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Biology, Status, and Recovery Potential of Northern Bottlenose Whales (*Hyperoodon ampullatus*)

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

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ABSTRACT

Northern Bottlenose Whales in Canada range from Georges Bank to southern Baffin Bay. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recognises two populations of Northern Bottlenose Whales in Canada: the Scotian Shelf population and the Davis Strait-Baffin Bay-Labrador Sea population. The Davis Strait population was designated Not at Risk by COSEWIC in 1993. The Scotian Shelf population was assessed as Endangered in 2002 and added to *Schedule 1* of the *Species at Risk Act (SARA)* in 2006. In 2011, COSEWIC reassessed both populations and designated the Scotian Shelf population as Endangered and the Davis Strait population as Special Concern. In anticipation of this assessment, Fisheries and Oceans Canada conducted a Recovery Potential Assessment (RPA) in November 2010. This RPA will inform the *SARA* listing decision by the federal Governor in Council, socio-economic analyses, and consultations with the public. The RPA will also inform the recovery strategy(ies) of Northern Bottlenose Whale populations listed as Threatened or Endangered under the *SARA*.

The most recent published population estimate (average population estimate for the 1988 to 2003 period) for the Scotian Shelf is 163 individuals. There was no trend in abundance during that period. This population ranges from Georges Bank to the eastern Scotian Shelf; however, the majority of sightings are highly aggregated in the Gully, Haldimand Canyon, and Shortland Canyon. There is no evidence that range has decreased. There is no estimate of abundance for the Davis Strait population. Vessel-based and aerial survey efforts yielded few sightings between 2003 and 2007. It is likely that this long-lived species is still recovering from whaling. This population ranges from the Labrador Sea to southern Baffin Bay. Sightings are aggregated in the deep waters of the Davis Strait along the shelf edge, from the mouth of Hudson Strait to the mouth of Cumberland Sound.

The whales' primary prey item is deepwater squid from the genus *Gonatus*. Northern Bottlenose Whale habitat is characterised by waters of more than 500 metres in bottom depth, particularly around steep-sided features, which provide access to sufficient accumulations of Gonatus squid.

Zone 1 of the Gully Marine Protected Area and areas with water depths greater than 500 metres in Haldimand and Shortland canyons have been declared Critical Habitat for the Scotian Shelf population. Northern Bottlenose Whales do not have any known dwelling-place similar to a den or nest during any part of their life cycle; hence, the concept of "residence" does not apply.

The main human-induced threats are anthropogenic ocean noise (particularly from oil and gas exploration and extraction) and entanglement/bycatch in fishing gear. The latter is the only documented source of human-induced harm or mortality in Canada. Potential mitigation measures include education of members of the fishing industry on safe handling and release techniques and on the risks to nearby feeding whales. Area closures could be used should areas of high entanglement risk be identified.

Biologie, situation, potentiel de rétablissement de la baleine a bec commune (*Hyperoodon ampullatus*)

RÉSUMÉ

La baleine à bec commune au Canada se trouve du banc de Georges au sud de la baie de Baffin. Le Comité sur la situation des espèces en péril au Canada (COSEPAC) reconnaît deux populations de baleines à bec communes au Canada : la population du plateau néo-écossais et la population du détroit de Davis, de la baie de Baffin et de la mer du Labrador. La population du détroit de Davis a été désignée par le COSEPAC comme n'étant pas en péril en 1993. La population du plateau néo-écossais a été évaluée comme étant en voie de disparition en 2002 et a été ajoutée à l'annexe 1 de la *Loi sur les espèces en péril* (LEP) en 2006. En 2011, le COSEPAC a réévalué les deux populations et a désigné la population du plateau néo-écossais comme étant en voie de disparition et la population du détroit de Davis comme étant préoccupante. Avant cette évaluation, Pêches et Océans Canada a réalisé, en novembre 2010, une évaluation du potentiel de rétablissement (EPR). Cette EPR présentera des analyses socio-économiques et des consultations publiques pour aider le gouverneur en conseil à prendre une décision concernant l'inscription à la LEP. L'EPR contribuera également aux programmes de rétablissement des populations de la baleine à bec commune désignées comme étant en voie de disparition ou menacées aux termes de la LEP.

