Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Northern Bottlenose Whale (*Hyperoodon ampullatus*), Scotian Shelf population, in Atlantic Canadian Waters

Northern Bottlenose Whale

May 2010

Fisheries and Oceans Canada
Pêches et Océans Canada

About the *Species at Risk Act* (SARA) Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003 and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

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

What is a recovery strategy?

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

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

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

What's next?

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

The series

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

To learn more

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

Recovery Strategy for the Northern Bottlenose Whale, Scotian Shelf population, in Atlantic Canadian Waters

May 2010

Recommended citation:

Department of Fisheries and Oceans Canada. 2010. Recovery Strategy for the Northern Bottlenose Whale, Scotian Shelf population, in Atlantic Canadian Waters. .Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada. vi + 61p.

Additional copies:

You can download additional copies from the SARA Public Registry (http://www.sararegistry.gc.ca/)

Cover illustration: Fisheries and Oceans Canada, Maritimes Region

Également disponible sous le titre "Programme de rétablissement de la baleine à bec commune (*Hyperoodon ampullatus*), population du plateau néo-écossais, dans les eaux canadiennes de l'Atlantique. Série des programmes de rétablissement

ISBN 978-1-100-13254-9
Cat. no. En3-4/66-2009E-PDF

PREFACE

The northern bottlenose whale is a marine mammal and is under the responsibility of the federal government. The *Species at Risk Act* (SARA, Section 37) requires the competent minister to prepare recovery strategies for listed extirpated, endangered and threatened species. The northern bottlenose whale was listed as endangered under SARA in April 2006. The development of this recovery strategy was led by Fisheries and Oceans Canada – Maritimes Region, in cooperation and consultation with many individuals, organizations and government agencies, as outlined in Appendix C. The strategy meets SARA requirements in terms of content and process (Sections 39-41).

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada or any other party alone. This strategy provides advice to jurisdictions and organizations that may be involved or wish to become involved in the recovery of the species. In the spirit of the National Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all responsible jurisdictions and Canadians to join Fisheries and Oceans Canada in supporting and implementing this strategy for the benefit of the northern bottlenose whale and Canadian society as a whole. Fisheries and Oceans Canada will support implementation of this strategy to the extent possible, given available resources and its overall responsibility for species at risk conservation.

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

This strategy will be complemented by one or more action plans that will provide details on specific recovery measures to be taken to support conservation of the species. The Minister of Fisheries and Oceans will take steps to ensure that, to the extent possible, Canadians interested in or affected by these measures will be consulted. Recognizing that the population may always remain relatively small, the key driver of this recovery strategy is the desire to maintain the Scotian Shelf population and to prevent further population decline by reducing threats.

RESPONSIBLE JURISDICTIONS

The responsible jurisdiction for the northern bottlenose whale is Fisheries and Oceans Canada. Northern bottlenose whales occur in the Atlantic Ocean including individuals occurring off the coast of the following provinces and/or territories.

- Nova Scotia
- Newfoundland and Labrador

AUTHORS

This document was prepared by DFO, in cooperation with other federal departments and the responsible jurisdictions described above. A broad range of stakeholders and interested parties also provided input into this strategy through a workshop approach, as referenced in Appendix C.

ACKNOWLEDGEMENTS

Fisheries and Oceans Canada held two workshops to gather multi-sectoral input on the contents of this recovery strategy. All who participated in the northern bottlenose whale recovery workshops (Appendix C) are acknowledged for their dedicated efforts in providing information, expertise and perspectives in the development of this recovery strategy.

STRATEGIC ENVIRONMENTAL ASSESSMENT

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*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally-sound decision making. Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The recovery planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts on non-target species or habitats. The results of the SEA are incorporated directly in the strategy itself, but are also summarized below. This recovery strategy will clearly benefit the environment by promoting the recovery of the northern bottlenose whale. The potential for the strategy to inadvertently lead to adverse effects on other species was considered; however, because the recovery objectives primarily recommend additional research on the species and education and outreach initiatives, the SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects.

RESIDENCE

SARA defines residence as: "*a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*" **[SARA S. 2(1)]**.

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

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

TABLES

FIGURES

EXECUTIVE SUMMARY

The northern bottlenose whale (*Hyperoodon ampullatus*) is found only in the North Atlantic, primarily in offshore waters deeper than 500 metres. There are several historic centres of abundance based on whaling information: west of Spitsbergen, around Iceland, off northern and western Norway, in Canadian waters of the Davis Strait, and along the edge of the eastern Scotian Shelf, the southern-most centre of abundance. The whales occupying the eastern Scotian Shelf and the Davis Strait are considered to constitute distinct populations and have been assessed separately by COSEWIC since 1996. Only the Scotian Shelf population, with less than 200 individuals, is currently considered at-risk by COSEWIC. In November 2002, COSEWIC designated the Scotian Shelf population as Endangered.

The Scotian Shelf population is observed regularly within and between three submarine canyons: the Gully, Shortland Canyon and Haldimand Canyon. Northern bottlenose whales have been sighted on the eastern Scotian Shelf in all four seasons and appear to be year-round residents. The Gully is widely considered to be the whales' primary habitat, and has been designated as a Marine Protected Area (MPA) under the *Oceans Act* since 2004. The Scotian Shelf population was listed as Endangered on Schedule I of the *Species at Risk Act* in April 2006, resulting in immediate legal protection and mandatory recovery requirements.

There is no current abundance estimate for the entire North Atlantic population of northern bottlenose whales. The total North Atlantic pre-whaling population has been variously estimated at c. 28,000, 40,000–50,000, and 90,000, with over 80,000 whales caught over the entire whaling period. The Scotian Shelf population represents an extremely small proportion of the global distribution and abundance as it is a very small and isolated population with localized movements.

Using sightings data and a photographic catalogue, Dalhousie University scientists estimated in 2004 the size of the Gully (now Scotian Shelf) population to be 163 individuals (95% CI 119–214). This varies from the 2000 estimate of 130 individuals (95% CI ~107–163). The 2004 population estimate used a more sophisticated estimation procedure that better reflects the entire Scotian Shelf population and is not thought to represent an actual increase in population size from the 2000 estimate. Specifically, the new model incorporates heterogeneity in movement, which was not taken into account in earlier estimates.

This recovery strategy identifies the entirety of Zone 1 of the Gully Marine Protected Area and areas with water depths of more than 500 metres in Haldimand Canyon and Shortland Canyon as critical habitat for the Scotian Shelf population. The primary reasons that these canyons constitute critical habitat are: (1) they provide exceptional foraging opportunities, (2) they support other critical life-history processes such as socialization, mating and calving, and (3) they are consistently used by a substantial proportion of the population. A schedule of studies is included that outlines further research and ongoing acoustic and visual monitoring of the area between the Gully and Shortland and Haldimand Canyons and to the west of the Gully that will contribute knowledge on the importance of identified critical habitat, as well as provide guidance on any additional critical habitat designation requirements.

Recognizing that the population may always remain relatively small due to natural limiting factors, the key driver of this recovery strategy is the desire to maintain the Scotian Shelf population and to prevent further population decline by reducing threats.

The overall goal of the northern bottlenose whale recovery strategy is therefore:

> *To achieve a stable or increasing population and to maintain, at a minimum, current distribution.*

To achieve this goal, four principal objectives have been identified:

Objective 1: Improve understanding of northern bottlenose whale ecology, including critical habitat requirements, carrying capacity, breeding, trophic interactions, links with other populations (e.g., Davis Strait), and sources of mortality.

Objective 2: Improve understanding of the population size, trend and distribution.

Objective 3: Improve understanding of and monitor anthropogenic threats, including fishing gear interactions, petroleum development, noise, and contaminants, and develop management measures to reduce threats where necessary.

Objective 4: Engage stakeholders and the public in recovery action through education and stewardship.

For each objective, a range of strategies is outlined herein to achieve these objectives. Implementing the strategies will require close collaboration among governments, independent scientific experts, stakeholders, and other interested parties, and will be dependent on resource availability, among other factors.

There are a number of knowledge gaps pertaining to northern bottlenose whales in Canadian waters, including their biology, ecology, social significance and potential threats. A list of actions is provided to address knowledge gaps.

Following the approval of this recovery strategy under the *Species at Risk Act* and posting on the public registry, a recovery action plan for the northern bottlenose whale will be developed within two years. In the interim, many of the strategies in this document can be acted on immediately, and therefore recovery implementation will be an ongoing activity that can occur in the absence of a formally adopted action plan.

INTRODUCTION

The northern bottlenose whale (*Hyperoodon ampullatus*) is a 6–9 metre beaked whale of the family Ziphiidae. It is found only in the North Atlantic, primarily in offshore waters deeper than 500 metres. There are several known areas of abundance for the species, two of which are off Canada: the edge of the eastern Scotian Shelf and the Davis Strait. The whales occupying each of these two areas are considered to constitute distinct populations and have been assessed separately by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) since 1996 (COSEWIC, 2003). Only the Scotian Shelf population, with less than 200 individuals, is currently considered at-risk by COSEWIC. The November 2002 assessment of the population, designated it as Endangered. The Scotian Shelf population is seen regularly within and between three submarine canyons: the Gully, Shortland Canyon and Haldimand Canyon. The first of these, the Gully, is widely considered to be the whales' primary habitat, and has been designated as a Marine Protected Area under the *Oceans Act* since 2004. COSEWIC is scheduled to reassess the status of the bottlenose whale off Canada in 2011.

The northern bottlenose whale, Scotian Shelf population, was listed as Endangered on Schedule I, Part 2 of the *Species at Risk Act* (SARA) in April of 2006, resulting in immediate legal protection and mandatory recovery requirements. The Minister of Fisheries and Oceans Canada, as the competent minister for aquatic species under SARA, is responsible for the development of a recovery strategy and action plan(s) for this species.

This recovery strategy is intended to serve as a blueprint for the recovery of the Scotian Shelf population of the northern bottlenose whale by summarizing the best available information on the biology and status of the population, and by identifying objectives and strategies for its recovery. The strategy will be followed by one or more action plans (produced as separate documents), which are also a requirement under the Act; Action plans list the measures proposed to implement the recovery strategy. Implementation of the strategy and subsequent action plans will require a collaborative effort among governments, scientific experts, and stakeholders. This recovery strategy builds on the substantial efforts of DFO and others to conserve northern bottlenose whales through the Gully Marine Protected Area (MPA) initiative. The MPA management plan and this recovery strategy will be used together to protect this species.

BACKGROUND

1.1. Status

1.1.1. Canadian

Northern bottlenose whale was assessed by COSEWIC in 1993 and assigned the status "not at risk". In April 1996, the Canadian population was split into two populations: the Scotia Shelf population and the Davis Strait population. The Scotian Shelf population was given the status special concern in April 1996. As outlined in the text box below, the status was later re-examined by COSEWIC in 2002, and the Scotian Shelf population was given the status endangered. The last COSEWIC assessment was based on an existing status report with an addendum. Since the 2002 assessment, a new population estimate of 163 animals has been provided by Dalhousie University (Whitehead and Wimmer 2004). The 2008 COSEWIC call for bids included re-assessments of the Scotian Shelf and the Davis Strait northern bottlenose whale populations.

COSEWIC Assessment Summary

Common name: Northern bottlenose whale (Scotian Shelf population)

Scientific name: *Hyperoodon ampullatus*

Last Examination and Change: 2002

Status: Endangered

Canadian Occurrence: Atlantic Ocean

Reason for Designation: The 2002 COSEWIC population estimate totals about 130 [1] individuals and appears to be currently stable. Oil and gas development in and around the prime habitat of this population poses the greatest threat and will likely reduce the quality of their habitat. However, there is little information as to how this species is, or is not, affected by oil and gas development activities.

Status History: The Northern bottlenose whale was given a single designation of Not at Risk in April 1993. The population was split into two populations in April 1996 to allow a separate designation of the Northern Bottlenose Whale (Scotian Shelf population). The Scotian Shelf population was designated Special Concern in April 1996. The status was re-examined and up-listed to Endangered in November 2002. The last assessment was based on an existing status report with an addendum.

[1] A 2004 assessment undertaken by Dalhousie University estimates the population to be closer to 163 individuals.

1.1.2. Global Status

The International Whaling Commission designated the northern bottlenose whale as a protected stock in 1977 and set a zero catch quota (IWC 1978). In 1976, the International Union for the Conservation of Nature and Natural Resources (IUCN, now the World Conservation Union) formally assigned the northern bottlenose whale with the status “vulnerable” (Mitchell 1976). It remained in this category until 1996 when the species was reassessed and assigned to the “conservation dependent” subcategory of the “lower risk” category. A new IUCN designation for northern bottlenose whale (released 12 August 2008) is “data deficient.” This designation is for the whole species globally; no subpopulations of this species are presently listed by the IUCN.

1.2. Distribution

1.2.1. Global Range

The northern bottlenose whale is found only in the North Atlantic (Figure 1). There are several historic centres of abundance based on whaling information: west of Spitsbergen, around Iceland, off northern and western Norway, in the Davis Strait, and along the edge of the eastern Scotian Shelf (Benjaminsen 1972, Benjaminsen and Christensen 1979, Reeves et al. 1993, Wimmer and Whitehead 2004). Stock identity is generally not well known.

The eastern Scotian Shelf is the most southerly centre of abundance (Wimmer and Whitehead 2004), although there have been strandings and sightings further south (Mitchell and Kozicki 1975). Recorded strandings of northern bottlenose whales in the Northwest Atlantic have occurred at Newport, Rhode Island (Mitchell and Kozicki 1975); Newfoundland (n=6; Sergeant and Fisher 1957; Ledwell and Huntington 2004, 2005, 2007); two locations in Massachusetts (Mitchell and Kozicki 1975); several locations in the Gulf of St. Lawrence (Wimmer and Whitehead 2004); the St. Lawrence River, 50 km east of Québec City (Fontaine 1995); Sable Island (Mitchell and Kozicki 1975, Lucas and Hooker 2000); Cobequid Bay in the Bay of Fundy (Mitchell and Kozicki 1975); and Sydney, Cape Breton (Wimmer and Whitehead 2004).

Northern bottlenose whales are usually found in very deep waters, typically offshore (Mead 1989). In the northwest Atlantic they are primarily distributed near the 1000 m isobath and are generally not found in partially enclosed seas, such as Hudson Bay or the Gulf of St. Lawrence (Reeves et al. 1993). Other than the stranding on Sable Island, the areas where they are known to have stranded in the northwest Atlantic are locations where the species does not occur regularly. Several of the northwest Atlantic stranding locations correspond with many of the stranding locations in the northeast Atlantic: embayments, fjords, seas largely enclosed from the open ocean, and estuaries; all locations where the whales are rarely seen other than the strandings (Kastelein and Gerrits 1991, Lick and Piatkowski 1998). Mitchell and Kozicki (1975) suggested that the whales may accidentally enter these relatively enclosed areas and become disoriented.

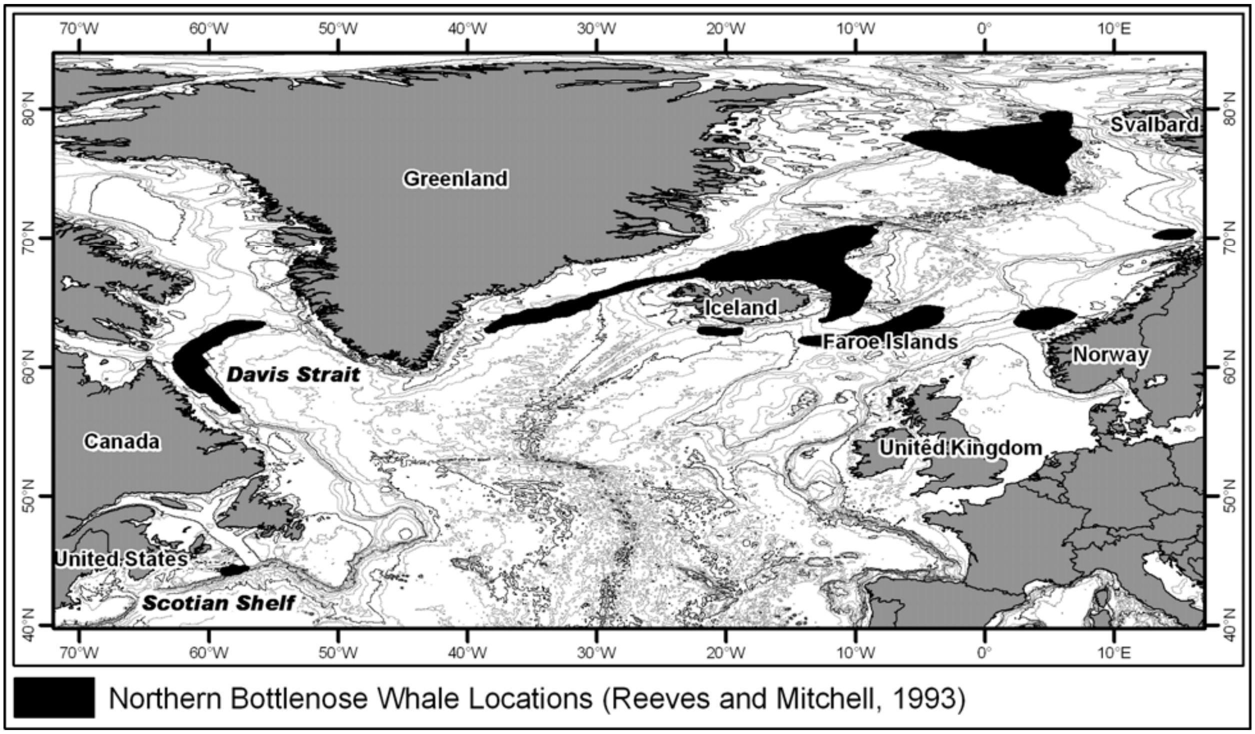

Figure 1.—Global range of northern bottlenose whale. Source: Reeves and Mitchell, 1993.

1.2.2. Canadian Range

In the northwest Atlantic, the northern bottlenose whale has been sighted regularly only in two locations: along the edge of the eastern Scotian Shelf and in the Davis Strait (Wimmer and Whitehead, 2004; Reeves et al. 1993). The Scotian Shelf population is considered genetically distinct from the population in the Davis Strait, as discussed in section 1.4.5. The full extent of the range of the Scotian Shelf population is unknown (DFO 2007a). Their distribution is aggregated; the vast majority of sightings have been in or near the Gully, Shortland Canyon, and Haldimand Canyon. There have been less frequent sightings elsewhere along the shelf break and occasional sightings over the shelf itself, although the level of confidence and quality assigned to these is low in some cases (see Figure 2). There is some evidence that northern bottlenose whales are also found at least occasionally on the edge of the Grand Banks and near the Flemish Cap (Mitchell 1974, Lens 1997). It is not known whether these individuals belong to the Scotian Shelf or Davis Strait populations (DFO 2007a). As noted above, there have been infrequent sightings of northern bottlenose whales off the northeastern coast of the United States; it is likely that these individuals belong to the Scotian Shelf population.

