P.H., J. Lien, and S.A. Macko. 1993. Evaluation of the diet of Sowerby's beaked whale, *Mesoplodon bidens*, based on isotopic comparisons among northwestern Atlantic cetaceans. Canadian Journal of Zoology 71: 858-861.

Parsons, E.C.M., S.J. Dolman, A.J. Wright, N.A. Rose, and W.C.G. Burns. 2008. Navy sonar and cetaceans: just how much does the gun need to smoke before we act? Marine Pollution Bulletin 56: 1248-1257.

Pereira, J.N., V.C. Neves, R. Prieto, M.A. Silva, I. Cascão, C. Oliveira, M.J. Cruz, J.V. Medeiros, J.P. Barreiros, F.M. Porteiro, and D. Clarke. 2011. Diet of mid-Atlantic Sowerby's beaked whales *Mesoplodon bidens*. Deep-Sea Research I 58: 1084-1090.

Pitman, R.L. 2002. Mesoplodont whales. Pp. 738-742, in W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.). Encyclopedia of Marine Mammals, Academic Press, San Diego.

Reijnders, P.J.H., A. Aguilar, and G.P. Donovan (eds.). 1999. Chemical Pollutants and Cetaceans. Journal of Cetacean Research and Management, Special Issue 1, Cambridge, UK. xii + 273 pp.

Richardson, W.J., C.R. Greene Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego, CA. xvi + 576 pp.

Ross, P.S., G.A. Stern, and M. Lebeuf. 2007. Trouble at the top of the food chain: environmental contaminants and health risks in marine mammals – A white paper on research priorities for Fisheries and Oceans Canada. Canadian Technical Report of Fisheries and Aquatic Sciences 2734: viii + 30 pp.

Ryan, K.L. 2009. NATO Undersea Research Centre marine mammal risk mitigation rules and procedures. Special Publication NURC-SP-2009-002. vi + 19 pp.

Sergeant, D.E., and H.D. Fisher. 1957. The smaller cetacea of eastern Canadian waters. Journal of the Fisheries Research Board of Canada 14(1): 83-115.

Sigurjónsson, J., T. Gunnlaugsson, and M. Payne. 1989. NASS-87: Shipboard sightings surveys in Icelandic and adjacent waters June-July 1987. Report of the International Whaling Commission 39: 395-409.

Southall, B.L. 2005. Final Report of the National Oceanic and Atmospheric Administration (NOAA) International Symposium: "Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology." Fisheries Acoustics Program, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration.

Tanabe, S. 2002. Contamination and toxic effects of persistent endocrine disrupters in marine mammals and birds. Marine Pollution Bulletin 45(1): 69-77.

Taylor, B., J. Barlow, R. Pitman, L. Ballance, T. Klinger, D. DeMaster, J. Hildebrand, J. Urban, D. Palacios, and J. Mead. 2004. A call for research to assess risk of acoustic impact on beaked whale populations. Paper SC/56/E36 submitted to the International Whaling Commission Scientific Committee, July 2004, Sorrento, Italy. 4 pp.

Taylor, B.L., R. Baird, J. Barlow, S.M. Dawson, J. Ford, J.G. Mead, G. Notarbartolo di Sciara, P. Wade, and R.L. Pitman. 2008. *Mesoplodon bidens*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. Website: http://www.iucnredlist.org [accessed 18 October 2013].

Van Waerebeek, K., A.N. Baker, F. Félix, J. Gedamke, M. Iñiguez, G.P. Sanino, E. Secchi, D. Sutaria, A. Van Helden, and Y. Wang. 2007. Vessel collisions with small cetaceans worldwide and with large whales in the southern hemisphere, an initial assessment. Latin American Journal of Aquatic Mammals 6(1): 43-69.

Vlasman, K.L., and G.D. Campbell. 2004. Field guide: diseases and parasites of marine mammals of the Eastern Arctic. Canadian Cooperative Wildlife Health Centre, University of Guelph, Guelph, ON.

Wade, P. R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science 14(1): 1-37.

Waring, G.T., J.M. Quintal, and S.L. Swartz. (eds.). 2001. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2001. NOAA Technical Memorandum NMFS-NE-168. vii + 307 pp.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel. (eds.). 2013. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2012. NOAA Technical Memorandum NMFS-NE-223. vi + 419 pp.

Weilgart, L.S. 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology 85: 1091-1116.

Weilgart, L. 2012. Are there technological alternatives to air guns for oil and gas exploration to reduce potential noise impacts on cetaceans? Pp. 605-607, in A.N. Popper and A. Hawkins (eds.). The Effects of Noise on Aquatic Life, Springer Science+Business Media, New York. xxviii + 695 p.