La plus récente estimation de la population publiée (estimation de la population moyenne entre 1988 et 2003) pour le plateau néo-écossais est de 163 individus. On ne dénote pas de tendance d’abondance au cours de cette période. Cette population s'étend du banc de Georges à l'est du plateau néo-écossais; cependant, la plupart des observations sont grandement concentrées dans les canyons Gully, Haldimand et Shortland. Il n'y a aucun signe que leur nombre aurait diminué. Il n'y a aucune estimation de l'abondance de la population du détroit de Davis. Des études par bateau et par avion n'ont pu relever que quelques observations entre 2003 et 2007. Il semble que cette espèce à espérance de vie élevée se remet encore de la pêche à la baleine. Cette population s'étend de la mer du Labrador au sud de la baie de Baffin. Elle se concentre dans les eaux profondes du détroit de Davis, sur le bord du plateau, de l'entrée du détroit d'Hudson à l'entrée de la baie Cumberland.

Les principales proies de ces baleines sont les calmars *Gonatus*. L'habitat de la baleine à bec commune se caractérise par des eaux de plus de 500 mètres de profondeur, particulièrement auprès de parois abruptes, qui lui fournissent un accès à un nombre suffisant de calmars *Gonatus*.

La zone 1 de la zone de protection marine du Gully et les zones de plus de 500 mètres de profondeur dans les canyons Haldimand et Shortland ont été désignées comme un habitat essentiel de la population du plateau néo-écossais. La baleine à bec commune n'occupe pas de résidence précise connue semblable à un nid ou un antre au cours de sa vie. C'est pourquoi le concept de résidence ne s'applique pas dans ce cas.

Les principales menaces provoquées par les activités humaines sont les bruits anthropiques dans l'océan (provenant surtout des activités d'exploration et d'extraction pétrolières et gazières), ainsi que l'enchevêtrement dans l'équipement de pêche et les prises accessoires. Ce dernier est la seule source documentée de dommages ou de mortalité causés par les humains au Canada. Les mesures d'atténuation potentielles comptent l'éducation des membres de l'industrie de la pêche sur les méthodes sécuritaires de manipulation et de libération des baleines, ainsi que sur les risques pour les baleines qui se nourrissent à proximité. Lorsque des zones à haut risque d'enchevêtrement sont repérées, ces zones pourront être fermées.

INTRODUCTION

In April 1993, the Northern Bottlenose Whale (*Hyperoodon ampullatus*) was given a single designation of Not at Risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In April 1996, the whales were split into two populations to allow a separate designation of the Scotian Shelf population. The Baffin Bay-Davis Strait-Labrador Sea (hereafter referred to as the Davis Strait) population has not been reassessed since it was designated Not at Risk in 1993. The Scotian Shelf population was designated Special Concern by COSEWIC in 1996. Its status was reassessed as Endangered in November 2002 with the following reason:

> "This population totals about 130 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."
>
> (COSEWIC 2002, p. iii)

This population was added to *Schedule 1* of the *Species at Risk Act* (*SARA*) in 2006. A Recovery Strategy was produced in 2010 (DFO 2010a).

Both the Scotian Shelf and the Davis Strait populations were scheduled for reassessment by COSEWIC during their April 2011 meeting. In anticipation of COSEWIC's assessment decision, Fisheries and Oceans Canada (DFO) conducted a Recovery Potential Assessment (RPA) in November 2010. This RPA will inform the *SARA* listing decision by the federal Governor in Council (GiC), socio-economic analyses, and consultations with the public. The RPA will also inform new or updated Recovery Strategy(ies) for Northern Bottlenose Whale populations listed as Threatened or Endangered under the *SARA*.

The *SARA* is intended to protect species at risk of extinction in Canada and promote their recovery. The *SARA* includes prohibitions on killing, harming, harassing, capturing, or taking individuals of species listed as Threatened or Endangered on *Schedule 1*. The *SARA* prohibits sale or trade of individuals of such species (or their parts), damage or destruction of their residences, or destruction of their critical habitat. The *SARA* also specifies that a recovery strategy must be prepared for species that are listed as Threatened or Endangered. The provisions of these recovery strategies will have to address all potential sources of harm, including harvesting activities, so that the survival and recovery of the populations concerned are not jeopardised.

Section 73 (2) of the *SARA* provides the competent Ministers with the authority to permit normally prohibited activities affecting a listed species, its critical habitat, or its residence, even when they are not part of a previously approved recovery plan. Such activities can only be approved if: 1) the activity is scientific research relating to the conservation of the species and conducted by qualified persons; 2) they will benefit the species or are required to enhance its chance of survival in the wild; or 3) affecting the species is incidental to carrying them out.