It has been estimated that a third to half of the Scotian Shelf population may be found in the Gully at any given time (Gowans et al. 2000b). During recent surveys, a smaller but still substantial proportion of the population has been found in Shortland and Haldimand Canyons, approximately 50 and 100 km northeast of the Gully respectively (Wimmer and Whitehead 2004). For that reason, the name "Gully" population was changed to "Scotian Shelf" population for the most recent COSEWIC status report. Canyon habitats appear to be highly attractive to this species, and therefore it is not unreasonable to suspect that the whales could be found in the smaller Verrill, Dawson and Logan canyons southwest of the Gully. To date northern bottlenose whales have rarely been observed in these areas (DFO 2007a).

Within the Gully, the whales are concentrated in a relatively small core area approximately 200 km^2 in size (Hooker et al. 2002a), and centred over depths of 500 to 1500 m (Hooker et al. 2002b) with a mean encounter depth of 1200 m. Wimmer and Whitehead (2004) found that bottlenose whales were regularly sighted at mean water depths of 1052 and 1126 m in Shortland and Haldimand canyons respectively.

Northern bottlenose whale historical distribution on the Scotian Shelf is not known, but there is no evidence from the whaling records or sightings data to suggest that distribution has been reduced (DFO, 2007a).

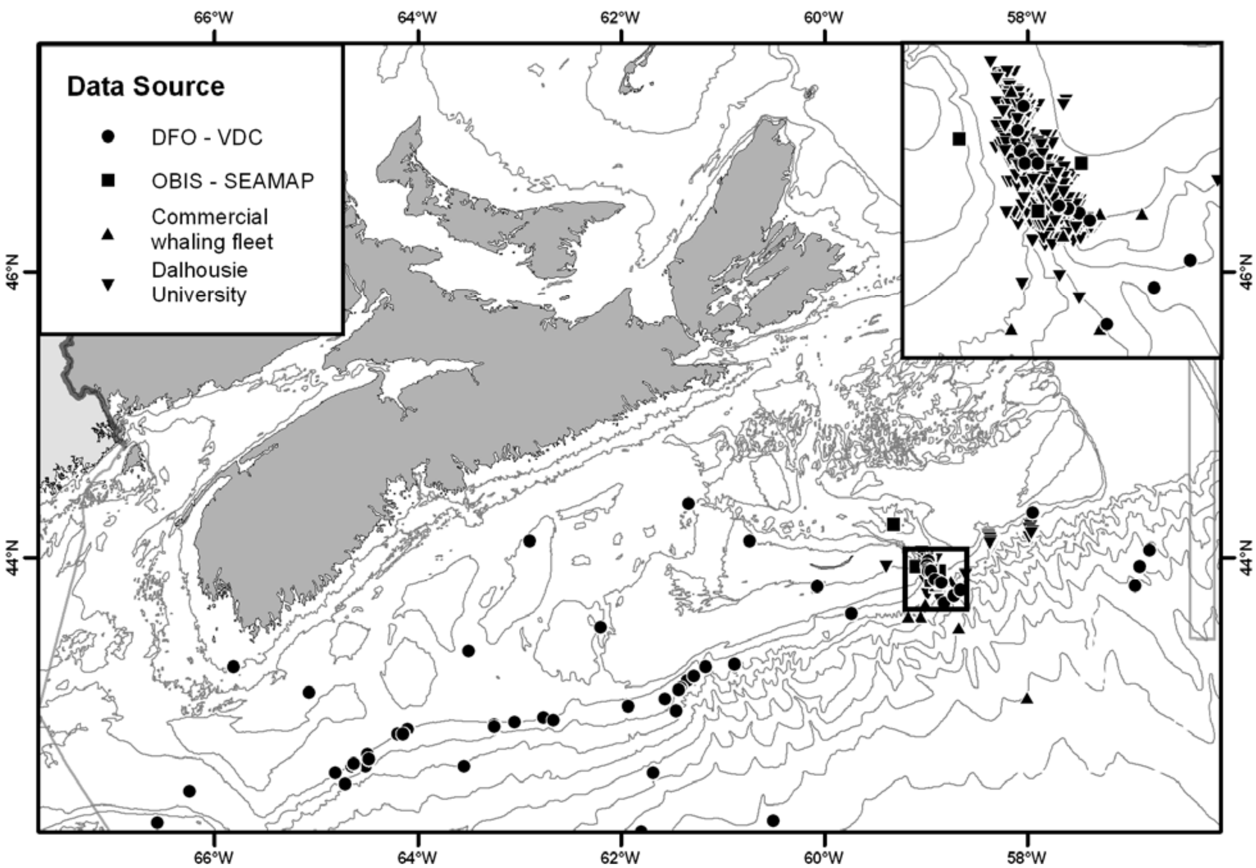

Figure 2.—Sightings of northern bottlenose whales along the Scotian Shelf. Inset shows sightings in the mouth of the Gully. (Based on incomplete sightings data. Shallow water sightings on the Scotian Shelf are likely spurious.)

1.3. Legal Protection

Northern bottlenose whales are listed as endangered under Schedule 1, Part 2 of SARA, therefore the protection measures set out in Section 32 of the Act apply (*i.e.*, no person shall kill, harm, harass, capture, take, possess, sell or trade an individual or individuals of the wildlife species). The Act also provides for the protection of the critical habitat of threatened and endangered species. Critical habitat is defined under Section 2 of the Act as *"…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species"* (see section 1.9 below).

In addition to SARA, other federal statutes that could be used to offer legal protection for northern bottlenose whales and their habitat in Canada include the *Fisheries Act* (under Marine Mammal Regulations, fishery regulations, and a series of habitat protection provisions) and the *Oceans Act*, both administered by the Minister of Fisheries and Oceans Canada. The Marine Mammal Regulations prohibit disturbance and deliberate killing of all whales and these regulations may be updated in the future to provide all whales with further protection from human activities, including additional provisions for activities such as marine mammal viewing. This additional protection would benefit the northern bottlenose whale should marine mammal viewing become an issue for this species in the future. The habitat protection provisions of the *Fisheries Act* prohibit the carrying out of works or undertakings that result in the harmful alteration, disruption or destruction of fish habitat, including marine mammal habitat, except when authorized by the Minister. Other provisions of the *Fisheries Act* could be used to restrict or prohibit fishing activities if deemed necessary. The *Oceans Act* gives the Minister of Fisheries and Oceans Canada authority to create Marine Protected Areas (MPAs) to protect endangered and threatened species. In May 2004 the Gully MPA was designated providing additional legal protection to a key habitat of this species (see section 2.5).

Environmental assessment processes also support the protection of species at risk. When an environmental assessment is required under the *Canadian Environmental Assessment Act* (CEAA), SARA requires that the adverse effects of a project on all listed species and their critical habitats be identified. Proposed activities undergo a CEAA environmental assessment process, and if a project is carried out, SARA (s.79) requires that adverse effects on a species at risk or its critical habitat be mitigated and monitored in a way that is consistent with any applicable recovery strategy and actions plans.

1.4. General Biology and Description

1.4.1. Name and Classification

Order *Cetacea*
Suborder *Odontoceti*
Family *Ziphiidae*
Subfamily *Hyperoodontinae*
Genus and species *Hyperoodon ampullatus*

Common species names
English: northern bottlenose whale
French: baleine à bec commune

1.4.2. Taxonomic Status

Two species of northern bottlenose whale have been recognized in the genus *Hyperoodon*. The northern bottlenose whale, *H. ampullatus,* is only found in the North Atlantic, while its congener, the Southern bottlenose whale, *H. planifrons,* is widely distributed throughout the Southern Ocean. The main differences between the two species rest in their geographical isolation and in the shape of the maxillary crests, those of *H. planifrons* being generally flatter than those of *H. ampullatus* (Fraser 1945, Mead 1989). While the two species are related, they are genetically distinct (Dalebout et al. 2004).

1.4.3. Physical Description

The following description is largely drawn from Christensen (1973), Mead (1989) and Gowans (2002). Northern bottlenose whales are 6 to 9 m in length, chocolate brown to yellow in colour and lighter on the flanks and underside. They have a distinctive large bulbous forehead (melon) and a prominent mouth or beak. Adult males develop a flat, squared-off forehead that becomes more prominent with age. Females and immature males have a smoother, rounded forehead. Females are somewhat smaller than males. Northern bottlenose whales found in the Gully are, on average, smaller (approximately 0.7 m) than those caught historically by whalers off Labrador (Whitehead et al. 1997b).

Northern bottlenose whales, like other beaked whales, have few functional teeth. Females and immature animals have no erupted teeth and adult males usually have only two, in the lower jaw (Mead 1989).

1.4.4. Population Structure

The exact age of any individuals in the Scotian Shelf population is not known. However, using melon profiles and genetic sampling, individuals have been assigned to one of three age-sex categories: female/immature male, subadult male or mature male (Gowans et al. 2000). Using reliably marked individuals, Wimmer and Whitehead (2004) found that proportions of the three age-sex categories are similar in the Gully, Haldimand Canyon and Shortland Canyon. Males, females and calves have been observed in all three canyons, and both males and females were taken from the Gully during the whaling period (Wimmer, pers. observation; Reeves et al. 1993). However, Whitehead and Wimmer's (2005) analysis indicates that the whales are not fully mixed between the three canyons. In other words, not all whales use the same areas. Individuals show preferences among the canyons, although some identified animals, generally males, have been observed moving between the canyons over short time intervals. This research indicates variability in habitat use by members of the population, including variability in the use critical habitat areas.

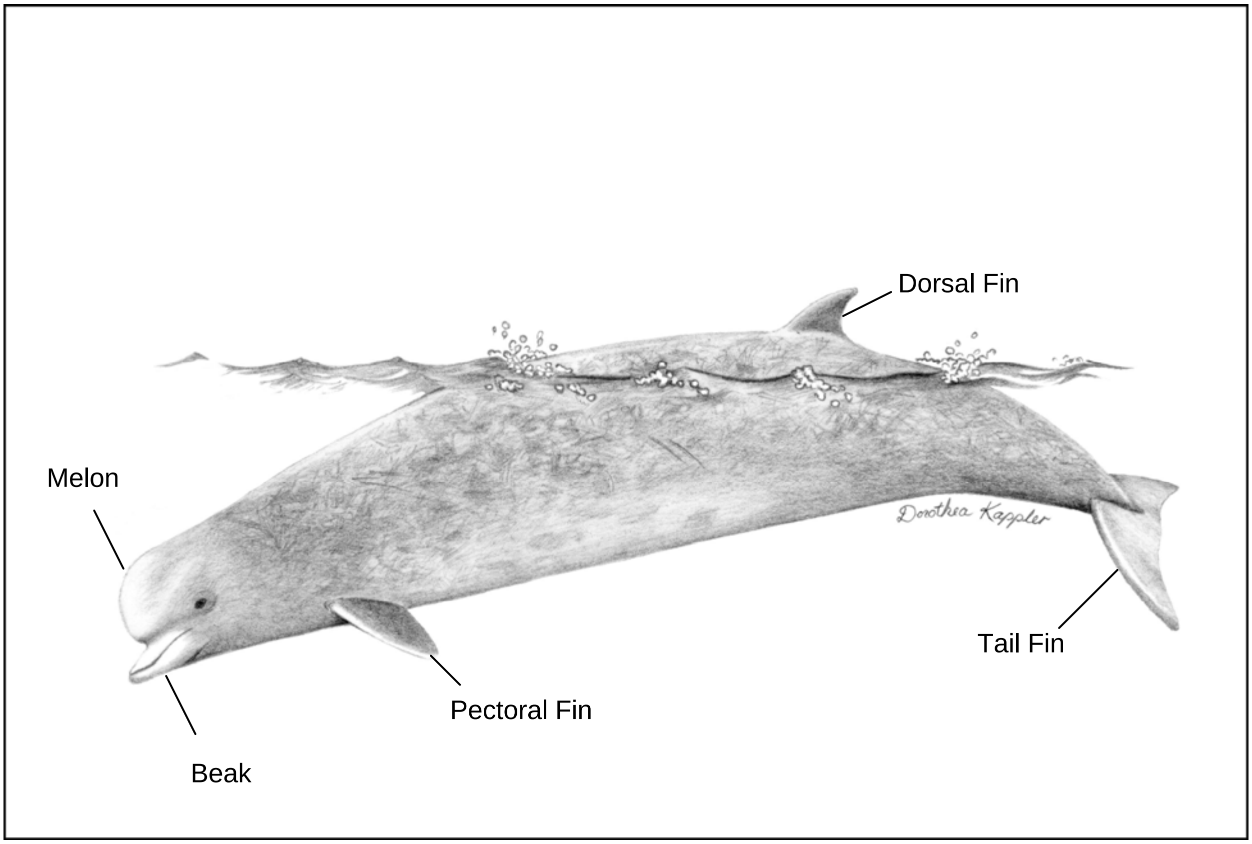

Figure 3.—Schematic depicting a mature northern bottlenose whale and key physical features. Source: Parks Canada – Dorothea Kappler.

1.4.5 Population Distinction/Genetic Diversity

Research led by Dalhousie University indicates that the whales of the Scotian Shelf are a separate population from those found off Labrador (Davis Strait population), based on both physical characteristics and genetic evidence (Whitehead et al. 1997b, Dalebout et al. 2006). Bottlenose whales are occasionally sighted off the Flemish Cap and the southern Grand Banks off Newfoundland. It is not known to which population these whales belong.

Through genetic analysis Dalebout et al. (2006) found that the Scotian Shelf population is distinct from the Davis Strait population and aggregations off Iceland. Their study indicates that large scale migrations between populations are unlikely (e.g., there are likely less than 2 individuals per generation moving between these areas). These results refute whalers' hypotheses of population links through seasonal migration.

Small genetically isolated populations of cetaceans are not uncommon (Dalebout et al. 2006); however, these are usually populations which inhabit bodies of water that are geographically isolated to some extent from the open ocean. That the Scotian Shelf population does not appear to have obvious barriers to their movement and remain centered in and around submarine canyons suggests a strong dependence on this specific habitat.

Genetic diversity was similar, albeit low, among the Scotian Shelf, Davis Strait and Iceland populations; however, there was no indication of a previous bottleneck. Dalebout et al. (2006) suggest that the current distributions are not the fragmented remnants of a historically widespread oceanic population and contend that this provides evidence for the uniqueness of the Scotian Shelf population. Their analysis also found that the Davis Strait and Iceland populations were more similar and that there is evidence of regular dispersal around Cape Farwell, the southern tip of Greenland.

Dalebout et al. (2006) found that while microsatellite diversity among northern bottlenose whales was similar to that of other oceanic cetaceans, it was higher than that of known threatened or highly isolated populations, such as the North Atlantic right whale. In small populations, loss of genetic diversity due to drift can lead to reduced fitness or compromise evolutionary potential (Frankham 1995). Low level exchange of migrants between regions can counteract this phenomenon and serve as a means of ‘genetic rescue’ for such at-risk populations (Tallmon et al. 2004). This may be what has occurred on the Scotian Shelf, as observed heterozygosity in the population was approximately equal to that of the larger Davis Strait and Iceland populations (Dalebout et al. 2006). The exact nature and extent of interchange between the Scotian Shelf and Davis Strait population remains an area of uncertainty.

1.4.6 Social Behaviour

Northern bottlenose whales are social animals and are most frequently seen in small groups of one to four (Mead 1989), although groups of up to twenty have been observed (Gowans 2002). Several different groups may be in view at the same time (Benjaminsen and Christensen 1979). Males appear to form lasting associations with other mature males, while females appear to associate with many different whales in looser associations (Gowans et al. 2001).

Whalers commented on the curiosity of this species, a characteristic that made them easier to catch (Ohlin 1893). Northern bottlenose whales will investigate vessels, particularly stationary ones. Mitchell (1977) found that he was able to attract the whales to a stationary vessel by hitting the side of the vessel. When a northern bottlenose whale was harpooned, its companions would not leave it until it was dead, allowing the whalers to often catch several whales at once (Gray 1882, several others cited in Benjaminsen and Christensen 1979). Mitchell (1977) believed that this care-giving (epimeletic) behaviour meant that northern bottlenose whales were more rapidly depleted than standard catch-effort estimates indicated.

1.4.7 Reproduction

Northern bottlenose whales in the Gully are thought to have a peak mating time in July and August (Whitehead et al. 1997a). A single calf is born to each impregnated female approximately 12 months later (Benjaminsen 1972). This calving and mating time is different from the Davis Strait population, who are thought to mate and calve between April and June, with a peak in April (Benjaminsen 1972). Benjaminsen and Christensen (1979) suggested a two-year breeding cycle; however, there is relatively little data to support or refute this conclusion. The reproductive cycle in the Gully population has not been examined in detail.

Benjaminsen (1972) concluded that male northern bottlenose whales off Iceland reached sexual maturity between 7 and 9 years of age; males examined off Labrador appeared to reach sexual maturity at 8 to 12 years (Benjaminsen and Christensen 1979). Christensen (1973) examined whales off Labrador and concluded that females reached sexual maturity at 8 to 12 years. The whales typically live to between 30 and 40 years old (Mead 1989).

1.4.8 Diving

Northern bottlenose whales are extraordinary divers that forage at depth. Whalers and early biologists noted that the whales stayed underwater for up to two hours and surfaced very near to where they dove (Gray 1882, Ohlin 1893). Ohlin (1893) observed a harpooned whale that dove, drawing out 500 fathoms (914 m) of line in "less than two minutes." A few northern bottlenose whales in the Gully have been tagged with suction cup time-depth recorders, and data from two animals have been successfully retrieved and analyzed (Hooker and Baird 1999). The whales dove to a maximum depth of 1,453 m and stayed submerged for up to 70 minutes (Hooker and Baird 1999). Sonar recordings taken above non-tagged diving whales suggested that the whales were regularly making deep dives (Hooker and Baird 1999). Benjaminsen and Christensen (1979) timed the dives of several northern bottlenose whales off Iceland and Labrador. They recorded times between 14 and 70 minutes from the moment the whale was observed submerging to the moment it was first observed surfacing. It is believed that the primary purpose of these dives is to forage for deep-water species, primarily squid that dwell at or near the bottom (see section 1.4.8).

The whales' diving behaviour reflects the vertical distribution of their primary prey, *Gonatus* squid. *Gonatus* spp. are mesopelagic squids with weak diel migration (Moiseev 1991, Hanlon and Messenger 1996). Their peak nighttime distribution of 300–500 m overlaps with daytime distribution of 400–800 m (Hanlon and Messenger (1996). Moiseev (1991) suggested that *Gonatus fabricii* is mainly found at depths of 550–1000 m, with some individuals moving to depths of 350 m and above at night. *Gonatus fabricii* have been sampled to 2,700 m in the Norwegian Sea (Kristensen 1983). As juveniles they have been observed in large shoals off Greenland and Labrador (Nesis 1965, Kristensen 1983). They do not seem to exhibit this shoaling behaviour as adults (Bjørke 2001). When young squid reach a mantle length of about 60 mm, they move from the top 60 m of the water column to depths below 200 m (Kristensen 1983, Bjørke 2001).

The known and potential physiological adaptations that make it possible for marine mammals to dive well beyond the limits of human divers are discussed in Boyd (1997), Kooyman and Ponganis (1997), Kooyman and Ponganis (1998), and Williams (2000).