Weir, C.R., C. Pollack, C. Cronin, and S. Taylor. 2001. Cetaceans of the Atlantic Frontier, north and west of Scotland. Continental Shelf Research 21:1047-1071.

Wenzel, F.W., P.T. Polloni, J.E. Craddock, D.P. Gannon, J.R. Nicolas, A.J. Read, and P.E. Rosel. Food habits of Sowerby's beaked whales (*Mesoplodon bidens*) taken in the pelagic drift gillnet fishery of the western North Atlantic. Fishery Bulletin 111(4): 381-389.

Whitehead, H.W. 2013. Trends in cetacean abundance in the Gully submarine canyon, 1988–2011, highlight a 21% per year increase in Sowerby's beaked whales (*Mesoplodon bidens*). Canadian Journal of Zoology 91: 141-148.

Whitehead, H., pers. comm. 2013. *Email correspondence to Ree Brennin*. May 2013. Professor, Department of Biology, Dalhousie University, Halifax, NS.

Williams, R., S. Gero , L. Bejder, J. Calambokidis, S.D. Kraus, D. Lusseau, A.J. Read, and J. Robbins. 2011. Underestimating the damage: interpreting cetacean carcass recoveries in the context of the *Deepwater Horizon*/BP incident. Conservation Letters 4(3): 228-233.

Wimmer, T., and H. Whitehead. 2004. Movements and distribution of northern bottlenose whales, *Hyperoodon ampullatus*, on the Scotian Slope and in adjacent waters. Canadian Journal of Zoology 82: 1782-1794.

WRS-NL (Whale Release and Strandings-Newfoundland and Labrador). 2013. Home page. Website: http://www.newfoundlandwhales.net/ [accessed 2 September 2013].

Yack, T.M., J. Barlow, J. Calambokidis, B. Southall, and S. Coates. 2013. Passive acoustic monitoring using towed hydrophone array results in identification of a previously unknown beaked whale habitat. Journal of the Acoustical Society of America 134(3) Pt.2: 2589-2595.

Zimmer, W.M., and P.L. Tyack. 2007. Repetitive shallow dives pose decompression risk in deep-diving beaked whale. Marine Mammal Science 23(4): 888-925.

Appendix A: Record of cooperation and consultation

Early engagement with other government departments, First Nations and other Aboriginal organizations, and stakeholders was initiated during the early drafting phase of this Management Plan in June 2013. An invitation to provide input regarding threats, management objectives, and conservation measures was extended to representatives from the following groups:

Canada-Nova Scotia Offshore Petroleum Board
Canadian Coast Guard
Canadian Parks and Wilderness Society (Nova Scotia Chapter)
Canadian Wildlife Federation
Canadian Wildlife Service, Environment and Climate Change Canada
Clearwater Seafood
Dalhousie University (Department of Biology)
Defence Research and Development Canada
Department of National Defence
Ecology Action Centre
EnCana
ExxonMobil
Geological Survey of Canada (Atlantic)
Kwilmu'kw Maw-klusuaqn Mi'kmaq Rights Initiative
Marine Animal Rescue Society
Maritime Aboriginal Peoples Council
Natural Resources Canada
Nova Scotia Department of Fisheries and Aquaculture
Nova Scotia Department of Energy
Nova Scotia Swordfishermen's Association
Parks Canada Agency
Seafood Producers Association of Nova Scotia
Shell Canada
Unama'ki Institute of Natural Resources
University of St. Andrews (Sea Mammal Research Unit)
World Wildlife Fund Canada

Appendix B: Effects on the environment and other species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[10]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

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

The potential for this Management Plan to inadvertently lead to adverse effects on other species or the environment was considered. No such adverse effects were identified. This Management Plan is expected to benefit other species that share similar threats and habitat, including the Northern Bottlenose Whale, which is listed as Endangered under the *Species at Risk Act*. This Management Plan will be implemented in coordination with the "Action Plan for the Northern Bottlenose Whale (*Hyperoodon ampullatus*), Scotian Shelf population, in Atlantic Canadian waters" (DFO 2016) to enhance positive environmental effects where possible. Implementation of the conservation measures in this Management Plan will contribute to achieving the following goal of the *Federal Sustainable Development Strategy (2013-2016)*[11]:

Goal 4: Conserving and Restoring Ecosystems, Wildlife and Habitat, and Protecting Canadians – Resilient ecosystems with healthy wildlife populations so Canadians can enjoy benefits from natural spaces, resources and ecological services for generations to come.

[10] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[11] http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=A22718BA-1