The decision to permit allowable harm must consider the species' current situation and its recovery potential, the impacts of human activities on the species and its ability to recover, as well as alternatives and measures to reduce these impacts to a level that will not jeopardise the survival and recovery of the species. Therefore, a RPA process was established by DFO Science in order to provide the information and scientific advice required to meet these various requirements. In the case of a species that has not yet been added to *Schedule 1*, the scientific information also could contribute to the decision as to whether or not to add the species to the list. Consequently, the information is used when analysing the socio-economic impacts of adding the species to the list as well as during subsequent consultations, where applicable.

SPECIES BIOLOGY

LIFE HISTORY

The Northern Bottlenose Whale is a medium-sized toothed whale that ranges in length from seven to nine metres at maturity (Thompson 1846, Hale 1931, Fraser 1964 *in* Mead 1989). Individuals from the Scotian Shelf population are, on average, 0.7 metres shorter than those caught by whalers off Labrador (Whitehead *et al*. 1997a). The whales are variable in colour, ranging from brown when young, to light brown or grey when older, and to yellowish brown or light grey, with whitish beaks and heads, when very old. On rare occasions old males become entirely yellow-white (Mead 1989). Mature adults exhibit sexual dimorphism in the shape and colouration of the head and a slightly longer body (Benjaminsen and Christensen 1979, H. Moors, DFO, pers. comm. 2010). Males have a much larger head, with a forehead that appears squared off, relative to their body size, while females and immature males have a bulbous forehead (COSEWIC 2011).

Males examined off Labrador appeared to reach sexual maturity between seven and 11 years of age, based on the histological appearance and growth rates of the testes (Benjaminsen and Christensen 1979). Christensen (1973) examined whales from the Labrador Sea and concluded that 80% of females reached sexual maturity between eight and 12 years. Individual life span is at least 27 years for females and 37 years for males (Christensen 1973, Mead 1989).

Peak mating occurs in July and August for the Scotian Shelf population of Northern Bottlenose Whales (Whitehead *et al*. 1997b), and pregnant females give birth to a single calf one year later (Benjaminsen 1972). In contrast, the Davis Strait population mates and calves between April and June, with a peak in April (Benjaminsen 1972). Christensen (1973) inferred a two-year breeding cycle based on a nearly 1:1 ratio of pregnant to lactating females off Labrador and the assumption that gestation and lactation each last one year. The reproductive cycle in the Scotian Shelf population has not been examined in detail. However, more frequent calf sightings would be expected if females gave birth every two years. There is evidence that both mating (Whitehead *et al*. 1997a, Hooker *et al.* 2002, Wimmer 2003) and calving (Gowans *et al*. 2001, Wimmer 2003) occur in the Gully.

The species is social, and the whales are usually seen in small groups of one to four individuals (Mead 1989) although groups of up to 20 have been observed (Gowans 2002). Males appear to form strong social bonds with other mature males while females appear to associate with many different individuals in looser associations (Gowans *et al*. 2001). These whales are described as curious as they are observed approaching and circling slow-moving or stationary vessels (Gray 1882, Mead 1989, Mitchell 1977, Reeves *et al.* 1993). This, combined with their habit of ‘standing-by’ an injured member of the pod, made them particularly vulnerable to whalers (Benjaminsen and Christensen 1979, Gray 1882, Mitchell 1977).

DISTRIBUTION

Northern Bottlenose Whales are found only in the northern North Atlantic, occurring in cool and subarctic waters. They are distributed primarily from Nova Scotia to Baffin Bay, across the North Atlantic along the east coast of Greenland, and from England to the west coast of Spitzbergen (Mead 1989) (Figure 1). The two centres of distribution in the western North Atlantic are the eastern Scotian Shelf edge and the Davis Strait (Christensen 1973, Benjaminsen and Christensen 1979, COSEWIC 2011) (figures 2, 3, and 4). Northern Bottlenose Whales have been sighted outside of these areas, such as along the edges of the Grand Banks and Georges Bank (figures 2, 3, and 4). Many of these sightings have been opportunistic and species identification may be, on occasion, incorrect. The National Marine Fisheries Service (NMFS) sighted two Northern Bottlenose Whales as far south as Cape May, New Jersey, in a 1988 survey (Reeves *et al.* 1993). Strandings have been documented further south, including one whale that was stranded in Rhode Island (Mitchell and Kozicki 1975), and further west, in the Gulf of St. Lawrence, but these individuals were considered strays. Opportunistic sightings data are biased by the distribution of effort. An absence of sightings does not prove an absence of the species in an area just as an aggregation of opportunistic sightings can indicate an area of high human activity, such as scientific research, rather than an aggregation of whales. The availability of survey data is limited.