1.4.9 Feeding Behaviour

Northern bottlenose whales feed mainly on squid, primarily from the genus *Gonatus* (Benjaminsen and Christensen 1979, Clarke and Kristensen 1980, Hooker et al. 2001b). In the Northeast Atlantic, the prey species is likely primarily *Gonatus fabricii*. Hooker et al. (2001b) examined the stomach contents of whales stranded in the Northwest Atlantic and conducted lipid and stable isotope analyses from biopsies of Gully whales. These analyses support the hypothesis that the whales are feeding primarily on *Gonatus* sp. Hooker et al. (2001b) suggested that the main prey species on the Scotian Shelf is *Gonatus steenstrupi*, based on their expected distribution and the presence of *streenstrupi* beaks in the stomachs of two stranded northern bottlenose whales from eastern Canada. Neither *Gonatus fabricii* nor *G. streenstupi* has been studied in detail off Nova Scotia. Remains of other prey have also been found in bottlenose whale stomachs. These include other species of squid, redfish (*Sebastes* sp.), cusk (*Brosme brosme*), turbot (*Reinhardtius hippoglossoides*), and several other species of fish, shrimps, and starfish (Banjaminsen and Christensen 1979, Clarke and Kristensen 1980, Lick and Piatkowski 1998). Stomach content analysis suggests that *Gonatus* is the most important component by far.

In other families of toothed whales, the teeth are generally used to pierce and hold prey. However, nearly all species of beaked whales have few (males) or no (females and immatures) erupted teeth (Mead 2002). Heyning and Mead (1996) provided some evidence that beaked whales capture their prey by suction feeding. There have been no studies of feeding mechanisms specific to northern bottlenose whales.

1.4.10 Use of Sound

Marine mammals use sound to communicate, to navigate in the marine environment and to find prey. Sound propagates much better than light through salt water, and vision is of little use below the photic zone or in murky waters. For that reason, whales and other marine mammals have highly developed hearing abilities (Richardson et al. 1995). It has been suggested that the melon of beaked whales is an adaptation to improve echo-location (Mitchell and Kozicki 1975, Boran et al. 2001).

Until recently, there have been few studies of sound use in beaked whales (Hooker and Whitehead 2002). Technological advances, specifically the development of the D-tag, have allowed researchers to investigate this issue in more detail (e.g. Jones et al. 2005; Tyack et al. 2004; Madsen et al. 2005; Johnson et al. 2005). Like other cetaceans, beaked whales are highly likely to use sound to navigate, communicate and to find prey (Hooker and Whitehead 2002). Beaked whales produce directional clicks with peak frequencies in the 25–40 kHz region (Tyack et al. 2004). Johnson et al. (2004) suggest that beaked whales echolocate for food during deep foraging dives by using ultrasonic clicks to ensonify their prey. They found that foraging events were terminated by a rapid click train and that impact sounds could often be heard when the prey was caught during increased dynamic acceleration by the foraging whale. Johnson et al. (2005) suggest that frequent clicks from untagged whales indicate that several whales forage together during deep dives and such group cohesion may be a contributing factor to strandings of these species related to use of active sonar.

Northern bottlenose whales make clicking noises (Winn et al. 1970, Hooker and Whitehead 2002). Hooker and Whitehead (2002) reported two major types of click series, one type that was generated at depth and another type at the surface. They noted that the clicks made by northern bottlenose whales foraging at depth were at the appropriate frequency for finding objects more than six centimetres in size. They thought it was likely that the whales used series of clicks to locate prey, most likely squid.

Hooker and Whitehead (2002) found that the peak frequencies of the surface clicks varied between 4 and 21 kHz while peak frequencies generated at depth fell between 21 and 25 kHz.[2] Click duration at surface was more variable than that generated at depth, which tended to be very regular.

While Hooker and Whitehead (2002) documented the frequencies at which northern bottlenose whale tended to make sounds, less is known about their entire vocal range or hearing abilities. Lawson et al. (2000) carried out an assessment of noise issues related to the Gully, and found no published data on the hearing ability of northern bottlenose whales. There are some data on the hearing ability of some small and medium-sized toothed whales (e.g., bottlenose dolphins, pilot whales, and killer whales), and a single study on sperm whales (see reviews in Richardson et al. 1995, Evans 2002 and Lawson et al. 2000).

1.4.11 Habitat Requirements

Northern bottlenose whales have been sighted on the eastern Scotian Shelf in all four seasons and appear to be year-round residents (Whitehead 1997b; DFO 2007a). Their distribution on the Scotian Shelf appears to be closely related to the presence of submarine canyons, particularly the Gully, where the overwhelming majority of sightings have been located. Wimmer and Whitehead (2004) found that some individuals also routinely occupy Shortland and Haldimand canyons to the east. As discussed below, the small scale of movements by individuals in the population and the observations of animals of all age and sex classes in all three canyons at various times of the year (Wimmer and Whitehead 2004; DFO 2007a), suggest that the canyons are primary, year-round habitat for all life stages. Movement between the canyons is likely through corridors along the shelf edge. In total, their home ranges are on the scale of a few hundred kilometres or less (Wimmer and Whitehead 2004).

The limited extent of Scotian Shelf bottlenose whale movements (approximately 3–5 km per day) while resident in the Gully, Shortland Canyon and Haldimand Canyon, in comparison to the typical movements of other oceanic species (often in excess of 50 km per day), indicates the presence of a rich and profitable food source (Hooker et al. 2002a). The use of these canyons is likely due to enhanced abundance of prey, namely squid of the genus *Gonatus*. Little is known about *Gonatus* spp. in the Gully and nearby canyons and it is not clearly understood why they may aggregate in these areas. Hooker et al. (2002a) speculate that it could be due to an influx of nutrients, the enhancement of benthic food sources, the existence of refuge-providing benthic structures, or the formation of mating aggregations. They suggest that the Gully ecosystem must be receiving a substantial energetic subsidy to support the energy consumption of the whales found there, since primary production in the canyon does not appear to be anomalously high.

Hooker et al. (2002b) found that sightings of northern bottlenose whale were related primarily to depth and (marginally less) to slope. They suggest that the abundance, distribution and changes in observations between years are likely due to variation in the abundance and distribution of their prey. These findings support the conclusion that northern bottlenose whale may exhibit preferences for particular oceanographic features, such as submarine canyons, due to their

[2] Humans can generally hear frequencies between 20 Hz and 15 to 20 kHz (high-frequency hearing capability declines with age) (Würsig and Evans 2001), thus humans would not be able to hear many of the whales' clicks.

influences on prey abundance and distribution. If food is narrowly distributed, whales may not be able to escape negative factors in their primary habitat (e.g., seismic data acquisition, fishing, and shipping).

The distribution of northern bottlenose whales off Labrador and in the Davis Strait is not obviously centered on canyons (Benjaminsen and Christensen 1979). Wimmer and Whitehead (2004) suggest that the contrast may be due to the size of the canyons on the eastern Scotian Shelf. The canyons in this area, particularly the Gully, are substantially larger than those of the northeastern USA or northern Labrador. Large canyons seem likely to have a disproportionate effect on oceanographic processes (Hickey 1997; Allen et al. 2001).

Compton (2004) recently used Ecological-Niche Factor Analysis to identify areas of key habitat for northern bottlenose whales within the Northwest Atlantic and to establish whether a habitat corridor links the Davis Strait and Scotian Shelf populations. The model predicted that shelf edges, submarine canyons and seamounts were areas of potential habitat for this species. All of these features are known to influence oceanographic processes and may lead to a concentration of prey species. Northern bottlenose whales were shown to exhibit high marginality in terms of sea floor slope, preferring the slopes of the continental shelf-edge.

Compton’s (2004) analysis also indicated that northern bottlenose whales have a fairly high ‘tolerance value’, i.e., they will tolerate unsuitable conditions in order to move from one suitable area to another. Many of the shelf areas of the Northwest Atlantic have steep-sided channels running through them. These channels may provide corridors for the movement of this species across relatively unsuitable areas to more suitable habitat. Several of the marginal or core habitat areas identified in Compton’s analysis are linked by these channels. Despite this finding of fairly high tolerance, the maximum distance animals will travel through unsuitable habitat in order to reach another core area is unknown. Given the limited range in movements observed by Scotian Shelf individuals, it is not clear if the distance around the Grand Banks to the eastern edge of the continental shelf is too far for individuals to travel (see discussion of optimal foraging theory and ideal free distribution in Wimmer and Whitehead 2004).

1.4.12 Migration and Movements

It has been suggested that northern bottlenose whales in other parts of the world follow a yearly migration; however, the evidence for this is somewhat contradictory. Whalers suggested that northern bottlenose whales migrated north in the spring and south in mid-summer or fall (see Gray 1882, several cited in Benjaminsen 1972, Mitchell and Kozicki 1975). Hooker (1999) and Gowans (2002) found little evidence of migrations and suggested that whalers’ observations may reflect the movement of whaling vessels rather than the movement of the whales. However, stomach contents of animals stranded in the Northeast Atlantic seem to suggest that the whales there travel over long distances. One of the squid beaks found in a whale stranded in the Faroe Islands belonged to a squid species rare north of 40°N, suggesting that that whale had been foraging 1000 km to the south quite recently (Clarke and Kristensen 1980). Since this whale stranded in August, the squid beak suggested a northward rather than southward movement in mid-summer (Hooker 1999). Strandings and sightings on the southwestern coast of Europe and the Cape Verde Islands (Hooker 1999) support the occasional occurrence of the whales far to the south of their centres of abundance.

Mitchell and Kozicki (1975) used strandings of northern bottlenose whales in Rhode Island and Massachusetts as evidence of a southward migration in the Northwest Atlantic during fall and winter months. However, they also noted winter strandings on Sable Island as evidence that whales remained in the Gully year-round. There is some evidence that whales found off Labrador are present in that area year-round as well (see Reeves and Mitchell 1993).

In the period since Mitchell and Kozicki's (1975) paper, there has been little evidence of a southward migration but increasing support for year-round residency in the area of the Scotian Shelf. Northern bottlenose whales are rare south of the Scotian Shelf in all seasons. Few northern bottlenose whales were observed during the Cetacean and Turtle Assessment Program (CETAP), a U.S. program that conducted extensive sighting surveys off the northeastern coast of the U.S. (Reeves and Mitchell 1993). Wimmer and Whitehead (2004) compiled published and unpublished sightings and strandings data from areas between New Jersey and the Grand Banks (excluding data collected by the Whitehead Lab). The majority of the reported sightings were along the shelf edge of the Scotian Shelf, although there were some sighted in deeper waters. The NOAA stock assessment program considers the species to be "extremely uncommon or rare" in U.S. waters (Waring et al. 1998). This suggests that a seasonal migration to more southern areas is unlikely (see genetic section below for further evidence supporting this conclusion).

It is widely accepted that the whales found in the Gully stay in the area year-round (see e.g., Whitehead and Wimmer 2002). The evidence for their year-round residence is based on sightings in all seasons of the year (Reeves et al. 1993). There has been very little observational effort made outside the summer months, but the small number of winter surveys in the Gully have consistently found northern bottlenose whales. Observations during the summer have established that individual whales routinely move into and out of the Gully, spending an average of 20 days before leaving (Gowans et al. 2000b). Individual residency periods are highly variable. Hooker et al. (2002b) investigated the movements and range use of individual whales within the core area. At any given time, only about 34–44% of the population is in the Gully and until 2001, researchers were not sure where the animals went when they left the Gully.

Wimmer and Whitehead (2004) examined the movements of individual northern bottlenose whale on the Scotian Shelf and determined that some of the known Gully individuals were regularly using Shortland and Haldimand canyons. The whales are likely moving between these three canyons along the slope of the Scotian Shelf, probably in the area between the 500 and 1500 metre isobath (based on their preferred depths). If so, this transit corridor may link the whales' primary habitat, but has not been well surveyed or studied. Wimmer and Whitehead (2004) estimated that northern bottlenose whale were encountered in Shortland and Haldimand canyons at a rate about half that in the Gully, which suggests about half the density.

Wimmer and Whitehead (2004) found that the population was not fully mixed and that there was heterogeneity in movement of individuals with at least some individuals preferring particular canyons. It also appears that males move more frequently than females between canyons and that male movement is related to the distribution of receptive females whereas female movement is more likely tied to food availability. Movement between canyons and the surrounding area could also reflect individuals moving to gain information on the surrounding habitat (i.e. trying to find other prey patches; see discussion in Wimmer and Whitehead, 2004).

Whitehead et al. (2003) examined the relationship between differences in niche breadth of several mesopelagic teuthivores and their movement patterns. They suggest that species that travel most widely, such as the sperm whale, encounter more prey items and have the widest niche breadth while the northern bottlenose whale, with its more localized movements and distribution, specializes predominantly on one prey species, *Gonatus* and thus, has a very narrow niche breadth. It is unknown whether prey specialization caused localized movements or *vice versa.* These findings suggest that northern bottlenose whales are tied to very specific habitat. Daily movements of Scotian Shelf northern bottlenose whale are on the order of a few kilometres and their home ranges a few hundred kilometres or less. These are relatively small displacements compared to other large pelagic species and are likely related to the limited types of prey they exploit.

1.5 Economic and Cultural Significance

During whaling times (until the 1970s), northern bottlenose whales were harvested commercially on the Scotian Shelf. Eighty-seven northern bottlenose whale from the Scotian Shelf population were were taken by whalers between 1962 and 1967 (Reeves et al. 1993, see statistics and comments in Committee for Whaling Statistics 1964, Mitchell 1974, and Sutcliffe and Brodie 1977). However, whaling has not occurred for this species for several decades and is not anticipated in Canadian waters in the foreseeable future. Because of their offshore location, the whales are not subject to commercial whale watching. Northern bottlenose whales, like many other marine mammal species, may provide ‘non-use’ benefits to society (e.g., ‘existence values’ that people derive from knowing that a species exists regardless of whether they have any plans to directly “use” that species in the future and ‘bequest values’ that people hold knowing that the species will be preserved for future generations). The value cannot be quantified at this time. In addition, there may be an economic value attributable to the information (i.e., ‘quasi-option value’) discovered through scientific research that has value for whale management purposes in Canada and internationally. Overall, the northern bottlenose whale is a high profile species in Atlantic Canada due to the Gully MPA effort and public awareness campaigns by environmental non-governmental organizations. It is also subject to extensive research. As such, northern bottlenose whales may have substantial non-use value to the Canadian public as a whole.

1.5.1 Aboriginal

It is recognized that whales are important to Aboriginal peoples, including Mi’kmaq, and the economic and cultural significance of northern bottlenose whales extends beyond issues associated with food, social and ceremonial harvest. Notwithstanding this, it is not clear to what extent, if any, northern bottlenose whales were traditionally harvested for coastal Aboriginal communities in Atlantic Canada. There are no historic or current identified harvests for food, social and ceremonial fisheries for northern bottlenose whales. Because the Scotian Shelf population resides in deep waters far offshore not easily accessed humans, it is possible that Aboriginal use of northern bottlenose whales was limited to infrequent coastal strandings.

Historic information on single or multiple coastal whale strandings in Atlantic Canada is unknown in terms of addressing the issue of Aboriginal use. The significance of historical Aboriginal use of northern bottlenose whales requires further study and dialogue with Aboriginal stakeholders.

1.6 Population Size and Trends

There is no current abundance estimate for the entire North Atlantic population of northern bottlenose whales (Gowans, 2002). The total North Atlantic pre-whaling population has been estimated variously at 28,376 (minimum estimate by Mitchell 1977), 40,000 to 50,000 (Gowans 2002), and 90,000 (Christensen 1984), with over 80,000 whales caught over the entire whaling period (Gowans 2002). The Scotian Shelf population likely represents an extremely small proportion of the global distribution and abundance as it is a very small and isolated population with localized movements.

Through sightings data and a photographic catalogue, Dalhousie University scientists have been able to estimate the size of the Gully (now Scotian Shelf) population. Whitehead and Wimmer (2004) estimate the population to be 163 individuals (95% CI 119–214). This differs from the 2000 estimate of 130 individuals (95% CI ~107–163; Gowans et al. 2000b). This new population estimate used more sophisticated estimation procedures that better reflect the entire Scotian Shelf population and is not thought to represent an actual increase in population size since the 2000 estimate. Specifically, the new model incorporates heterogeneity in movement, which was not taken into account in earlier estimates.

The population of northern bottlenose whales was assessed using mark-recapture techniques. This method includes two basic components: the collection of photographs of individual whales and statistical analysis to determine which mathematical population model best fits the observed data. Photographs of individual whales were collected while at sea in the Gully, Shortland and Haldimand canyons from 1988-2003, including date, time and position. These data were entered into the social analysis program SOCPROG developed by Hal Whitehead (Whitehead and Wimmer, 2005; Appendix A). The population size estimate is then based on calculations from well-marked animals and extrapolations are made for the total population size.

Gowans et al. (2001) and Whitehead and Wimmer (2005) have indicated that the size of the northern bottlenose whale population found on the Scotian Shelf has been relatively stable between 1988 and 2003. Whitehead and Wimmer (2005) did not find a statistically significant temporal trend in the Scotian Shelf population size. Similarly, DFO’s Recovery Potential Assessment concluded that “there is no discernable trend in abundance in the models.”

Although whaling operations took a high number of whales (87) from the Gully and the edge of the Grand Banks relative to the current size of the Scotian Shelf population, the pre-whaling population size is not known and it is impossible to determine with certainty whether it has recovered from whaling removals (DFO 2007a).

Since little is known about historical population sizes, it is not clear whether this population was ever much larger than its present-day size. Consequently, it is difficult to establish recovery targets or evaluate recovery success. The minimum size for a secure Scotian Shelf population is not known and the impacts of removing individuals from the population are poorly understood. DFO's Recovery Potential Assessment (DFO 2007a) concluded that the potential biological removal (PBR) for this population is 0.3 individuals per year. The PBR represents the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The PBR is a conservative estimate characterized by uncertainty given the lack of understanding of the population dynamics and structure in response to the historic take of 25 to 87 animals over forty years ago.

The northern bottlenose whale of the Davis Strait are the closest population center to those found on the Scotian Shelf. Based on historical whaling data, opportunistic sightings reported to DFO and an aerial survey conducted in March 1978, it has been assumed that this population is larger and more widely dispersed than the Scotian Shelf population (Whitehead et al. 2004); however, no recent studies have been done to determine if this is still the case. Wimmer and Whitehead (2004) conducted a survey along the 1000 m contour and in historically important whaling areas off Labrador in 2002. In 22 days, they only experienced 7 encounters of 18 individuals (compared to 2 subsequent 2 day surveys in the Gully which had a total of 24 encounters of 41 individuals). They found that the distribution of northern bottlenose whales off Labrador/Davis Strait did not increase with latitude as expected (e.g. Benjaminsen & Christensen 1979); rather, whales were generally encountered on the more southern sections of the survey. Much of the recent information about Northern bottlenose whale distribution of the Davis Strait has come from opportunistic sightings by turbot fishermen (Compton 2004). The paucity of sightings suggests the size of the population is smaller than previously assumed.

1.7 Biological Limiting Factors

Several aspects of the biology and ecology of northern bottlenose whales on the Scotian Shelf could be limiting factors in their recovery.