On the Scotian Shelf, Northern Bottlenose Whales have been sighted most often in the deep waters of three submarine canyons (the Gully, Shortland Canyon, and Haldimand Canyon) (Figure 5) and along the shelf edge (Figure 3) (Wimmer 2003). Whalers, and more recently researchers, have long documented these whales in the Gully (Mitchell 1974, Reeves *et al*. 1993), and more recent research has established that the whales also are found regularly in the Shortland and Haldimand canyons to the northeast of the Gully (Wimmer and Whitehead 2004). Wimmer and Whitehead (2004) examined the movements of individual bottlenose whales using photo-identification techniques and determined that some of the individuals known from the Gully were regularly sighted in the Shortland and Haldimand canyons. However, they found that the population was not mixing fully and that there was heterogeneity in the movement of individuals with at least some individuals preferring particular canyons. Males also appeared to move between canyons more frequently than females.

Much less is known about the distribution of the Davis Strait population. These whales appear to be concentrated in the deep waters of the Davis Strait along the shelf edge, from the mouth of Hudson Strait to the mouth of Cumberland Sound (Figure 4). Sightings records indicate that their full range is from the Labrador Sea to the top of the southern part of Baffin Bay (Figure 4). The northernmost sightings are at approximately 70°N (Gray 1882). Benjaminsen and Christensen (1979) found that Norwegian whalers made most of their catch in waters greater than 1000 metres in depth, with very few caught on the continental shelf. British whalers reported 92 kills along the slope off Cumberland Sound area from 1877 to 1893 (Reeves *et al*. 1993, A. Reeves, DFO, pers. comm. 2010).

Northern Bottlenose Whales in some areas of their global distribution are thought to migrate northwards in the spring and southwards in the summer (Benjaminsen 1972). The Scotian Shelf population, however, is believed to remain year round on the shelf edge (Whitehead *et al*. 1997a, Whitehead and Wimmer 2002, Compton 2004). Whales have been sighted during all seasons in the Davis Strait as well (Reeves *et al*. 1993).

HABITAT

Beaked whales usually inhabit deep water, which is correlated with the distribution of their prey (Kenney *et al*. 1996, Hooker *et al*. 1999). Previous research has shown some correlation between the distribution of other cetacean species and both physical features (Hui 1979) and temporally variable oceanographic conditions (Tynan 1997, Hooker *et al*. 1999). However, uncertainty remains regarding which environmental factors have the greatest influence on Northern Bottlenose Whale distribution. They are linked primarily to steep-sloped, deep shelf-edge waters and cold sea surface temperatures (Benjaminsen and Christensen 1979, Hooker *et al.* 1999, Compton 2004, Herfst 2004). Northern Bottlenose Whales are usually sighted in waters of 500 to 1500 metres in depth (Hooker *et al*. 1999, Hooker *et al*. 2002) with a mean bottom depth of 1200 metres. Reeves *et al*. (1993) stated that the whales are primarily distributed near the 1000-metre isobath in the Northwest Atlantic. Wimmer and Whitehead (2004) found that bottlenose whales were regularly sighted in waters with mean depths of 1052 and 1126 metres in the Shortland and Haldimand canyons, respectively. They have been caught rarely in waters less than 1000 metres (Benjaminsen and Christensen 1979). Northern Bottlenose Whales are predicted to occur primarily in cool waters with temperatures averaging around 2.7°C (Benjaminsen and Christensen 1979, Compton 2004, Herfst 2004) although they have been observed in waters ranging from -2°C to 24°C (Reeves *et al*. 1993, H. Moors, DFO, pers. comm. 2010, COSEWIC 2011).

FORAGING AND DIET

Foraging Northern Bottlenose Whales are capable of diving to great depths to feed. On the Scotian Shelf, one tagged whale made regular dives to depths greater than 800 metres (maximum recorded depth 1453 metres) (Hooker and Baird 1999) which places the Northern Bottlenose Whale among the deepest-diving marine mammals. Many of the recorded dives were to or near the ocean floor, suggesting benthic or bathypelagic feeding (Hooker and Baird 1999). Dive durations of whales under normal conditions have been recorded up to a maximum of 70 minutes (Benjaminsen and Christensen 1979, Hooker and Baird 1999).

Compared to other deep-diving squid-eaters, Northern Bottlenose Whales appear to have a much more specialised diet (Whitehead *et al*. 2003). Their primary prey item is deepwater squid from the genus *Gonatus*. Hooker *et al*. (2001) suggested that the Scotian Shelf population was consuming primarily *Gonatus* sp*.* based on stomach content, stable isotope, and fatty acid analyses. The stomach contents of five whales captured on the Scotian Shelf in 1967 were reported to be squid; the genus was not noted (Reeves *et al.* 1993). Benjaminsen and Christensen (1979) found that the stomachs of all 108 Davis Strait whales examined contained squid, exclusively *Gonatus fabricii.* Although squid were the major prey item, half of the stomachs also contained some fish (including redfish (*Sebastes* sp.), Greenland halibut (*Reinhardtius hippoglossoides*), rabbitfish (*Chimaera monstrosa*), spiny dogfish (*Squalus acanthias*), ling (*Molva molva*) and skate (*Raja* sp.), and one stomach contained pandalid shrimp.

G. fabricii is often found at depths of 400 to 1100 metres (Moiseev 1991, Bjørke and Gjøsæter 1998) with a maximum depth recorded of 2700 metres (Kristensen 1981a). During surveys from 1986 to 1989, *G. fabricii* was captured in mid-water trawls off the eastern Scotian Shelf at tow depths from 50 to 1000 metres (Vecchione and Pohle 2002). *G. steenstrupi* occurs to depths of 1000 metres (Kristensen 1981b). Using mid-water trawls, Kenchington *et al.* (2009) reported individuals from both *G. fabricii* and *G. steenstrupi* at the Gully in 2007. *G. fabricii* is found in arctic and subarctic waters from Baffin Bay to the Grand Banks, off the Scotian Shelf to areas south of Georges Bank (Kristensen 1981b, Stephen 1982, Roper *et al.* 1984, Pohle *et al.* 1992, Dalley *et al.* 1999, Nesis 2001) (Figure 6), whereas *G. steenstrupi* has a more high-temperate to boreal distribution in waters off Newfoundland and the Grand Banks (Roper *et al.* 1984) with some records off the eastern Scotian Shelf (Dawe and Stephen 1988, Kenchington *et al.* 2009) (Figure 6). Little is known of their abundance and distribution in Canadian waters.

HUMAN-INDUCED THREATS

HISTORICAL THREATS

Whaling

Northern Bottlenose Whales were exploited by three groups in Canadian waters. From 1877 to 1913, British whalers hunted near the Cumberland Sound, Davis Strait, and the waters off Greenland, and reported approximately 1669 kills (Reeves *et al*. 1993) (Figure 7). The Norwegians entered the Northern Bottlenose Whale hunt in the late 1800s, and targeted whales in the northeastern Atlantic. Between 1969 and 1971, the Norwegians took 818 whales off Labrador (Reeves *et al*. 1993) (Figure 8). The hunt took place mainly between April and June (Benjaminsen and Christensen 1979). They have not hunted this species since 1971. A

Canadian hunt based out of Blandford, Nova Scotia, took place between 1962 and 1967. During this period, 87 whales were taken from the Scotian Shelf population (Reeves *et al*. 1993). Almost all georeferenced records (25) from this hunt were from the Gully or adjacent areas (Figure 9).

CURRENT THREATS

Entanglement/Bycatch in Fishing Gear

Frequency of entanglements and incidental catch of Northern Bottlenose Whales in fishing gear appears to be low. Some incidents have been reported, but the resultant mortality rate was not quantified. During the past 30 years, only nine entanglements or catches have been documented in Atlantic Canada by DFO (Table 1), four of which were reported from the Scotian Shelf, one from the Grand Banks, and three from the Davis Strait area (DFO 2010a, COSEWIC 2011) (Figure 10). The entanglements or bycatch on the Scotian Shelf and adjacent areas include interactions with trawl (targeting squid or silver hake), pelagic longline (targeting swordfish). One whale was released alive; its long-term survival is not known. The condition upon release and longer-term survival of the other whales are not known. One of the whales entangled in pelagic longline, identified as unattached swordfish gear, was seen and recorded in the Gully by Dalhousie University researchers (H. Whitehead, pers. comm. 2010). Based on the condition of the whale, they presumed this entanglement was fatal.

Of the three fisheries implicated in the reported entanglements, only one is still active. The squid and the silver hake fisheries along the edge of the eastern Scotian Shelf are no longer prosecuted. These fisheries ended in the mid 1980s and the late 1990s, respectively, and, therefore, do not pose a threat. The swordfish longline fishery, as well as other pelagic longline fisheries, is still conducted in areas of known Northern Bottlenose Whale distribution.