Northern bottlenose whales in the Scotian Shelf population exhibit low levels of variability in mitochondrial DNA and low rates of interchange with the nearest population in the Davis Strait (see section 1.4.5). While areas of habitat connectivity have been identified (Compton 2004), it is not known how far Scotian Shelf northern bottlenose whales will travel and therefore whether genetic interchange is feasible.

Northern bottlenose whales are a long-lived species (>40 years; Christensen 1973) that reproduce at a rate that is average by cetacean standards but relatively slow compared to other orders of animals (interbirth interval of ~2 years; Benjaminsen and Christensen 1979). Recovery from potential past and present impacts is therefore likely to be a slow process.

As noted above, habitat availability may be a limiting factor for this population. Their canyon-centered distribution and limited movements on the Scotian Shelf indicates a rich and localized prey supply. Their dependence primarily on one specific prey species may limit their recoverability as it restricts the type and amount of habitat they can inhabit. It is possible that the population has reached the carrying capacity of habitats on the Scotian Shelf, but this is not known with certainty (DFO, 2007a). Because this population occupies the southern extent of the species' distribution, the whales are unlikely to have access to alternative habitat to the south.

1.8 Threats

The Recovery Potential Assessment (RPA) for the Scotian Shelf population of northern bottlenose whales identifies entanglement/bycatch in fishing gear, oil and gas activities and acoustic disturbance as important threats (DFO, 2007a). It is also known, as discussed above, that the Scotian Shelf population was historically subject to whaling removals, from which it may not have recovered. Other potential threats identified by the RPA and/or COSEWIC include contaminants, vessel traffic, and changes to food supply. Each of these threats is described below. A summary and categorization of threats is also presented in Table 3 in Appendix B. Human activities occurring in the area occupied by northern bottlenose whales are summarized visually in the DFO publication "The Scotian Shelf: An Atlas of Human Activities" which can be accessed at http://www.mar.dfo-mpo.gc.ca/oceans/e/essim/atlas/essim-atlas-e.html.

1.8.1 Impacts of Historical Whaling

Whalers, mainly from Norway, targeted northern bottlenose whales during two periods: from the 1880s to the 1920s and from the mid-1930s to the early 1970s (Benjaminsen and Christensen 1979). Highest catches occurred from 1890 to 1905 and from 1960 to 1970 (Hooker 1999). In the latter period, a shore station was set up at Blandford, Nova Scotia and harvesters targeted the whales found in and around the Gully. Eighty-seven northern bottlenose whale were captured from the Scotian Shelf population and taken to Blandford between 1962 and 1967 (Reeves et al. 1993, see statistics and comments in Committee for Whaling Statistics 1964, Mitchell 1974, and Sutcliffe and Brodie 1977). Twenty-five whales are confirmed to have capture coordinates in the Gully from 1964–1967 whaling station data (Reeves et al. 1993) and the other whale captures (n = 62) were from as far as the edge of the Grand Banks.

Most of the northern bottlenose whales were caught in 1962 and 1963 when the whalers had a small boat that was not capable of capturing the larger fin whales that they later targeted (Gillespie 1962, Committee for Whaling Statistics 1964, Jenkins 1990). Unfortunately, data specific to the Blandford station for 1962 and 1963 cannot be found. However, the whalers were well aware of the affinity of the whales for the area of the Gully. The owner of the whaling station commented on the "schools of northern bottlenose whale" that were seen and caught in deep waters near Sable Island (Karlsen quoted in Gillespie 1962: 8).

By the mid-1970s, there was some consensus that the North Atlantic population as a whole had been reduced by whaling; however, Norwegian experts did not believe the decline was severe (Christensen et al. 1977, Jonsgård 1977) while others thought it more serious (Holt 1977, Mitchell 1977). The International Whaling Commission designated the northern bottlenose whale as a protected stock in 1977 and set a zero catch quota (IWC 1978). By that time, Canada had already ended whaling and the Blandford whaling station was closed (Jenkins 1990). As noted above, the pre-whaling size of the Scotian Shelf population is not known, and therefore it is impossible to determine whether the population has recovered from whaling removals.

1.8.2 Entanglement in Fishing Gear

Interactions between fishing activities and northern bottlenose whales are not completely understood and are only generally discussed in the COSEWIC Status Report. Recorded observations have shown a small number of northern bottlenose whales entangled in, or interacting with, fishing gear. Since the early 1980s, there have been 8 records of entanglements documented in Atlantic Canada from the At-Sea Observer Program (including 3 records from Newfoundland Region) and one line-gear entanglement in the Gully observed by Dalhousie University. Several of these entanglements occurred in the silver hake and squid fisheries, which are no longer widely exploited around the whales' primary habitat. Three entanglements have been recorded in longline gear, involving both bottom and pelagic fisheries. One of the three longline entanglements involved pelagic gear on the Grand Banks and the whale was released alive. Another two entanglements involved otter stern trawlers in the Greenland halibut fishery off Labrador. It is possible that additional entanglements have occurred but were not observed or reported.

COSEWIC (2002) notes observations of scars and marks on the beaks and backs of this species that are similar to entanglement marks recognized on other whale species. These marks may suggest that interactions with gear, particularly deployed lines, occur more frequently than observed. The low number of observed incidents may reflect the low levels (<10%) of observer coverage on some of these fleets during the period. Several industry representatives, however, note very low encounter rates with this species to date.

Regular fishing activity by a relatively small group of fishing interests does overlap with known northern bottlenose whale habitat. The primary fisheries are for groundfish with fixed (longline) gear (mainly directing for halibut) and pelagic longline (mainly directing for swordfish). The pelagic longline fishery crosses the mouth of canyons as part of an extensive continuum along the edge and slope of the Scotian Shelf, but is excluded from deepwater areas of the Gully MPA, as discussed below.

Other fishing activities in these areas, such as for snow crab or deep water crab species, occur in the vicinity of bottlenose whale habitat, but are currently exploited in shallower waters outside the whales' main aggregation areas. These fisheries are expected to increase given their overall expansion into the offshore in recent years, and may or may not overlap with primary northern bottlenose whale habitat in the future. Historically, mobile groundfish activities were more common throughout this part of the eastern Scotian Shelf, and could potentially expand in the area in the future, depending on the status of target species and other factors.

There is currently a restriction on all fishing activity in the deep water areas of the Gully MPA (Zone 1). This zone contains a significant portion of the northern bottlenose whale population and primary habitat on the Scotian Shelf. Limited access to the remainder of the MPA (Zones 2 and 3) has been maintained for groundfish longline (halibut) and pelagic longline (swordfish, tuna, and shark) vessels. The fishing controls in the MPA regulations have been included in license conditions and variation orders for all relevant fisheries.

1.8.3 Oil and Gas Activities

Active production of petroleum from offshore reserves on the Scotian Shelf has been ongoing since 1992, when the Cohasset Panuke project began producing oil from wells near Sable Island. The Cohasset Panuke project terminated in 1999, but was followed in the same year by the ongoing Sable Offshore Energy Project, which involves the development of five natural gas fields on Sable Island Bank. The nearest development platform to the Gully is about 35 km away and is located in relatively shallow water. Production activities on the Deep Panuke natural gas field are scheduled to commence in early 2011. . This field lies near the site of the obsolete Cohasset Panuke project, over 100 km from northern bottlenose whale critical habitat.

Current petroleum exploration licenses on the eastern Scotian Shelf do not directly overlap with the critical habitats of the northern bottlenose whale; however there are licenses adjacent to the Gully (west and northwest of the canyon). As well, there are exploration licenses that overlap or are close to the known distribution of this species on the Scotian Shelf.

The Scotian Slope is viewed as a relatively new frontier for oil and gas activity in the region, with only preliminary analysis of the overall hydrocarbon potential and recoverable resources conducted to date. In 2002, the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) produced the report *"Hydrocarbon Potential for the Deep-water Scotian Slope"* which provides a preliminary evaluation of resources in all the deep water areas off Nova Scotia. The report generally concludes that this deep water area substantially increases Nova Scotia's overall offshore hydrocarbon potential. In time, the results from more recent seismic and drilling programs conducted in the eastern slope region will provide a greater indication of this potential and may dictate the extent of future exploration and development activity in the region.

According to COSEWIC, oil and gas exploitation "has the potential to harm the northern bottlenose whale directly through the noise of the drilling and other operations, spills and discarded material, but also indirectly because of an increase in shipping traffic." Potential threats from acoustic disturbance, discarded materials and vessel collisions, however, are not limited to the activities of the oil and gas industry. Acoustic disturbance, contaminants, and vessel collisions, as they relate to petroleum exploitation and other activities, are all discussed separately below, and therefore are not elaborated in this sub-section.

Three Significant Discovery Licenses (SDL) exist in close proximity to proposed critical habitat for northern bottlenose whales on the Scotian Shelf:

- SDL-2259 (Banquereau field) west of Shortland Canyon, owned by ExxonMobil Canada, and
- SDL-2120C and SDL-2255L (Primrose field) in the Gully MPA Zone 3, owned by Shell Canada and ExxonMobil Canada, respectively.

Discovery Licenses were granted by the government of Canada in perpetuity. No exploration or development is anticipated in these areas in the near future.

1.8.4 Acoustic Disturbance

The northern bottlenose whale vocalizes by broadband clicks covering the frequency range from several kilohertz to at least 30 kHz, and although further research is required, the species likely has sensitive hearing within this frequency range. As noted by Hooker and Whitehead (2002), northern bottlenose whales use sound to navigate, communicate, and find prey. Because of their sensitive hearing and reliance on sound, anthropogenic noise in the marine environment has been identified as a potential threat to northern bottlenose whales (COSEWIC 2002c, Harris et al. 2007). Effects of human-induced ensonification could potentially include habituation, behavioural disturbance (including displacement and interference with communication, feeding, socializing, and response to other threats), temporary or permanent hearing impairment, acoustic masking, or even physical injury, stranding and mortality (Richardson et al. 1995, DFO 2004). However, significant uncertainty remains regarding the extent and likelihood of these effects and the level of sound exposure required to produce them (DFO 2004).

A variety of anthropogenic activities in the marine waters of Atlantic Canada produce underwater sounds within the frequency range detectable by northern bottlenose whales. Potential sources of acoustic disturbance include military exercises (active SONAR, underwater detonations), marine scientific research using sound, oil and gas exploration and extraction, vessel traffic, low-level aircraft traffic in the Gully MPA (<150 metres height), and construction (Harris et al. 2007). Military SONAR has been implicated in fatal stranding events in other beaked whale species (DFO 2007a). Within the high-use habitat areas of northern bottlenose whales, the sources of noise of most concern to date have related to nearby or potential oil and gas exploration (COSEWIC 2002).

There are no documented cases of marine mammal mortality upon exposure to oil and gas exploration seismic surveys (DFO 2004). However, this statement must be qualified, because sublethal or longer-term effects could have occurred and not have been detected by the monitoring programs typically in place (DFO 2004). Although poorly understood, exposure to seismic sound such as those mentioned above (e.g., temporary or permanent hearing shifts, behavioural disturbance), could potentially have a range of sub-lethal effects on northern bottlenose whales. Maximum acoustic energy from seismic arrays is in the 20–160 Hz frequency range, which is substantially lower than the peak hearing range for northern bottlenose whales. Seismic arrays can also produce significant acoustic energy in the 1–20 kHz range (Evans 2002), overlapping with the sensitive hearing range of beaked whales; however, Lawson et al. (2000) indicate that no data exists to estimate the northern bottlenose whale audiogram.

Furthermore, it has been suggested that deep diving species may be especially sensitive to seismic noise because sound may be concentrated in water layers at depth and therefore travel farther (Evans 2002). The northern bottlenose whale has been identified specifically as one of the deep-diving species that may be particularly sensitive to seismic noise (Evans 2002).

In May to June of 2003, Encana Corporation conducted a study in association with a seismic acquisition program on the eastern Scotian Shelf to determine the response of cetaceans to the seismic array (Potter et al. 2007). The researchers compared encounter rates for marine mammals between periods when the seismic array was active and inactive in order to evaluate the animals' response. The program covered the Scotian Slope east of Haldimand Canyon and encountered a number of northern bottlenose whales. However, the analysis conducted was not species specific (i.e., results were aggregated for several species of baleen and toothed whales). The researchers concluded that the number of whales observed within visual range was only slightly less when the seismic array was operating than when it was turned off (1.16:1 off to on; not statistically significant). However, whales tended to congregate in larger groups when the array was active and were less vocal. Also, whales tended not to approach the vessel within 100 m when the array was operating (Potter et al. 2007). Drawing any concrete conclusions about the impact of seismic sound on northern bottlenose whales from these results is difficult.

There is significant uncertainty regarding the level of sound exposure required to cause adverse effects in marine mammals. Other jurisdictions, such as the United States, have attempted to define specific quantitative criteria for acceptable received sound levels in the marine environment. However, given the variable response of marine mammals to sound and the substantial scientific uncertainty in this regard, Canada has not followed suit. A DFO study (Lee et al. 2005) conducted in July of 2003 found that northern bottlenose whales in the Gully were not displaced by received sounds of 145 dB re 1 μPa generated by a seismic survey >20 km to the southwest. Other than these observations, relatively little is known about the sound levels that northern bottlenose whales can withstand without being disturbed or injured.

Since the mid-1990s, DFO, the CNSOPB and the petroleum industry have been proactive through the application of several mitigation measures to reduce impacts on northern bottlenose whales (described later). Some companies holding nearby licenses have developed expanded environmental assessments, enhanced mitigation measures, operational codes of conduct, environmental effects monitoring programs, and implemented the Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment (DFO 2007b). These precautionary measures reflect some of the uncertainties and concerns surrounding the potential effects of this industry on sensitive species such as the northern bottlenose whale.

1.8.5 Contaminants

The most recent COSEWIC status report for northern bottlenose whales notes that floating marine pollution in the area of the Gully could be a threat to the whales, with the greatest threat represented by discarded fishing gear or other materials in which the whales could become entangled (Whitehead et al. 1996). Dufault and Whitehead (1994) found high levels of floating debris in the Gully compared with other areas of the Scotian Shelf that they investigated; however, relatively few surveys and areas were involved.

Increasing levels of pollutants due to hydrocarbon exploration and development in the area have been mentioned as a potential threat to the health of whales (see e.g., Faucher and Whitehead 1995, Whitehead and Wimmer 2002b). Drill cuttings in the vicinity of drilling platforms, produced water, accidental spills of hydrocarbons, and increased marine traffic are potential sources of increased pollutants; however, there is no clear evidence of harmful pollution occurring in the whales' habitat in recent years. The Sable Offshore Energy Project (SOEP) has several gas fields currently in production. The nearest field, Venture, is about 35 km from the boundary of the Gully MPA. Monitoring of the SOEP along the Gully MPA boundary and within the MPA has not revealed any significant presence of contaminants in the primary habitat of the northern bottlenose whale.

Analysis of pollutant samples is ongoing by university scientists. A newly released study (Hooker et al. 2008) suggests that DDT levels in whales of the Scotian Shelf population increased between 1996 and 2003, however the cause of this increase is unknown. This study also suggests that Scotian Shelf whales are more contaminated than those in the Davis Strait. Additionally, the study detected higher levels of CYP1A1 protein expression in 2003 than in other years, possibly indicating that the whales were exposed to a pollution event in that year. Overall, however, contaminant levels in the Scotian Shelf population are similar to those in other offshore cetaceans and are not thought to be high enough to cause health problems.

Surveys of persistent beach litter by Lucas (1992) on Sable Island in the 1980s and early 1990s revealed that 92 percent of the litter was plastic material generated by various marine activities, particularly the fishing industry. Based on her observed entanglements of two species of seal and three species of seabird, and the ingestion of plastic and latex by leatherback turtles, litter in Scotian Shelf waters is a hazard for all marine animals.

Munitions dumpsites may be considered as potential sources of contaminants. DND Formation Safety and Environment advises that a 1945 mustard gas site at 42.8333 N 60.1833 W, off the continental shelf in greater than 2,000 m depth, is the closest dumpsite at about 120 km southwest of the Gully MPA boundary.

At-sea shipping spills are also a potential source of contaminants hazardous to marine mammals.

1.8.6 Changes to food supply

Access to an abundant food source appears to be a key determinant of northern bottlenose whale distribution on the Scotian Shelf. In particular, it appears that the whales rely heavily on squid of the genus *Gonatus*. Indirect evidence suggests that the abundance of prey species in the Gully and adjacent canyons is exceptionally high, making it attractive for northern bottlenose whales to aggregate there. Disruption of the food supply within the whales' primary habitat could potentially result in abandonment of these areas. Since there may be few alternative areas that offer equally lucrative foraging opportunities, this could have a dramatic impact on the population. Any future commercial squid fishery on important prey species of northern bottlenose whales would also be considered as a new threat to the whales.

1.8.7 Vessel Strikes

Cetaceans are struck by vessels when vessels fail to detect or are unable to avoid the animals. Collisions can result in behavioral modifications, serious injury and mortality. The level of impact depends on the species as well as the size, type and speed of the vessel. Vessel strikes pose a particularly high risk to populations with concentrations of animals in areas of high traffic density. The mechanisms involved in cetaceans' failure to detect and avoid being struck by vessels are poorly understood but may be related to hearing ability at the frequency produced by vessel engines (see e.g., Terhune and Verboom 1999).

Collisions with vessels have been identified by COSEWIC as a potential threat to northern bottlenose whales (Whitehead et al. 1996). There are no confirmed instances of ship strikes to northern bottlenose whales, and individuals of this species are likely capable of avoiding most collisions. However, because of their distribution far offshore, the remains of mortally wounded northern bottlenose whales would unlikely be discovered if a serious ship strike were to occur, and therefore the possibility cannot be ruled out. Gowans (1999) observed scars on whales that could have been caused by collisions with vessels. Lucas and Hooker (2000) found a dead Sowerby's beaked whale (*Mesoplodon bidens*) on Sable Island with injuries consistent with a ship strike.

Although the Gully is near several major shipping routes, the present level of marine traffic through the Gully is thought to be relatively low (Herbert, pers. comm.). Voluntary measures to reduce the risk of interactions between vessels and marine mammals are in place for the Gully. There are some commercial, navy, and fishing vessels and occasional research vessels that pass through the canyon, estimated at approximately one ship per day (Herbert, pers. comm.).

Evidence of vessel strikes on northern bottlenose whales has been observed in recent analysis of melon markings and scars by Mitchell (2008).

1.9 Critical Habitat

1.9.1 Identification of Critical Habitat

Critical habitat as defined under section 2 of SARA is *"…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.*"

According to DFO's recovery potential assessment (RPA) (DFO 2007a) for the northern bottlenose whale, critical habitat for the Scotian Shelf population is characterized as "waters of more than 500 metres in bottom depth in the canyons along the edge of the Scotian Shelf that provide access to sufficient accumulations of prey (*Gonatus* squid) to allow northern bottlenose whales not only to meet their individual caloric requirements but to socialise, mate, and rear their young." The RPA identified three canyons along the edge of Scotian Shelf that appear to contain critical habitat for northern bottlenose whales: the Gully, Haldimand Canyon, and Shortland Canyon.

In concurrence with the RPA, this recovery strategy identifies the entirety of Zone 1 of the Gully Marine Protected Area and areas with water depths of more than 500 metres in Haldimand Canyon and Shortland Canyon – specifically those areas illustrated in Figure 4 – as critical habitat for the Scotian Shelf population. Since northern bottlenose whales use the full depth range in these areas, breathing and socializing at the surface and diving to feed at or near the bottom, critical habitat for this species should be considered to include the entire water column and the seafloor.

Factors considered important in the selection of northern bottlenose whale critical habitat were: a) connectivity issues between the Gully MPA Zone 1 and Shortland and Haldimand Canyons, and b) the inclusion of a range of depths and latitudes. Coordinate selection in Shortland and Haldimand Canyons followed the depth ranges (500–2,200 m) that are known to capture the observed locations of northern bottlenose whales and include as much of the canyon-defining bathymetry as possible (Figure 4). The basemap bathymetry used was Canadian Hydrographic Service (CHS) Chart 4045. All geographical coordinates (latitude and longitude) are expressed in the North America Datum 1983 (NAD83) geodetic reference system. The three critical habitat polygons for the Gully Zone 1 and Shortland and Haldimand Canyons capture greater than 95% of the known whale sightings on the Scotian Shelf.

For the purposes of plotting coordinates on paper or electronic charts and for ease of inclusion and interpretation in regulations, coordinate pairs were selected that have non-decimal seconds, rounded to every fifth of a second. Clear and concise boundary coordinates make it easier for users to understand, interpret and use. Each pair of coordinates for the east-west or north-south boundaries fall on the same latitude or longitude line so that the rhumb line boundaries are orthogonal where possible, except for boundary lines that follow any azimuth to fulfill the requirement to encompass the whales' depth ranges.

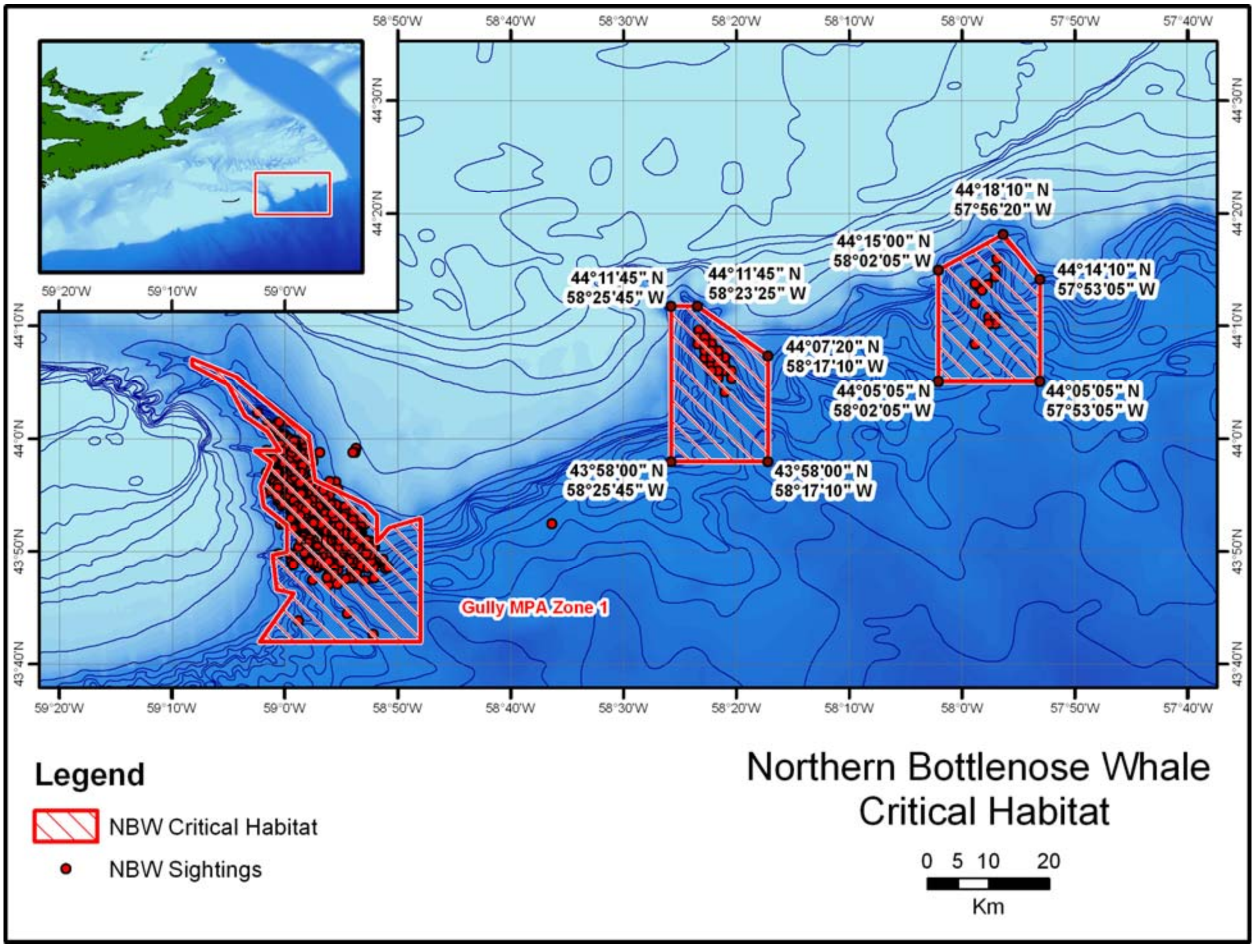

Figure 4.—Critical habitat of northern bottlenose whale. (Gully MPA Zone 1 coordinates are available at:
http://gazette.gc.ca/archives/p2/2004/2004-05-19/html/sor-dors112-eng.html

The primary reasons that these three canyons constitute critical habitat are: (1) they provide exceptional foraging opportunities, (2) they support other critical life-history processes such as socialization, mating and calving, and (3) they are consistently used by a substantial proportion of the population (see 1.4.3 and 1.4.4 above). Almost all of the survey sightings for this population have been in Zone 1 of the Gully or in waters greater than 500m bottom depth in Shortland Canyon and Haldimand Canyon. It seems likely that the canyons are distinct on the Scotian Shelf in their capacity to support aggregations of northern bottlenose whales, and as such it is reasonable to conclude that they are essential to the species' survival. Additional analysis on the critical habitat of northern bottlenose whales, and a more detailed rationale for the identification of these three canyons, is provided in DFO 2007a.

There are three smaller canyons further west, Verrill, Dawson and Logan canyons, but northern bottlenose whales have been rarely observed in these areas (DFO, 2007a). Nevertheless, given the apparent affinity of the Scotian Shelf population for submarine canyons, they may be important habitat should the population increase. The area between the Gully and Haldimand and Shortland Canyons, through which the whales must regularly transit in order to move between foraging areas, may also be important to the survival of the population. However, virtually no research has been done on the routes taken by the whales between the canyons. A schedule of studies is provided in Table 1 outlining additional research that should be undertaken to determine whether there are other areas that constitute critical habitat for this population.

Carrying capacity of northern bottlenose whales on the Scotian Shelf is unknown. The density of whales is higher in the Gully than in Haldimand or Shortland Canyon. This could indicate that there is room for expansion in the latter two canyons. However, a large canyon such as the Gully can have proportionately higher productivity due to its oceanography and bathymetry meaning that it would be able to support higher densities of whales than smaller canyons. The lack of population growth and apparent low birth rates could mean that northern bottlenose whales are close to or at carrying capacity, although low birth rates may be unrelated to carrying capacity.

1.9.2 Schedule of studies to identify additional Critical Habitat

This recovery strategy identifies all known areas of critical habitat; however, it is recognised that other areas of critical habitat may exist. Future research to identify additional northern bottlenose whale critical habitat should focus, at least in the near term, on corridors between the Gully, Shortland Canyon and Haldimand Canyon through which the whales are likely travelling regularly:. The following schedule of studies (Table 1) is proposed to determine if these areas constitute additional critical habitat for this population:

Table 1: - Schedule of studies to identify additional critical habitat for northern bottlenose whales

Nature of Study	Objective	*Timeframe
Acoustic and visual monitoring of shelf break between the Gully, Shortland Canyon, and Haldimand Canyon.	Identify routes used by whales moving between canyons and evaluate the importance of specific corridors.	Initiated. Target for completion: 2011.

Potential partners for these studies include Dalhousie University, other academic researchers, the fishing and petroleum industries, and others.

1.9.3 Activities that could destroy critical habitat and the protection of critical habitat

The Gully, Shortland Canyon and Haldimand Canyon represent critical habitats for the northern bottlenose whales primarily because of the lucrative foraging opportunities that they provide. Any human effect on the canyon habitat that removed its functional attributes rendering it unable to serve its critical function to provide foraging opportunities for northern bottlenose whales could be considered the destruction of critical habitat. This could involve changing the features or processes that result in concentrations of *Gonatus* squid in the canyons, or excluding whales from accessing these concentrations. Large scale industrial development such as that associated with oil and gas extraction could result in physical changes to bathymetry or oceanography; the development of fixed structures; the production of persistent, intense noise (Machinery, ship, aircraft/ seismic/ sonar); ocean dumping; and the release of pollutants (chemical and physical) into the marine environment which can respectively result in the alteration of habitat, acoustic disturbance and contamination (reduced habitat quality).

2.0 RECOVERY

2.1 Recovery Feasibility

2.1.1 Biological Feasibility

Although the Scotian Shelf population numbers fewer than 200 individuals, evidence suggests that it is a naturally small population that may never have exceeded a few hundred animals (DFO, 2007a). As previously stated, whaling in the 1960s took 87 whales from this population; it is not known whether or to what extent recovery from these removals has occurred. Recent analyses reveal no discernable trend in population size since the late 1980s, which could suggest that the population is at carrying capacity (Whitehead and Wimmer, 2005; DFO, 2007a). Alternatively, it is possible that anthropogenic limiting factors are preventing population growth. Regardless, since it does not appear that the population is currently declining measurably, and since there is evidence that the population has been stable despite low abundance for at least several decades, it is reasonable to conclude that maintaining a stable or increasing population is feasible.

2.1.2 Technical Feasibility

Recovery feasibility depends in part on the ability to successfully manage threats. Mitigation and management measures are available for the identified threats to this population, and some of these measures are already being implemented. As discussed in section 2.7.2 and elsewhere in this document, the primary habitat of northern bottlenose whales in the Gully has been protected since 2004 through the establishment of a Marine Protected Area (MPA). Although it is too early to determine whether the establishment of the Gully MPA is providing significant benefits to northern bottlenose whales, it is likely that the protected area designation will make a major contribution to the alleviation of threats. Outside the MPA, other mitigation measures are being developed and implemented to address threats, as discussed in section 2.7.2. Overall, it seems reasonable to conclude that threats can be and to some degree are being mitigated. This supports the conclusion that it is feasible to achieve the recovery goal for this population.

2.2 Recovery Goal

The overall goal of the recovery strategy of northern bottlenose whale is:

to achieve a stable or increasing population and
to maintain, at a minimum, current distribution.

It is difficult to provide quantitative targets for the recovery of the Scotian Shelf population of the northern bottlenose whale because a clear threshold that would ensure long-term survival has not been determined and because the historic population size is not known. Nevertheless, it is important to specify a desired population trend to provide a context for the development and implementation of recovery measures. In light of the paucity of information on a secure population size, a reasonable population target is a stable or increasing population. The distribution of northern bottlenose whales on the Scotian Shelf does not appear to have changed over time, although there is some uncertainty in this regard. Current distribution should be maintained as a minimum.

2.3 Recovery Objectives and Strategies

The following objectives, if realized, may help to achieve a stable or increasing population for northern bottlenose whales on the Scotian Shelf and maintenance, at a minimum, of their current distribution:

- **Objective 1**: Improve understanding of northern bottlenose whale ecology, including critical habitat requirements, carrying capacity, breeding, trophic interactions, links with other populations (e.g., Davis Strait), and sources of mortality.
- **Objective 2**: Improve understanding of the population size, trend and distribution.
- **Objective 3**: Improve understanding of and monitor anthropogenic threats, including fishing gear interactions, petroleum development, noise, and contaminants, and develop management measures to reduce threats where necessary.
- **Objective 4**: Engage stakeholders and the public in recovery action through education and stewardship.

For each objective, a series of strategies has been proposed, as described below. Implementing the strategies will require collaboration between governments, independent scientific experts, stakeholders, and other interested parties, and will be dependent on resource availability, among other factors.

Objective 1: Improve understanding of northern bottlenose whale ecology, including critical habitat requirements, carrying capacity, breeding, trophic interactions, links with other populations (e.g., Davis Strait), and sources of mortality.

Corresponding Strategies:

a. Undertake studies of prey species in northern bottlenose whale habitat.
b. Continue to examine photo-identification data from the Gully and Haldimand and Shortland Canyons to investigate reproduction and movement.
c. Investigate and where appropriate employ acoustic methods of monitoring northern bottlenose whales.
d. Undertake studies of carrying capacity, population viability, and interactions with other populations (e.g., Davis Strait).
e. Maintain a strandings database including the results of thorough necropsies of strandings.

Research needs and knowledge gaps are discussed in more detail in section 2.5 below.

Objective 2: Improve understanding of the population size, trend and distribution

Corresponding Strategies:

a. Continue photo-identification such that a population trend can be calculated with precision of +/– 5%.
b. Investigate and where appropriate employ acoustic methods of monitoring northern bottlenose whales.
c. Routinely monitor visible presence of northern bottlenose whales in known habitat areas.
d. Investigate the distribution of northern bottlenose whale in areas adjacent to known habitat.

Objective 3: Improve understanding of and monitor anthropogenic threats, including fishing gear interactions, petroleum development, noise, and contaminants, and develop management measures to reduce threats where necessary.

Corresponding strategies for fishing gear interactions:

a. Investigate and monitor the spatial distribution of fishing gear in northern bottlenose whale habitat.
b. Explore mechanisms for monitoring and documenting fishing gear interactions with northern bottlenose whales.
c. Develop protocols for disentanglement, if appropriate based on (b).
d. Assess the likelihood of interactions with northern bottlenose whales when evaluating new or returning fisheries.
e. Consider additional spatial management measures if deemed necessary.
f. Investigate the feasibility, costs and benefits of gear modifications or similar mitigation if deemed necessary.

Corresponding strategies for petroleum development:

a. Evaluate potential effects on northern bottlenose whales from petroleum-related activities, including through established environmental assessment processes.
b. Ensure that appropriate mitigation measures are in place for exploration and development activities.
c. Monitor exploration and development activities, including the effectiveness of mitigation measures, so that potential hazards can be identified in advance of adverse effects.
d. Continue the development and adoption of best practices.

Corresponding strategies for anthropogenic noise:

a. Periodically monitor noise in known northern bottlenose whale habitat.
b. Identify sources of noise and ensure that appropriate mitigation or management measures are in place for all sources.
c. Investigate management thresholds for marine noise in northern bottlenose whale habitat.

d. Investigate the effects of noise on northern bottlenose whales.
e. Evaluate the potential effects of noise when conducting environmental assessments on activities in northern bottlenose whale habitat and adjacent areas.

Corresponding strategies for contaminants:

a. Routinely collect samples from northern bottlenose whales, using an accepted methodology, and test for contaminants.
b. Establish a mechanism for recording and archiving samples or test results (e.g., a tissue bank) so that contaminant levels can be compared over time.
c. Investigate potential sources and routes of contaminants.
d. Monitor water and sediment quality in northern bottlenose whale habitat.

Corresponding Strategies for other activities and threats:

a. Monitor and track tourism, research and other human activities in northern bottlenose whale habitat.
b. Where necessary, ensure that appropriate mitigation measures are in place for other activities, such as scientific research, carried out in northern bottlenose whale habitat.
c. Use experience from other species to develop protocols for research and tourism.

Objective 4: Engage stakeholders and the public in recovery through education and stewardship

Corresponding Strategies:

a. Develop education materials on northern bottlenose whales and their habitat(s).
b. Distribute education materials to stakeholder groups and the public.
c. Identify stewardship opportunities and disseminate information about these opportunities to an appropriate target audience.

2.4 Performance Indicators

Measurable performance indicators will be a critical component of the recovery action plan for the northern bottlenose whale to gauge the extent that recovery activities are successful in contributing to the stated recovery goal for the species. For the strategies identified under each of the four recovery objectives in this recovery strategy, a set of measurable indicators should be devised. Inevitably, many of the indicators will reflect the current lack of knowledge about northern bottlenose whale, and will be related to research activities. During regular intervals when the recovery strategy and action plan are reviewed, progress indicators should be revised to reflect increasing knowledge. Table 2 outlines preliminary, qualitative measures of recovery progress for which quantitative indicators will need to be defined at the action planning stage.

Table 2.—List of general indicators of progress to assist in determining the extent that recovery is being achieved. Each set of indicators corresponds to a specific recovery objective.

Recovery Objective	Measure of Progress
Objective 1: *Improve understanding of northern bottlenose whale ecology, including critical habitat requirements, carrying capacity, breeding, trophic interactions, links with other populations (e.g., Davis*	▪ Sources of mortality have been identified and quantified. ▪ Carrying capacity of northern bottlenose whale habitat has been quantified.

Recovery Objective	Measure of Progress
Strait), and sources of mortality.	▪ Studies outlined in table 1 have been completed. ▪ Prey composition and prey availability have been evaluated. ▪ Qualified, trained persons have responded to all strandings in a timely manner.
Objective 2: *Improve understanding of the population size, trend and distribution.*	▪ Population size has been regularly assessed (c. ≤ 5 years). ▪ Population trend estimates are considered accurate within +/– 5%. ▪ Abundance has been regularly monitored in the Gully, Haldimand and Shortland Canyons and adjacent areas. ▪ A population trend has been regularly calculated using the most recent available data.
Objective 3: *Improve understanding of and monitor anthropogenic threats, including fishing gear interactions, petroleum development, noise, and contaminants, and develop management measures to reduce threats where necessary.*	▪ The contribution of anthropogenic threats to mortality has been quantified for each known threat. ▪ The extent and severity of threats has been routinely monitored. ▪ Anthropogenic mortality is within the recommended potential biological removal (PBR), and individual mortalities and mortality trends are tracked for this population. ▪ Additional management measures have been put in place to protect against PBR being exceeded.
Objective 4: *Engage stakeholders and the public in recovery through education and stewardship*	▪ Awareness and training programmes are underway to target key user groups, government, and the general public. ▪ Education materials have been developed and disseminated. ▪ Stakeholders and the public are engaged in stewardship activities.

2.5 Knowledge Gaps

There are a number of knowledge gaps pertaining to northern bottlenose whales in Canadian waters, including, but not limited to, their biology and ecology, habitat requirements, and potential threats. The following is a list of efforts that are required in order to address these knowledge gaps.