The pelagic longline fleet has traditionally fished swordfish (*Xiphias gladius*) from June through October along the edge of the continental shelf from Georges Bank to the Grand Banks. The fishing would move from west to east following the swordfish seasonal movements as the waters warmed. The large pelagic longline fishery is now a multi-species fishery with longliners targeting swordfish and tunas from May through December from Georges Bank to east of the Flemish Cap, along the edge of the continental shelf and the Grand Banks of Newfoundland, and southwards. When targeting swordfish, the fleet primarily fishes in the cooler water along the edge of the continental shelf and the Grand Banks (Paul *et al.* 2010).

There is currently a restriction on all fishing activity in the deep water areas of the Gully Marine Protected Area (MPA) Zone 1 (DFO 2008) (Figure 11). This zone contains a significant portion of the Northern Bottlenose Whale population and its primary habitat on the Scotian Shelf. Limited access to the remainder of the MPA (Zones 2 and 3) (Figure 11) have been maintained for groundfish longline (halibut) and pelagic longline (swordfish, tuna, and shark) vessels.

In the Davis Strait area, a fisherman reported a dead Northern Bottlenose Whale caught by the caudal peduncle in a Greenland halibut gillnet (Table 1). Fisheries observers reported one whale wrapped in longline targeting Greenland halibut. This whale was released alive. Another reported a whale caught by trawler fishing for Greenland halibut. Entanglements and bycatch may occur more frequently, but are not observed or reported.

The Greenland halibut fishery in Northwest Atlantic Fisheries Organization (NAFO) Division 0B (Figure 12) began in 1981 (DFO 2006). The Canadian quota (7000 metric tonnes in 2010, DFO 2010b) is shared among Nunavut, Newfoundland, and Maritimes regions (DFO 2006). Offshore fishing takes place mainly over the months of May through December. There are currently no restrictions on fishing seasons. Based on observer data, the fishery takes place almost exclusively between the 500 metre and 1500 metre isobaths. Bottom trawl, longline, and gillnet have been used as gear. However, landings from longliners have been negligible in recent years (DFO 2006). Management measures in the 2006-2008 Fishery Management Plan for 0B include 100% observer coverage from January to April for all vessels, 100% observer coverage for mobile gear, and 20% observer coverage for fixed gear (DFO 2006). This level of observer coverage is not always achieved. Onboard observers are required to report all cetacean sightings (DFO 2006). An inshore longline under-ice fishery for Greenland halibut also exists in Cumberland Sound. A separate quota of 500 metric tonnes was established for this fishery in December 2004, that includes provision for a summer fishery in the inner portion of Cumberland Sound. Other small, inshore, exploratory longline under-ice fisheries have occurred in other areas of Nunavut over the years (DFO 2006).

There has been a Greenland halibut fishery in Division 0A since 1996. The 0A quota (6500 metric tonnes in 2010; DFO 2010b) has been allocated to the Nunavut Wildlife Management Board (NWMB). The fishery is currently prosecuted by bottom trawl and gillnet. Longline have not been present since 2004. Management measures included in the 2006-2008 Fishery Management Plan for Greenland halibut is 100% observer coverage in 0A although this goal is not always reached (DFO 2006). Onboard observers are required to report all cetacean sightings (DFO 2006).

The Greenland halibut fishery in NAFO Subarea 2 + Divisions 3KLMNO is prosecuted by gillnet and bottom trawl with a total quota of approximately 6000 metric tonnes in 2010 (DFO 2010b) (including some foreign allocations).

In a study conducted by Mitchell (2008), which used photographs of Northern Bottlenose Whale melons, only one example of entanglement and one of vessel collision was observed in photographs prior to May 2004. The first was a female who exhibited scars from fishing line around her beak, the second was a male with a mark from a boat interaction. Mitchell (2008) noted two other photographs that were observed to have entanglement markings but were not included in study due to quality of photographs and an unidentified individual. Photos observed after the May 2004 time period showed no evidence of entanglement or collision markings on the whales' melons. However, two photos showed markings on the back area (Mitchell 2008).