2.5.1 Ecology and Biology

Population size, structure and trends

Although whaling operations took a high number of whales (87) from the Gully and the edge of the Grand Banks relative to the current size of the Scotian Shelf population, the pre-whaling population size is not known. Distribution is also not fully understood. Northern bottlenose whale have been sighted along the eastern and western Grand Banks; however, it is not known to which population they belong. In order to fully understand the Scotian Shelf population, and its interactions with neighbouring populations, more information is needed, including:

- The historical size of the Scotian Shelf northern bottlenose whale population.
- Estimates of vital rates (e.g., birth and death rates) are required for modeling population dynamics and the determination of recovery reference points.
- The age and sex class structure for the Scotian Shelf population and how they are distributed within and use Shortland and Haldimand canyons.
- The proportion of the population which regularly use Shortland and Haldimand canyons.
- The sex ratio in the Scotian Shelf and Davis Strait populations.
- The current size of the Davis Strait population and estimates of temporal trends relative to the Scotian Shelf population.
- The population identity of the northern bottlenose whales found at least occasionally at the edge of the Grand Banks.

Distribution, habitat, movements and prey

The distribution of northern bottlenose whales on the Scotian Shelf and other population centers is discussed in detail above. Dalebout et al. (2006) estimated that fewer than two individuals per generation move between these areas. Compton (2004) demonstrated that there are possible habitat corridors connecting the two areas; however, it is not known if Scotian Shelf northern bottlenose whale, with their limited range of movement, use these areas to move into Davis Strait waters off Newfoundland and Labrador. It has been assumed that the Scotian Shelf northern bottlenose whales are primarily distributed around the submarine canyons because of aggregations of prey; however, there is very little evidence to show that this is the case. As well, the few prey studies which have been completed indicate that *Gonatus* squid is the primary prey item, but no information on the distribution or species of *Gonatus* is available for this area. Scotian Shelf northern bottlenose whales likely are dependent on a specific type of prey. If that prey is narrowly distributed, whales may not be able to escape negative factors (e.g. seismic data acquisition, fishing, and shipping).

Gonatus spp. are the major prey item of northern bottlenose whales in the Gully (Hooker et al. 2001). It is not known if Davis Strait northern bottlenose whale are targeting different prey items than Scotian Shelf northern bottlenose whale. The foraging habits and thus, habitat requirements could be different between the two Canadian populations.

While basic information is available, either currently or historically, there are still large information gaps. The information needed includes:

- The distribution and behaviour of the whales during winter (current knowledge of winter distribution is based on few observations).
- Prey abundance and distribution in known habitat areas, as well as prey abundance and distribution outside the canyons to determine more precisely the attributes that make certain canyons critical to northern bottlenose whales.
- Their potential use of three other submarine canyons at the edge of the Scotian Shelf (Logan, Dawson and Verill Canyons).
- Prey abundance and other environmental features in other canyons, if the whales appear to be using these canyons to determine whether other canyons on the Scotian Shelf

possess characteristics that would make them critical habitat to northern bottlenose whales.

- Distribution, habitat and prey requirements of Davis Strait northern bottlenose whale relative to the Scotian Shelf population.
- The distribution and lifecycle of the whale's likely prey (*Gonatus* spp.) and its ecology in the waters of the Scotian Shelf. The influence of canyons on *Gonatus* aggregation. *Gonatus* species diversity found on the Scotian Shelf.
- Use of Gulf of St. Lawrence and St. Lawrence River in light of documented strandings.
- Use of habitat corridors identified by Compton (2004) and their significance to the protection of and recovery of the Scotian Shelf population of northern bottlenose whale.
- If individuals are observed to use the corridors, are they members of the Scotian Shelf or Davis Strait population? The Davis Strait population may have larger home ranges, and thus may be more likely to move into the Scotian Shelf area rather than vice versa.
- An assessment of habitat carrying capacity and quantification of habitat requirements to determine whether identified critical habitat is sufficient, in terms of quantity and quality, to meet recovery goal.

2.5.2 Threats

All known human activities occurring in or around the Scotian Shelf, and in particular those occurring in or near the habitat of the northern bottlenose whale have been summarized visually in the DFO publication "The Scotian Shelf: An Atlas of Human Activities" which can be accessed at http://www.mar.dfo-mpo.gc.ca/oceans/e/essim/atlas/essim-atlas-e.html. This document is updated as new information becomes available. A short list of threats where gaps in knowledge have been identified is as follows:

- Contaminant loads in both the Davis Strait and Scotian Shelf population (larger sample sizes are needed from both populations).
- Impacts of contamination on northern bottlenose whale should be examined.
- The impact of continued and possibly future human activity on northern bottlenose whale mortality and recovery, in particular, the issue of gear entanglement and other fishery interactions.
- The impact, both cumulative and immediate, of anthropogenic noise.

2.6 Statement of when one or more Recovery Action Plans will be Completed

An action plan outlines the projects or activities required to meet the goals and objectives outlined in the recovery strategy. This includes information on the species habitat, protection measures, and an evaluation of the socio-economic costs and benefits. It is the second part of the two-part recovery planning process and is used to implement the projects or activities to improve the species status.

Following the approval of the final recovery strategy under SARA a recovery action plan for the northern bottlenose whale will be developed within **two years** of its posting on the Public Registry. In the interim, many of the strategies in this document can be acted on, and therefore recovery implementation will be an ongoing activity that can occur in the absence of any formal action plan.

2.7 Actions Completed or Underway

Many northern bottlenose whale recovery and research efforts have been initiated by government and non-government organizations in the past 20 years. The summary below is not intended to be exhaustive, but highlights some of the main activities that are expected to contribute to the recovery of this population.

2.7.1 Research

In 1988, scientists at Dalhousie University started a long-term study of the northern bottlenose whales of the Gully (Whitehead and Wimmer 2002a). This initiative is the first long-term field research program targeting live beaked whales (Gowans 2002). It has included regular shipboard visual surveys, studies of dive behaviour, movement, vocalization, diet analysis, habitat associations, acoustics, population analysis, and other activities.

Fisheries and Oceans Canada has also conducted abundance and distribution surveys within northern bottlenose whale habitat, including a systematic shipboard survey in 2003 (Gosselin and Lawson, 2004). Currently, DFO in cooperation with Dalhousie University is implementing an acoustic monitoring program in the Gully and adjacent canyons, using autonomous acoustic recorders. These devices record vocalizations of northern bottlenose and other whales, as well as background and anthropogenic noise. Analysis of the recordings provides an indication of distribution and abundance of the whales and contributes to the evaluation of acoustic disturbance.

Through the Gully Seismic Research Program, a number of studies have been conducted in recent years on marine mammals of the outer Scotian Shelf, and the potential effects on these species of petroleum exploration. Several of these studies have included research on northern bottlenose whales. Results of the Gully Seismic Research Program are summarized in Environmental Studies Research Funds Report 151 (Lee et al. 2005).

2.7.2 Mitigation of Threats

To address growing concerns about human impacts on the Scotian Shelf population, DFO designated a “Whale Sanctuary” in the Gully in 1994, and provided guidelines for vessels operating in the area. In the mid-1990s, DFO declared the Gully an Area of Interest for a Marine Protected Area (MPA) under the *Oceans Act*. As part of this initiative, interim protection was put in place, including restrictions on fisheries and petroleum activities in the area. Following several years of planning, design and consultation, the Gully MPA was established by regulation in May 2004. The Gully MPA comprises 2,364 km^2 and includes the habitat of deep-sea corals and a large variety of whale species, including the northern bottlenose whale. The regulations include general prohibitions against disturbance, damage, destruction or removal of any living marine organism or any part of its habitat. The regulations also prohibit activities that deposit, discharge or dump substances within the MPA or in the vicinity of the MPA that contravene the general prohibitions. This part of the regulations recognizes that human activities outside the MPA have the potential to cause harmful impacts within the MPA. The "General Guidelines for Marine Protected Areas" published in the "Annual Edition of Notices to Mariners" contains regulatory information and operational guidance to vessels for marine mammal protection and pollution prevention in the Gully MPA.

The MPA provides the highest level of ecosystem protection in the central portion of the Gully canyon (referred to as Zone 1), an area of known importance for the northern bottlenose whale. The Gully MPA Management Plan (DFO 2008) sets out management objectives and strategies to protect the canyon ecosystem. It identifies "Protecting cetaceans from impacts caused by human activities" as a Priority Conservation Issue, and states that steps should be taken to "minimize and manage harmful impacts and stresses from human activities on cetacean populations and their habitats" in the Gully. Specifically, the Gully Management Plan notes that the northern bottlenose whale should be given particular attention, "given the high use of the deep canyon area by much of the population and the presence of the whale on a year-round basis." The Gully MPA Management Plan proposes the following actions to address the protection of cetaceans in the MPA:

- Eliminate activities that are known or likely to harm, disturb, or kill whales or damage or destroy their habitats within the Gully MPA.
- Carry out research on human activities where impacts on whales are uncertain, such as the impacts of different types of noise.
- Set strict guidelines for activities that could potentially impact whales or their habitats.
- Monitor the health of the Gully whale population.

These proposed actions are consistent with and should contribute to the recovery goal, objectives and strategies for the northern bottlenose whale outlined in sections 2.2 and 2.3.

The Canada Nova Scotia Offshore Petroleum Board (CNSOPB) adopted a "Gully Policy" in 1997 which stated that no oil and gas activity would be permitted in the Gully while DFO was consulting and developing the MPA. Additionally, oil and gas operators holding nearby licenses have developed expanded environmental assessments (both under CEAA and the previous CNSOPB environmental assessment process), enhanced mitigation measures, operational codes of conduct and environmental effects monitoring. Exclusive and non-exclusive seismic programs and drilling programs near the Gully from 1999 onward renewed longstanding questions about anthropogenic sound and the potential for behavioural effects on whales and other organisms.

Similar conservation initiatives, as described above, have been initiated in recent years for northern bottlenose whales in Shortland and Haldimand canyons. The CNSOPB conducted a strategic environmental assessment for this area in 2002 and highlighted environmental sensitivities in the area, and there have been attempts to address conservation concerns through both CEAA and CNSOPB environmental assessments of individual exploration activities.

Fisheries and Oceans Canada has developed a Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment (DFO 2007b). The Statement of Practice outlines planning considerations, assessment protocols, and mitigation measures that should be taken into account when conducting seismic surveys. It focuses heavily on procedures for reducing the risk of harm to marine mammals, especially threatened and endangered species. Many of the mitigation measures in the Statement of Practice are being implemented by proponents and by the offshore petroleum boards.

Maritime Forces Atlantic have programs in place to manage their Operating Areas ensuring that military activities are conducted in a responsible and sustainable manner, and in compliance with the *Fisheries Act* and *Species at Risk Act* (as well as other federal legislation). Active sonar transmissions and ship discharges are prohibited in MPA's and will not normally be undertaken in other areas of identified critical habitat without notification to Fisheries and Oceans Canada to ensure that the magnitude of impacts is acceptable and the activities will not contravene the *Species at Risk Act*. Additionally, military activities involving active sonar use in Canadian waters are infrequent throughout the year.

The International Maritime Organization (IMO) has developed a *Guidance document for minimizing the risk of ship strikes with cetaceans* (July 2009). Promotion of such measures among the shipping industry and other relevant stakeholders offers some promise in diminishing the threat vessel traffic poses to this species.

A variety of efforts by the Oceans and Coastal Management Division, DFO, are underway in Maritimes Region that aim to provide an integrated, ecosystem-based and collaborative ocean management framework, including the Eastern Scotian Shelf Integrated Management (ESSIM) Initiative. These efforts involve a variety of stakeholders and regulators and provide a planning forum in which to develop and implement ecosystem objectives and indicators to guide the management of a variety of activities, including those that affect the northern bottlenose whale.

The Nova Scotia Swordfishermen's Association produced a Code of Conduct for Responsible Sea Turtle Handling and Mitigation Measures that also deals with responses to marine mammal by-catch.

2.8 Allowable Activities

Subsection 83(4) of SARA enables recovery strategies and action plans to exempt persons engaging in certain activities from the general prohibitions under SARA. In order for this provision to apply, individuals must also be authorized under another Act of Parliament to be carrying out such activities.

The recovery potential assessment for the northern bottlenose whale calculated potential biological removal (PBR) for this population as a measure of allowable harm. PBR represents the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The assessment concluded that the PBR for the Scotian Shelf population is 0.3 individuals per year.

Given that the level of allowable harm for this population is low, and the extent of mortality associated with human activities has not been quantified, this recovery strategy does not invoke section 83(4) of SARA to exempt any activities from the prohibitions. Persons wishing to carry out activities that are likely to contravene the prohibitions of SARA with respect to northern bottlenose whales, Scotian Shelf population, may apply to the Minister of Fisheries and Oceans Canada for a permit or agreement under section 73 of SARA. Such permits and agreements will only be issued if the conditions set out in the Act are met.

REFERENCES

Allen SE, Vindeirinho C, Thomson RE, Foreman MGG, Mackas DL (2001) Physical and biological processes over a submarine canyon during an upwelling event. *Canadian Journal of Fisheries and Aquatic Science* 58: 671-684.

Anonymous. 2001. Joint interim report Bahamas Marine Mammal Stranding Event of 15-16 March 2000. Prepared for the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce and the Secretary of the Navy. http://www.nmfs.noaa.gov/pr/pdfs/health/stranding_bahamas2000.pdf.

ARC (Atlantic Reference Centre). 2002. Electronic Atlas of Specimens from the Atlantic Reference Centre of the Huntsman Marine Science Centre.

Arch, J. 2000. Group function of northern bottlenose whales (*Hyperoodon ampullatus*) in the Gully: evidence from group structure and disturbance reactions. Master's Thesis, Department of Biology, Dalhousie University.

Au, W.W.L. 2002. Echolocation. In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego: Academic Press. pp. 358-367.

Balcomb, KC III and D.E. Claridge 2001. A mass stranding of cetaceans caused by naval sonar in the Bahamas. *Bahamas Journal of Science*. Vol. 8, no. 2, pp. 2-12. May 2001.

Benjaminsen, T. 1972. On the biology of the bottlenose whale, *Hyperoodon ampullatus* (Forster). *Norwegian Journal of Zoology* 20: 233-241.

Benjaminsen, T. and I. Christensen. 1979. The natural history of the bottlenose whale, *Hyperoodon ampullatus* (Forster). In: H.E. Winn and B.L. Olla, eds. *Behaviour of marine animals. Current Perspectives in Research*. Volume 3: Cetaceans. New York: Plenum Press. pp. 143-164.

Bjørke, H. 2001. Predators of the squid *Gonatus fabricii* (Lichtenstein) in the Norwegian Sea. *Fisheries Research* 52: 113-120.

Bloch, D, G. Desportes, M. Zachariassen, and I. Christensen. 1996. The northern bottlenose whale in the Faroe Islands, 1584-1993. *Journal of Zoology (London)* 239: 123-140.

Boran, J.R., P.G.H. Evans, and M.J. Rosa. 2001. Behavioural ecology of cetaceans. In: P.G.H. Evans and J.A. Raga, eds. *Marine Mammals: Biology and Conservation*. New York: Kluwer Academic/Plenum. pp. 197-242.

Bowles, A.E., M. Smultea, B. Würsig, D.P. DeMaster and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. *Journal of the Acoustical Society of America* 96: 2469-2484.

Boyd, I.L. 1997. The behavioural and physiological ecology of diving. *Trends in Ecology and Evolution* 12 (6): 213-217.

Breeze, H. 2002. Commercial fisheries of the Sable Gully and surrounding region: Historical and present activities. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2612.

Carter, B. 1997. Length distribution of northern bottlenose whales (*Hyperoodon ampullatus*) in the Gully with a comparison between this population and another residing in the Labrador Sea. Honours thesis, Department of Biology, Dalhousie University.

CCG (Canadian Coast Guard). 2008. Chapter 5: General Guidelines for Marine Mammal Critical Areas. In: 2008 Annual Edition Notices to Mariners 1 to 46. http://www.notmar.gc.ca/eng/services/2008-annual/section-a/notice-5.pdf.

Chadwick, D.H. 1998. Bottlenose Whales. *National Geographic* 194(2): 78-89.

Christensen, I. 1973. Age determination, age distribution and growth of bottlenose whales, *Hyperoodon ampullatus* (Forster), in the Labrador Sea. *Norwegian Journal of Zoology* 21: 331-340.

Christensen, I. 1975. Preliminary report on the Norwegian fishery for small whales: Expansion of Norwegian whaling to Arctic and northwest Atlantic waters, and Norwegian investigations of the biology of small whales. *Journal of the Fisheries Research Board of Canada* 32: 1083-1094.

Christensen, I. 1977. Observations of whales in the North Atlantic. In: Twenty-seventh Report of the Commission (covering the twenty-seventh fiscal year 1975-76). Cambridge, UK: International Whaling Commission. pp. 388-399.

Christensen, I. 1984. The history of exploitation and status of the Northeast Atlantic bottlenose whale (*Hyperoodon ampullatus*). SC/35/SM15. Abstract only. In: *Thirty-fourth Report of the Commission*. Cambridge, UK: International Whaling Commission. pp. 745-746.

Christensen, I., Å. Jonsgård, and C.J. Rørvik. 1977. Some notes concerning the bottlenose fishery in the North Atlantic after the Second World War, with particular reference to the westward expansion. In: *Twenty-seventh Report of the Commission (covering the twenty-seventh fiscal year 1975-76)*. Cambridge, UK: International Whaling Commission. pp. 226-227.

Clarke, A., M.R. Clarke, L.J. Holmes and T.D. Waters. 1985. Calorific values and elemental analysis of eleven species of oceanic squids (Mollusca: Cephalopoda). *Journal of the Marine Biological Association of the United Kingdom* 65: 983-986.

Clarke, M.R., ed. 1986. *A handbook for the identification of cephalopod beaks*. Oxford: Clarendon Press.

Clarke, M.R. and T.K. Kristensen. 1980. Cephalopod beaks from the stomachs of two northern bottlenose whales (*Hyperoodon ampullatus*). *Journal of the Marine Biological Association of the United Kingdom* 60: 151-156.

CNSOPB (Canada-Nova Scotia Offshore Petroleum Board). 1999. Canada-Nova Scotia Offshore Petroleum Board Policies. Sable Gully. http://www.cnsopb.ns.ca/marine_protected_area.php.

CNSOPB (Canada-Nova Scotia Offshore Petroleum Board). 2002a. Annual Report, 2001-2002. http://www.cnsopb.ns.ca/pdfs/0102_eng.pdf.

CNSOPB (Canada-Nova Scotia Offshore Petroleum Board). 2002b. Strategic Environmental Assessment of Potential Exploration Rights Issuance for Eastern Sable Island Bank, Western Banquereau Bank, the Gully Trough and the Eastern Scotian Slope. http://www.cnsopb.ns.ca/pdfs/GullySEAJune03.pdf

CNSOPB (Canada-Nova Scotia Offshore Petroleum Board). 2005. Offshore interests. http://www.mar.dfo-mpo.gc.ca/oceans/e/essim/atlas/images/Ocean%20Use%20Atlas_smaller_img_106.jpg.

Committee for Whaling Statistics. 1964. International Whaling Statistics 51. Oslo.

Committee for Whaling Statistics. 1968. International Whaling Statistics 61. Oslo.