In addition to entanglements and bycatch, non-lethal interactions with fishing gear have been reported. On the Scotian Shelf, Fertl and Leatherwood (1997) report 15 instances of Northern Bottlenose Whales following trawls to feed whilst the gear was being hauled back. Jack Lawson (DFO, pers. comm. 2012) reports having many photographs, personal communications, and observer reports of Northern Bottlenose Whales associated with Greenland halibut fisheries off the northern Labrador coast and the western Davis Strait. In some cases Northern Bottlenose Whales have become entangled in longline and gill nets from these fisheries as well (J. Lawson, DFO, pers. comm. 2012). Some fishers complain that these whales are taking the bait or catch off the lines (perhaps exacerbated by some fishers apparently feeding bait or bycatch to nearby Northern Bottlenose Whales). Some fishermen have reported that the interaction between Northern Bottlenose Whales caused them to abandon the longline gear in favour of the bottom-set gillnets (M. Treble, DFO, pers. comm. 2010). Greenland halibut fishermen on the eastern side of the Davis Strait do not report similar whale depredation. There is no recovery of "whale-damaged" fish from lines to confirm the case. It is therefore possible that other species, such as deepwater sharks, are causing some of the damage and loss. During a Greenland halibut survey in NAFO Division 0A, whales approached the vessel on five occasions (MacDonald 2005). On three of these occasions, the whales followed the trawl during haulback to feed on the catch. During this trip, whales were also observed feeding on discarded scraps from a longliner, where crew were cleaning their catch of Greenland halibut (MacDonald 2005).

Acoustic Disturbance

Acoustic disturbance is considered a threat to individuals of this species as well as to their habitat. Potential sources of acoustic disturbance include military exercises (SONAR, detonations), marine scientific research using sound, oil and gas exploration and extraction, vessel traffic, aircraft traffic, and construction. There has been one documented mortality of a Northern Bottlenose Whale in the Northeast Atlantic as a result of military acoustic disturbance (Simmonds 1991). Military SONAR also has been implicated in fatal stranding events in other beaked whale species (Schrope 2002, Weilgart 2007). COSEWIC (2002) suggested that oil and gas development within the high-use habitat areas of the Northern Bottlenose Whales poses the greatest threat, and it will likely reduce the quality of their habitat. This was provided as a reason, in part, for their designation as Endangered.

There are no documented cases of marine mammal mortality upon exposure to seismic surveys used in oil and gas exploration, although there are for similar seismic operations with different objectives. There is only circumstantial evidence of associations with infrequent standings of marine mammals (DFO 2004). Seismic surveys may have sub-lethal harmful effects on Northern Bottlenose Whales as they do on other cetacean species. There is documented displacement and migratory diversion in some marine mammal species exposed to seismic sound (DFO 2004). The duration of these effects may or may not extend beyond the duration of exposure. The ecological significance of such effects is expected to be low, but may displace animals that are feeding, resting, or breeding (DFO 2004). Cumulative effects could be high, particularly if individuals are forced to suboptimal alternate areas (DFO 2004).

There is also the potential for indirect effects such as reduced prey availability. For example, strandings of giant squid were reported in Spain during periods of seismic survey activity. Should this acoustic disturbance disperse or harm the squid on which Northern Bottlenose Whales rely, there may be negative impacts on the whales. This type of indirect effect has not been documented.

Marine Pollution

Increasing levels of pollutants due to hydrocarbon exploration and other human usage poses a potential threat to the health of whales (COSEWIC 2002). It is not known if contaminants have any lethal or sub-lethal effects on Northern Bottlenose Whales. Drill cuttings in the vicinity of drilling platforms, produced water, accidental spills of oil and other toxic chemicals, and increased marine traffic are potential sources of increased pollutants in the whale's habitat.

In the shelf areas surrounding the Gully MPA, the extraction of oil and gas interests have increased (Hooker *et al.* 2008*).* A study was conducted from 1996 to 2003 that examined the contaminant levels in Northern Bottlenose Whales from the Gully and Davis Strait areas (Hooker *et al.* 2008). Concentrations of PCBs and other organochlorine compounds, as well as P4501A (CYP1A1) proteins (biomarker), in skin and blubber biopsy samples from Northern Bottlenose Whales in the Gully were compared to concentrations in whales in the Davis Strait areas. Samples from the Gully animals were collected before (1996 to 1997) and after (2002 to 2003) major oil and gas development in the surrounding areas. In general, CYP1A1 activity scores were low, with 2003 scores higher than the previous years, and the samples from Davis Strait were also higher than the Gully samples. There were a range of PCB congeners detected (DDT, PCB, chlordanes, HCHs, and Dieldrin) with differences occurring between males and females, and the Gully samples were higher than the Davis Strait samples (Hooker *et al.* 2008). In general, the results from the Hooker *et al.* study are consistent with other large odontocetes. Contaminant levels were below those suspected of causing health problems (Hooker *et al.* 2008).

In their study of stomach contents of whales from Labrador and Iceland, Benjaminsen and Christensen (1979) found plastic bags, pieces of fishing net, a glove, and other pieces of plastic. The harm, if any, caused by the ingestion of garbage has not been evaluated.