Compton, R.C. 2004. Predicting key habitat and potential distribution of northern bottlenose whales (*Hyperoodon ampullatus*) in the Northwest Atlantic Ocean. MSc. applied marine science, University of Plymouth, UK.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002a. Harbour Porpoise. http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002b. COSEWIC Database, Whale, Northern Bottlenose. http://www.cosewic.gc.ca/eng/sct1/searchform_e.cfm.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002c. COSEWIC assessment and update status report on the northern bottlenose whale *Hyperoodon ampullatus* (Scotian shelf population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 22 pp. http://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_northern_bottlenose_whale_e.pdf

Culik, B. 2002. *Hyperoodon ampullatus* (Forster, 1770). In: *Review on Small Cetaceans: Distribution, Behaviour, Migration and Threats*. Compiled for the Convention on Migratory Species, December 2002. http://www.cms.int/publications/culik_report.htm.

Dalebout, M.L., C.S. Baker, J.G. Mead, V.G. Cockcroft and T.K. Yamada. 2004. A comprehensive and validated molecular taxonomy of beaked whales, Family Ziphiidae. *Journal of Heredity* 95: 459-473.

Dalebout, M.L., S.K. Hooker and I. Christensen. 2001. Genetic diversity and population structure among northern bottlenose whales, *Hyperoodon ampullatus*, in the western North Atlantic Ocean. *Canadian Journal of Zoology* 79: 478-484.

Dalebout, M.L., D.E. Ruzzante, H. Whitehead and N.I. Oien. 2006. Nuclear and mitochondrial markers reveal distinctiveness of a small population of bottlenose whales (*Hyperoodon ampullatus*) in the western North Atlantic. *Molecular Ecology* 15: 3115-3129.

Davis, R.A., D.H. Thomson and C.I. Malme. 1998. Environmental Assessment of Seismic Exploration on the Scotian Shelf. Prepared for Mobil Oil Properties Canada Ltd., Shell Canada Ltd., and Imperial Oil Ltd. for Submission to the Canada-Nova Scotia Offshore Petroleum Board. Halifax, Nova Scotia. http://www.cnsopb.ns.ca/pdfs/shelf.pdf.

Dawe E.G., Bowering, W.R. and Joy, J.B. 1998. Predominance of squid *(Gonatus* spp.) in the diet of Greenland halibut *(Reinhardtius hippoglossoide*s) on the deep slope of the northeast Newfoundland continental shelf. *Fisheries Research* 36: 267-273.

Desharnais, F. and N.E.B. Collison. 2001. Background noise levels in the area of the Gully, Laurentian Channel and Sable Bank. Defence Research Establishment Atlantic. Prepared for Fisheries and Oceans Canada, Oceans and Coastal Management Division.

DFO, 2004. Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals. DFO Can. Sci. Advis. Sec. Habitat Status Report 2004/002. http://www.dfo-mpo.gc.ca/csas/Csas/status/2004/HSR2004_002_e.pdf.

DFO, 2007a. Recovery potential assessment of northern bottlenose whale, Scotian Shelf population. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/011. http://www.dfo-mpo.gc.ca/csas/Csas/status/2007/SAR-AS2007_011_E.pdf.

DFO, 2007b. Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment. http://www.dfo-mpo.gc.ca/oceans-habitat/oceans/im-gi/seismic-sismique/index_e.asp.

DFO, 2008. The Gully Marine Protected Area Management Plan. http://www.dfo-mpo.gc.ca/Library/333121.pdf.

Dufault, S. and H. Whitehead. 1994. Floating marine pollution in 'the Gully' on the Continental Slope, Nova Scotia, Canada. *Marine Pollution Bulletin* 28: 489-493.

ENS (Environmental News Service). 2002. Judge halts Baja research after two whale deaths. http://www.whales.org.au/news/news2002.html.

Evans, P.G.H. 2002. Biology of cetaceans in the North-East Atlantic (in relation to seismic energy). Chapter 5. 35 pp. In: M.L. Tasker and C. Weir, eds. *Proceedings of the Seismic and Marine Mammals Workshop*, London, 23-25 June 1998. http://www.seawatchfoundation.org.uk/docs/Evans2002BiologyOfCetaceansNEAtlanticSeismic.pdf.

Faucher, A. and L. Weilgart. 1992. Critical marine mammal habitat in offshore waters: the need for protection. In: J.H.M. Willison, S. Bondrup-Neilsen, C. Drysdale, T.B. Herman, N.W.P. Munro and T.L. Pollock, eds. *Science and the management of protected areas: Developments in landscape management and urban planning*. Amsterdam: Elsevier. pp: 75-78.

Faucher, A. and H. Whitehead. 1995. Importance of habitat protection for the northern bottlenose whale in the Gully, Nova Scotia. In: N.L. Shackell and J.H.M. Willison, eds. *Marine protected areas and sustainable fisheries*. Wolfville, Nova Scotia, Canada: Science and Management of Marine Protected Areas Association. pp. 99-102.

Fontaine, P.-H., 1995. Échouage d'une baleine à bec sur les battures de Montmagny, le 6 novembre 1994. *Le Naturaliste Canadien*, Summer 1995. pp. 48-53.

Frankel, A.S. 2002. Sound Production. In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego: Academic Press. pp. 1126-1138.

Frankham R (1995b) Inbreeding and extinction: a threshold effect. *Conservation Biology* 9, 792-799.

Frantzis, A. 1998. Does acoustic testing strand whales? *Nature* 392 (6671): 29.

Fraser, F.C. 1945. On a specimen of the southern bottlenose whale, *Hyperoodon planifrons*. *Discovery Report* 23: 19-36.

Gentry, R.L. 2002. Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000. NOAA - Office of Protected Resources. http://www.nmfs.noaa.gov/pr/pdfs/health/galapagos_stranding.pdf.

Gillespie, G.J. 1962. Whale hunting off Nova Scotia. *Trade News* 15(4): 8-9, 14.

Gillespie, G.J. 1964. Canadian whaling venture. *Trade News* 17(4): 5-8.

Gordon, J.C.D., D. Gillespie, J. Potter, A. Frantzis, M.P. Simmonds, and R. Swift. 1998. The effects of seismic surveys on marine mammals. In: M.L. Tasker and C. Weir, eds. *Proceedings of the Seismic and Marine Mammals Workshop*, London, 23-25 June 1998. Sea Mammal Research Unit, University of St. Andrews, Scotland. http://smub.st-and.ac.uk/seismic/pdfs/6.pdf.

Gowans, S. 1999. Social organisation and population structure of northern bottlenose whales in the Gully. PhD Dissertation, Dalhousie University, Halifax, NS.

Gowans, S. 2002. Bottlenose whales *Hyperoodon ampullatus* and *H. planifrons*. In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego: Academic Press. pp. 128-129.

Gowans, S., M.L. Dalebout, S.K. Hooker, and H. Whitehead. 2000a. Reliability of photographic and molecular techniques for sexing northern bottlenose whales (*Hyperoodon ampullatus*). *Canadian Journal of Zoology* 78: 1224-1229.

Gowans, S. and L. Rendell. 1999. Head-butting in northern bottlenose whales (*Hyperoodon ampullatus*): A possible function for big heads? *Marine Mammal Science* 15: 1342-1350.

Gowans, S. and H. Whitehead. 2001. Photographic identification of northern bottlenose whales (*Hyperoodon ampullatus*): Sources of heterogeneity from natural marks. *Marine Mammal Science* 17: 76-93.

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

Gowans, S., H. Whitehead, and S.K. Hooker. 2001. Social organization in northern bottlenose whales, *Hyperoodon ampullatus*: not driven by deep-water foraging? *Animal Behaviour* 62: 369-377.

Gray, D. 1882. Notes on the characteristics and habits of the bottlenose whale (*Hyperoodon rostratus*). *Proceedings of the Zoological Society of London*, Dec. 19 1882: 726-731.

Grover, D. 1989. Northern bottlenose whales, *Hyperoodon ampullatus*, and sperm whales, *Physeter macrocephalus*, in the Gully, east of Sable Island, Nova Scotia: distributions and possible competitive interactions. Honours Thesis, Department of Biology, Dalhousie University.

Hanlon, R.T. and J.B. Messenger. 1996. *Cephalopod Behaviour*. Cambridge, UK: Cambridge University.

Harris, L.E., C.L. Waters, R.K. Smedbol and D.C. Millar. 2007. Assessment of the Recovery Potential of the Scotian Shelf population of northern bottlenose whale, *Hyperoodon ampullatus*. DFO Can. Sci. Advis. Sec. Res. Doc. 2007-078. http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ResDocs-DocRech/2007/2007_078_e.htm

Herbert, G. Section Head, Integrated Management. Oceans and Coastal Management Divisions. Oceans, Habitat and Species at Risk Branch. Fisheries and Oceans Canada. Personal communication with the authors.

Heyning, J.E. and J.G. Mead. 1996. Suction feeding in beaked whales: morphological and observational evidence. *Contributions in Science (Natural History Museum of Los Angeles County)* 464: 1-12.

Hickey, B.M. 1997. The response of a steep-sided narrow canyon to strong wind forcing. *Journal of Physical Oceanography* 27: 697-726.

Holt, S.J. 1977. Does the bottlenose whale necessarily have a sustainable yield, and if so is it worth taking? *Twenty-seventh Report of the Commission*. Cambridge, UK: International Whaling Commission. pp. 206-208.

Hooker, S.K. 1999. Resource and habitat use of northern bottlenose whales in the Gully: ecology, diving and ranging behaviour. Ph.D. Dissertation, Dalhousie University, Halifax, Nova Scotia.

Hooker, S.K. and R.W. Baird. 1999. Deep-diving behaviour of the northern bottlenose whale, *Hyperoodon ampullatus* (Cetacea: Ziphiidae). *Proceedings of the Royal Society of London, Series B: Biological Sciences* 266 (1420): 671-676.

Hooker, S.K. and R.W. Baird. 2001. Diving and ranging behaviour of Odontocetes: a methodological review and critique. *Mammal Review* 31: 81-105.

Hooker, S.K., R.W. Baird, S. Al-Omari, S. Gowans, H. Whitehead. 2001a. Behavioral reactions of northern bottlenose whales (*Hyperoodon ampullatus*) to biopsy darting and tag attachment procedures. *Fishery Bulletin* 99: 303-308.

Hooker, S.K. and I.L. Boyd. 2002. Oceanographic sampling using marine mammals: Implications for the study of oceanography and marine mammal foraging ecology. The Challenger Society for Marine Science UK Marine Science 2002, Plymouth (UK), 9-13 Sep 2002.

Hooker, S.K., S.J. Iverson, P. Ostrom, and S.C. Smith. 2001b. Diet of northern bottlenose whales inferred from fatty-acid and stable-isotope analyses of biopsy samples. *Canadian Journal of Zoology* 79: 1442-1454.

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.

Hooker, S.K. and H. Whitehead. 2002. Click characteristics of northern bottlenose whales (*Hyperoodon ampullatus*). *Marine Mammal Science* 18: 69-80.

Hooker, S.K., H. Whitehead, and S. Gowans. 1999. Marine Protected Area Design and the Spatial and Temporal Distribution of Cetaceans in a Submarine Canyon. *Conservation Biology* 13: 592-602.

Hooker, S.K., H. Whitehead, and S. Gowans. 2002a. Ecosystem consideration in conservation planning: energy demand of foraging bottlenose whales (*Hyperoodon ampullatus*) in a marine protected area. *Biological Conservation* 104: 51-58.

Hooker, S.K. H. Whitehead, S. Gowans, R.W. Baird. 2002b. Fluctuations in distribution and patterns of individual range use of northern bottlenose whales. *Marine Ecology Progress Series* 225: 287-297.

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.

IWC (International Whaling Commission). 1978. Chairman's report of the Twenty-ninth Meeting. Twenty-eighth Report of the Commission. Cambridge, UK: International Whaling Commission. pp. 18-27.

IWC (International Whaling Commission). 2002. Classification of the Order Cetacea. http://www.iwcoffice.org/conservation/cetacea.htm.

Jenkins, J. 1990. The Blandford Whaling Station 1964-1972. Halifax, NS: Oceans Institute of Canada.

Jepson, P.D., M. Arbelo, R. Deaville, I. A. P. Patterson, P. Castro, J. R. Baker, E. Degollada, H.M. Ross, P. Herráez, A. M. Pocknell, F. Rodríguez, F. E. Howie, A. Espinosa, R. J. Reid, J. R. Jaber, V.Martin, A. A. Cunningham, A. Fernández. 2003. Gas bubble lesions in stranded cetaceans. *Nature*. 425.

Johnson, M. P., Madsen, P. T., Aguilar-De Soto, N., Zimmer, W. M. X. and Tyack, P. 2004. Beaked whales echolocate for prey. *Proceedings of the Royal Society of London* B. doi 10.1098.

Johnson, M., P. Madsen, and P. Tyack. 2005. A binaural acoustic recording tag reveals details of deep foraging in beaked whales. *Journal of the Acoustical Society of America*, Vol. 117, No. 4, Pt. 2, April 2005

Jones, B.A., Stanton, T.K., Lavery, A.C., Johnson, M.P., Madsen, P.T. and P. L. Tyack. 2005. A scattering analysis of echoes due to biosonar signals emitted by foraging beaked whales. *Journal of the Acoustical Society of America*, Vol. 118, No. 3, Pt. 2, September 2005.

Jonsgård, A. 1977. A note on the value of bottlenose whales in relation to minke whales and the influence of the market situation and the prices on Norwegian whaling activity. *Twenty-*

seventh Report of the Commission. Cambridge, UK: International Whaling Commission. pp. 502-504.

Kastelein, R.A. and N.M. Gerrits. 1991. Swimming, diving, and respiration patterns of a northern bottlenose whale (*Hyperoodon ampullatus*, Forster, 1770). *Aquatic Mammals* 17: 20-30.

Ketten, D.R., J. Lien and S. Todd. 1993. Blast injury in humpback whale ears: evidence and implications. *Journal of the Acoustical Society of America* 94: 1849-1850.

Kooyman, G.L. and P.J. Ponganis. 1997. The challenges of diving to depth. *American Scientist*, 85: 53-539.

Kooyman, G.L. and P.J. Ponganis. 1998. The physiological basis of diving to depth: birds and mammals. *Annual Review of Physiology* 60: 19-32.

Kristensen, T.K. 1981. The genus *Gonatus* Gray, 1849 (Mollusca: Cephalopoda) in the North Atlantic. A revision of the North Atlantic species and description of *Gonatus steenstrupi* n. sp. *Steenstrupia* 7: 61-99.

Kristensen, T.K. 1983. *Gonatus fabricii*. In: P.R. Boyle, ed. *Cephalopod Life Cycles*. Vol. 1. Toronto: Academic Press. pp. 159-173.

Kristensen, T.K. 1984. Biology of the squid *Gonatus fabricii* (Lichtenstein, 1818) from West Greenland waters. Meddelelser om Grønland, *Bioscience* 13. 20 pp.

Lawson, J.W., R.A. Davis, W.J. Richardson and C.I. Malme. 2000. Assessment of noise issues relevant to key cetacean species (northern bottlenose and sperm whales) in the Sable Gully Area of Interest. Prepared for Oceans Act Coordination Office, Maritimes Region, Department of Fisheries and Oceans Canada.

Ledwell, W.J., and J. Huntington. 2004. Marine animal entrapments in fishing gear in Newfoundland and Labrador, and a summary of the whale release and strandings program during 2004. A report to the Department of Fisheries and Oceans Canada, Newfoundland and Labrador Region.

Ledwell, W.J., and J. Huntington. 2005. Whale, leatherback sea turtle and basking shark entrapments in fishing gear in Newfoundland and Labrador , and a summary of the whale release and strandings program during 2005. A report to the Department of Fisheries and Oceans Canada, Newfoundland and Labrador Region.

Ledwell, W.J., amd J. Huntington. 2007. Incidental entrapments in fishing gear reported in 2007 in Newfoundland and Labrador, and a summary of the whale release and strandings program. A report to the Department of Fisheries and Oceans Canada, Newfoundland and Labrador region.

Lee, K. H. Bain and G.V. Hurley (Eds.) 2005. Acoustic Monitoring and Marine Mammal Surveys in the Gully and Outer Scotian Shelf before and during Active Seismic Programs. Environmental Studies Research Funds Report No. 151.

Lens, S. 1997. Interactions between marine mammals and deep water trawlers in the NAFO regulatory area. International Council for the Exploration of the Sea. ICES Council Meeting Papers. CM 1997/Q:08.

Lick, R. and U. Piatkowski. 1998. Stomach contents of a northern bottlenose whale (*Hyperoodon ampullatus*) stranded at Hiddensee, Baltic Sea. *Journal of the Marine Biological Association of the United Kingdom* 78: 643-650.

Lucas, Z. 1992. Monitoring Persistent Litter in the Marine Environment on Sable Island, Nova Scotia. *Marine Pollution Bulletin* 24(4): 192-199.

Lucas Z.N. and S.K. Hooker. 2000. Cetacean strandings on Sable Island, Nova Scotia, 1970-1998. *Canadian Field Naturalist* 114 (1): 45-61

MacDonald, R. 2005. Distribution and fisheries interactions of northern bottlenose whales (*Hyperoodon ampullatus*) in Davis Strait/Baffin Bay.

Madsen, P. T., Johnson, M., Aguilar de Soto, N., Zimmer, W. M. X. and P. Tyack. 2005. Biosonar performance of foraging beaked whales *(Mesoplodon densirostri*s). *The Journal of Experimental Biology* 208, 181-194.

Madsen, P.T., B. Møhl, B.K. Nielsen and M. Wahlberg. 2003. Male sperm whale behaviour during exposures to distant seismic survey pulses. *Aquatic Mammals* 28(3): 231-240.

Malakoff, D. 2002. Suit ties whale deaths to research cruise. *Science* 298: 722-723.

Martín Martel, V. 2002. Summary of the report on the atypical mass stranding of beaked whales in the Canary Islands in September 2002 during naval exercises. Society for the Study of the Cetaceans in the Canary Archipelago (SECAC). Unpublished report. 11p.

Mead J.G. 1989. Bottlenose whales - *Hyperoodon ampullatus* (Forster, 177) and *Hyperoodon planifrons* Flower, 1882. In: S.H. Ridgway and S.R. Harrison, eds. *Handbook of Marine Mammals*. Vol. 4: River Dolphins and the Larger Toothed Whales. London: Academic Press. pp. 321-348.

Mead, J.G. 2002. Beaked whales, Overview *Ziphiidae*. In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego: Academic Press. pp. 81-84.

Mitchell, E. 1974. Present status of northwest Atlantic fin and other whale stocks. In: Schevill, W.E., ed. The Whale Problem: A Status Report. International conference on the biology of whales, Shenandoah National Park, Virginia, 1971. Cambridge, MA: Harvard University. pp. 108-169.

Mitchell, E. 1975. Porpoise, dolphin and small whale fisheries of the world. Status and problems. Morges, Switzerland: International Union for Conservation of Nature and Natural Resources.

Mitchell, E. 1976. Northern bottlenose whale *Hyperoodon ampullatus* (Forster 1770). In: *Red Data Book. Volume I: Mammalia*. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland.

Mitchell, E. 1977. Evidence that the northern bottlenose whale is depleted. In: *Twenty-seventh report of the Commission (covering the twenty-seventh fiscal year 1975-76)*. Cambridge, UK: International Whaling Commission. pp. 195-203.

Mitchell, E. and V.M. Kozicki. 1975. Autumn stranding of a northern bottlenose whale (*Hyperoodon ampullatus*) in the Bay of Fundy, Nova Scotia. *Journal of the Fisheries Research Board of Canada* 1019-1040.

Mitchell, J. 2008. Prevalence and characteristics of melon markings on northern bottlenose whales (*Hyperoodon ampullatus*) in the Gully and the effects of the Marine Protected Area on marks of anthropogenic origin. Honours thesis, Biology Department, Dalhousie University.

Moiseev, S.I. 1991. Observation of the vertical distribution and behavior of nektonic squids using manned submersibles. *Bulletin of Marine Science* 49: 446-456.

NAMMCO (North Atlantic Marine Mammal Commission). 1997. Report of the third meeting of the scientific committee. Annual Report of the North Atlantic Marine Mammal Commission, Tromsø, Norway, 1995, 71–126.

Nesis, K.N. 1965. Distribution and feeding of young squids *Gonatus fabricii* (Licht.) in the Labrador Sea and the Norwegian Sea. *Oceanology* 5: 102-108.

Ocean Studies Board, Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals. 2003. *Ocean Noise and Marine Mammals*. Washington, DC: National Academies Press. http://www.nap.edu/catalog.php?record_id=10564.

Ohlin, A. 1893. Some remarks on the bottlenose-whale (*Hyperoodon*). *Lunds Universitets Årsskrift* 29:1-13 + 1 plate.

Pathological Anatomy Unit, Veterinary School, University of Las Palmas de Gran Canaria. 2002. Mass Stranding of Beaked Whales in Fuerteventura and Lanzarote 24-27 September 2002.

Pierson, M.O., J.P. Wagner, V. Langford, P. Birnie, and M.L. Tasker. 1998. Protection from, and mitigation of, the potential effects of seismic exploration on marine mammals. In: M.L. Tasker and C. Weir, eds. *Proceedings of the Seismic and Marine Mammals Workshop*, London, 23-25 June 1998. Sea Mammal Research Unit, University of St. Andrews, Scotland. http://smub.st-and.ac.uk/seismic/pdfs/7.pdf.

Potter, J.R., M. Thillet, C. Douglas, M.A. Chitre, Z. Doborzynski and P.J. Seekings, Visual and Passive Acoustic Marine Mammal Observations and High-Frequency Seismic Source Characteristics Recorded During a Seismic Survey, *IEEE Journal of Oceanic Engineering* 32(2), April 2007, http://www.arl.nus.edu.sg/objects/04383222.pdf.

Reeves, R.R., 1978. Bottlenose whales. *Oceans* 11(6): 61-63.

Reeves, R.R. 2002. Hunting of Marine Mammals. In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. *Encyclopedia of Marine Mammals*. San Diego: Academic Press. pp. 592-596.

Reeves, R. and E. Mitchell. 1993. Status report on the northern bottlenose whale, *Hyperoodon ampullatus*, in Canada. Prepared for the Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario.

Reeves, R.R., E. Mitchell, and H. Whitehead. 1994. Status of the northern bottlenose whale, *Hyperoodon ampullatus*. *Canadian Field-Naturalist* 107: 490-508.

Reeves, R.R., Smith, B.D., Crespo, E.A. and di Sciara, G.N. (compilers) 2003. Dolphins, Whales and Porpoises: 2002-2010 Conservation Action Plan for the World's Cetaceans. IUCN/SSC Cetacean Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. *Marine Mammals and Noise*. San Diego: Academic Press.

Right Whale Recovery Team. 2000. Canadian North Atlantic Right Whale Recovery Plan. Prepared for World Wildlife Fund and the Department of Fisheries and Oceans Canada. Dartmouth, NS: Department of Fisheries and Oceans.

Rutherford, R.J. and H. Breeze. 2002. The Gully Ecosystem. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2615.

Santos, M.B., M.R. Clarke, and G.J. Pierce. 2001. Assessing the importance of cephalopods in the diets of marine mammals and other top predators: problems and solutions. *Fisheries Research* 52 (1-2): 121-139.

Santos, M.B., G.J. Pierce, C. Smeenk, M.J. Addink, C.C. Kinze, S. Tougaard, and J. Herman. 2001. Stomach contents of northern bottlenose whales *Hyperoodon ampullatus* stranded in the North Sea. *Journal of the Marine Biological Association of the United Kingdom* 81: 143-150.

Sergeant, D.E. and H.D. Fisher. 1957. The Smaller Cetacea of eastern Canadian waters. *Journal of the Fisheries Research Board of Canada* 14: 83-115.

Sergeant, D.E., A.W. Mansfield and B. Beck. 1970. Inshore records of Cetacea for Eastern Canada, 1949-1968. *Journal of the Fisheries Research Board of Canada* 27: 1903-1915.

Simard, P. 1995. A survey of the physical and biological oceanographic features of "The Gully" in relation to the distribution of northern bottlenose whales (*Hyperoodon ampullatus*). Honours thesis, Department of Biology, Dalhousie University, Halifax, Nova Scotia.

Simmonds, M.P. and L.F. Lopez-Jurado. 1991. Whales and the military. *Nature* 351: 448.

Smith, S.C. 2001. Examination of Incidental Catch from the Canadian Atlantic Large Pelagic Longline Fishery. Unpublished contract report prepared for Fisheries and Oceans Canada.

SOEP (Sable Offshore Energy Project). 2003. The Gully Code of Practice. http://www.soep.com/cgi-bin/getpage?pageid=1/8/2.

Southwell, T. 1884. The bottle-nose whale fishery in the North Atlantic Ocean. *United States Commission of Fish and Fisheries* 10: 221-227.

Sub-committee on small cetaceans, International Whaling Commission. 1989. Report of the sub-committee on small cetaceans. Thirty-ninth Report of the International Whaling Commission. Cambridge, UK: International Whaling Commission. pp. 117-129.

Sutcliffe Jr, W.H. and P.F. Brodie. 1977. Whale distributions in Nova Scotia waters. Fisheries and Marine Service Technical Report 722.

Tallmon DA, Luikart G, Waples RS (2004) The alluring simplicity and complex reality of genetic rescue. *Trends in Ecology and Evolution* 19, 489-496.

Terhune, J.M. and W.C. Berboom. 1999. Right whales and ship noise. Letter. *Marine Mammal Science* 15: 256-258.

Tyack, P.L., Johnson, M. and P. T. Madsen. 2004. Echolocation in wild toothed whales. *Journal of the Acoustical Society of America* 115(5), Pt. 2, May 2004.

Vecchione, M. and J. Galbraith. 2001. Cephalopod species collected by deepwater exploratory fishing off New England. *Fisheries Research* 51: 385-391.

Ward, P.D., M.K. Donnelly, A.D. Heathershaw, S.G. Marks and S.A.S. Jones. 1998. Assessing the impact of underwater sounds on marine mammals. In: M.L. Tasker and C. Weir, eds. *Proceedings of the Seismic and Marine Mammals Workshop*, London, 23-25 June 1998. Sea Mammal Research Unit, University of St. Andrews, Scotland. http://smub.st-and.ac.uk/seismic/pdfs/8_4.pdf.

Waring, G.T., D.L. Palka, P.J. Clapham, S. Swartz, M.C. Rossman, T.V.N. Cole, K.D. Bisack and L.J. Hansen. 1998. Northern bottlenose whale (*Hyperoodon ampullatus*): Western North Atlantic Stock. In: U.S. Atlantic Marine Mammal Stock Assessments. NOAA technical memorandum NMFS-NE 116. pp. 61-62.

Whitehead, H., J. Arch, S. Gowans, S. Hooker, and C. Scarfe. 1999. Research on bottlenose whales in the Gully, Nova Scotia. Final report on research in 1999. Prepared for World Wildlife Fund Canada, Canadian Wildlife Service: Endangered Species Recovery Fund, and Department of Fisheries and Oceans.

Whitehead, H., W.D. Bowen, S.K. Hooker, and S. Gowans. 1998. Marine Mammals. In: W.G. Harrison and D.G. Fenton, eds. *The Gully: A Scientific Review of Its Environment and Ecosystem*. Canadian Stock Assessment Secretariat Research Document 98/83. 186-221.

Whitehead, H., M. Dalebout, D. Herfst, S. Hooker and T. Wimmer. 2004. Final report: Bottlenose whales in the Western North Atlantic, 2003. Prepared for Department of Fisheries and Oceans, Canada, National Geographic Society, USA, Royal Society of London, UK and Whale Dolphin Conservation Society, UK.

Whitehead, H., A. Faucher, S. Gowans, and S. McCarrey. 1997a. Status of the northern bottlenose whale, *Hyperoodon ampullatus*, in the Gully, Nova Scotia. *Canadian Field-Naturalist* 111: 287-292.

Whitehead, H., S. Gowans, A. Faucher, and S.W. McCarrey. 1997b. Population analysis of northern bottlenose whales in the Gully, Nova Scotia. *Marine Mammal Science* 13: 173-185.

Whitehead, H., C.D. MacLeod and P. Rodhouse. 2003. Differences in niche breadth among some teuthivorous mesopelagic marine mammals. *Marine Mammal Science* 19: 400-406.

Whitehead, H. and T. Wimmer. 2002a. Research on bottlenose whales off Nova Scotia. Final report on research in 2001. Prepared for Canadian Whale Institute, Department of Fisheries and Oceans, Whale and Dolphin Conservation Society, World Wildlife Fund and Canadian Wildlife Service: Endangered Species Recovery Fund.

Whitehead, H. and T. Wimmer. 2002b. Update to the status of the northern bottlenose whale, *Hyperoodon ampullatus* (Scotian Shelf population). Prepared for COSEWIC. 27 November 2002.

Whitehead, H. and T. Wimmer. 2005 Heterogeneity and the mark-recapture assessment of the Scotian Shelf population of northern bottlenose whale (*Hyperoodon ampullatus*). *Canadian Journal of Fisheries and Aquatic Science* 62: 2573-2585.

Williams, T.M., R.W. Davis, L.A. Fulman, J. Francis, B.J. Le Boeuf, M. Horning, J. Calambokidis, and D.A. Croll. 2000. Sink or Swim: Strategies for cost-efficient diving by marine mammals.

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.

Wimmer, T., H. Whitehead, and J. Bock. 2002. Research on bottlenose whales off Nova Scotia. Final report on research in 2002. Prepared for Department of Fisheries and Oceans, Whale and Dolphin Conservation Society and World Wildlife Fund Canada/Canadian Wildlife Service: Endangered Species Recovery Fund.

Winn, H.E., P.J. Perkins, and L. Winn. 1970. Sounds and behavior of the northern bottle-nosed whale. In : Proceedings of the 7th Annual Conference on Biological Sonar and Diving Mammals, Stanford Research Institute, Menlo Park, California. pp. 53-59.

Würsig, B. and P.G.H. Evans. 2001. Cetaceans and Humans: Influences of noise. In: P.G.H. Evans and J.A. Raga, eds. *Marine Mammals: Biology and Conservation*. New York: Kluwer Academic/Plenum. pp. 565-587.

APPENDIX A – Glossary

Action Plan: Action plans are the second part of a two-part recovery planning process. The first part, the recovery strategy, describes scientific baseline information about the species, its critical habitat and threats, as well as establishing objectives that will assist its survival and recovery. These recovery strategies are implemented through action plans, which outline the measures needed to meet the objectives set out in recovery strategies, and indicate when they are to take place.

Anthropogenic: related to or resulting from the influence of humans on nature or the environment.

Azimuth: a compass bearing measured in degrees from True North.

Benthic: of or relating to the bottom sediments and subsurface layers.

Cetacean: any of the order Cetacea of aquatic, mostly marine mammals, including whales, dolphins, and porpoises.

Congener: a member of the same taxonomic genus as another plant or animal.

COSEWIC: Committee on the Status of Endangered Wildlife in Canada. A body of Canadian government, academic and non-academic government experts that assess species at risk of extinction nationally.

DDT: Dichloro-Diphenyl-Trichloroethane, one of the best known synthetic pesticides.

DNA: Deoxyribonucleic acid, a nucleic acid that contains the genetic instructions used in the development and functioning of all known living organisms.

Endangered: a species facing imminent extirpation or extinction.

Epimeletic behaviour: maternal behavior demonstrated by a mother caring for her young in the early stages.

Heterozygosity: the fraction of individuals in a population that are heterozygous for a particular locus or gene, i.e., an individual that has 2 different alleles for a trait.

Maxillary crest: the dorsal surface of the skull starting from above the upper jaw.

Mesopelagic: of, or relating to oceanic depths from c. 200 to 1000 meters.

Microsatellite: any of numerous short segments of DNA (deoxyribonucleaic acid) that are distributed throughout the genome, that consist of repeated sequences of usually two to five nucleotides, and that tend to vary from one individual to another.

Mitochondrial DNA: the DNA (deoxyribonucleaic acid) found in organelles called mitochondria, as distinct from DNA found in the cell nucleus.

Mortality: death rate.

Niche: a habitat supplying the factors necessary for the existence of an organism or species.

Pelagic: of or relating to the open ocean or the oceanic environment, not close to the ocean bottom.

Photic zone: the water column depth from the surface to where light intensity falls to 1 percent of that at the surface; this depth varies with light attenuation through the water column.

Potential Biological Removal: the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.

Seismic: sound waves created at sea by vessel-towed air gun arrays designed to penetrate the seabed to delimit oil and gas reservoirs.

SOCPROG: a series of MATLAB programs written by Hal Whitehead for analyzing data on the social structure, population structure and movements of identified individuals.

Teuthivores: animals that eat squid.

APPENDIX B – Threat Categorization

Table 3 summarizes known and hypothetical threats to the northern bottlenose whale. Each threat is categorized based on the following attributes:

Threat category – Broad category indicating the type of threat.

General threat – The general activity causing the specific threat.

Specific threat – The specific factor or stimulus causing stress to the population.

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

Extent – Indicates whether the threat is widespread, localized, or unknown across the species range.

Occurrence – Indicates whether the threat is historic (contributed to decline but no longer affecting the species), current (affecting the species now) or hypothetical (may affect the species in the future).

Frequency – Indicates whether the threat is a one-time occurrence, continuous (on-going), recurrent (reoccurs from time to time but not on an annual or seasonal basis), or unknown.

Causal certainty – Indicates whether the best available knowledge about the threat and its impact on population viability is high (evidence causally links the threat to stresses on population viability), medium (correlation between the threat and population viability, expert opinion, etc.), or low (assumed or plausible threat only).

Severity – Indicates whether the severity of the threat is high (very large population-level effect), moderate, low, or unknown.

Level of concern – Indicates whether managing the threat is an overall high, medium, or low concern for recovery of the species, taking into account all of the above factors. The terms low, medium and high are qualitative terms and are not further defined.

Local – indicates threat information relates to a specific site or narrow portion of the range of the species. For the purposes of this recovery strategy, local implies a specific site or narrow portion of the range of the Scotian Shelf population.

Range-wide – indicates threat information relates to the whole distribution or large portion of the range of the species. For the purposes of this recovery strategy, range-wide implies the entire range of the Scotian Shelf population.

Table 3.—Threat Summary and Categorization

1	**Historic Whaling**	**Threat Information**		
Threat Category	Consumptive use	**Extent**	Rangewide	
			Local	**Range-wide**
General Threat	Whaling	**Occurrence**		Historic
		Frequency		N/A
Specific Threat	Direct mortality	**Causal Certainty**		High
		Severity		High
Stress	Reduced population	**Level of Concern**	Low	
2	**Entanglement**	**Threat Information**		
Threat Category	Accidental mortality	**Extent**	Rangewide	
			Local	**Range-wide**
General Threat	Fishing Activity	**Occurrence**		Current
		Frequency		Recurrent (infrequent)
Specific Threat	Entanglement	**Causal Certainty**		Medium
		Severity		Unknown
Stress	Individual mortality	**Level of Concern**	Medium	
3	**Oil and Gas Exploitation**	**Threat Information**		
Threat Category	Disturbance / Pollution	**Extent**	Rangewide	
			Local	**Range-wide**
General Threat	Petroleum Exploration and Development	**Occurrence**	Current	
		Frequency	Ongoing/Recurrent	
Specific Threat	Acoustic disturbance, release of contaminants	**Causal Certainty**	Low	
		Severity	Unknown	
Stress	Physiological or behavioural changes, reduced productivity and/or reproductive success, habitat degradation	**Level of Concern**	Low to Medium	
4	**Acoustic Disturbance**	**Threat Information**		
Threat Category	Disturbance	**Extent**	Rangewide	
			Local	**Range-wide**
General Threat	Anthropogenic sound	**Occurrence**		Current
		Frequency		Recurrent
Specific	Acoustic disturbance	**Causal Certainty**		Medium

Threat		**Severity**		Unknown
Stress	Masking, TTS, PTS, physiological or behavioural changes, displacement, reduced productivity and/or reproductive success	**Level of Concern**	Medium	
5	**Contaminants**	**Threat Information**		
Threat Category	Pollution	**Extent**	Rangewide	
			Local	**Range-wide**
General Threat	Petroleum development, shipping, fishing, land-based activities.	**Occurrence**		Current
		Frequency		Recurrent
Specific Threat	Consuming contaminated prey, direct exposure, habitat degradation	**Causal Certainty**		Low
		Severity		Unknown
Stress	Reduced reproductive success, reduced productivity, physiological changes	**Level of Concern**	Low to Medium	
6	**Changes in Food Supply**	**Threat Information**		
Threat Category	Changes in Ecological Dynamics	**Extent**	Local	
			Local	**Range-wide**
General Threat	Changes in Food Supply	**Occurrence**	Hypothetical	
		Frequency	N/A	
Specific Threat	Reduced foraging success	**Causal Certainty**	Low	
		Severity	Unknown	
Stress	Reduced reproductive success and/or productivity	**Level of Concern**	Low	
7	**Vessel Collisions**	**Threat Information**		
Threat Category	Accidental Mortality	**Extent**	Rangewide	
			Local	**Range-wide**
General Threat	Shipping	**Occurrence**		Hypothetical
		Frequency		Recurrent
Specific Threat	Collisions with vessels	**Causal Certainty**		Low
		Severity		Low
Stress	Physical injury or mortality of individuals	**Level of Concern**	Low	

APPENDIX C - Record of Consultations

DFO held two workshops the gather multi-sectoral input on the contents of this recovery strategy. Generally, workshop participants included representatives from DFO Maritimes and Newfoundland Regions, Transport Canada, the Department of National Defense, various departments from the province of Nova Scotia, academia, Aboriginal groups, environmental non-government organizations, the fishing industry, and the oil and gas industry and its regulators, Detailed lists of participants are available in the documents cited below.

Millar, D. 2007. Report on the Northern Bottlenose Whale Recovery Workshop, June 5, 2007. Oceans and Habitat Report 2007-04.

Workshop to Review Draft Recovery Strategy for Northern Bottlenose Whale, June 25, 2008, Bedford Institute of Oceanography, Dartmouth. (Final version of DFO's Meeting Minutes prepared by Oceans and Coastal Management Division as distributed to participants on September 18, 2008.)