Ecological Considerations

Northern Bottlenose Whales appear to have a fairly specialised diet consisting predominantly of squid of the *Gonatus* genus. Cephalopod species are of increasing importance as a fishery resource and many species are being taken either directly or indirectly as bycatch around the world (Pierce and Guerra 2004). Directed fishing for squid in the Northwest Atlantic became significant in the late 1960s (Rathjen *et al*. 1978). In the Northwest Atlantic, there are two directed squid fisheries: *Illex illecebrosus* and *Loligo forbesi* (Pierce and Guerra 2004). There is no current fishery for the main Northern Bottlenose Whale prey species, *Gonatus* sp. Should a large-scale fishery develop for these squid, it may compromise the whales' ability to meet energetic requirements. However, in a study conducted by Arkhipkin and Fedulov (1986) which examined movements of *Illex illecebrosus* using mid-water trawl sets, the Arctic squid (*Gonatus fabricii*) was the most abundant squid caught apart from *I. illecebrosus*. Most literature on bycatch in different fisheries list squid as bycatch but do not often identify the species of squid caught. The study by Arkhipkin and Fedulov (1986) show that the Arctic squid (*Gonatus fabricii*) potentially could be caught as bycatch is in the *Illex illecebrosus* fishery.

Northern Bottlenose Whales have few predators apart from humans. Whaling crew have observed killer whales attacking and feeding on individuals, but these were considered unusual events (Johnsgắrd 1968a, 1968b).

Other potential threats include climate change and anthropogenic activities that would alter the bathymetry of or impede the whales' access to the deepwater canyons in their habitat.

CONSERVATION AND PROTECTION

The Northern Bottlenose Whale was first protected by the International Whaling Commission (IWC), on the advice of its scientific committee in June 1977 (IWC 1978) and is currently protected from whaling under the IWC Convention (IWC 2006). In addition, the species has protection internationally under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and nationally under the *SARA* (Scotian Shelf population only), the Marine Mammal Regulations in the *Fisheries Act*, and the Gully MPA Regulations.

Under the *Canadian Fisheries Act*, it is illegal to take or kill any fish without a permit. As marine animals, Northern Bottlenose Whales are defined as 'fish' in the interpretation of the *Act*. No person shall destroy fish by any means other than fishing except as authorised by the Minister or under regulations made by the Governor in Council under this *Act*. It further states that, except where the retention of an incidental catch is expressly authorised, incidentally caught fish shall be returned to the place from which it was taken in a manner that causes it the least harm.

In 1996, Northern Bottlenose Whale populations were split into the two populations to allow a separate designation of the Scotian Shelf population. The Scotian Shelf population was reassessed as Endangered in November 2002 (COSEWIC 2002) and was added to *Schedule 1* of the *SARA* in 2006. The *SARA* includes prohibitions on killing, harming, harassing, capturing, or taking individuals of species listed as Threatened or Endangered on *Schedule 1*. The *SARA* prohibits sale or trade of individuals of such species (or their parts), damage or destruction of their residences, or destruction of their critical habitat. The *SARA* also specifies that a recovery strategy must be prepared for species that are listed as Threatened or Endangered. The provisions of these recovery strategies are to address all potential sources of harm, including harvesting activities, so that the survival and recovery of the populations concerned are not jeopardised (DFO 2010a).

Several initiatives have been undertaken to protect this population of Northern Bottlenose Whale. The recovery target for the Scotian Shelf population is to maintain a stable or increasing population and to maintain, at a minimum, current distribution. Zone 1 of the Gully MPA and areas with water depths of more than 500 metres in Haldimand Canyon and Shortland Canyon have been declared Critical Habitat for the Scotian Shelf population (DFO 2012a).

In 2004, the Gully (Figure 11) was declared a MPA, which afforded it, and the organisms that inhabit it, some measure of protection. The Gully MPA comprises 2364 square kilometres 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. This part of the regulations recognises that human activities outside the MPA have the potential to cause harmful impacts within the MPA. The MPA provides the highest level of ecosystem protection in the central portion of the Gully canyon (referred to as Zone 1) (Figure 11), an area of known importance for the Northern Bottlenose Whale.

INFORMATION IN SUPPORT OF A RECOVERY POTENTIAL ASSESSMENT

STATUS AND TRENDS

1. Evaluate present abundance, range, and number of populations of Northern Bottlenose Whales.

COSEWIC recognises two populations of Northern Bottlenose Whales in Canada: the Scotian Shelf population and the Davis Strait population. The majority of sightings on the Scotian Shelf have been in or near the Gully, Shortland Canyon, and Haldimand Canyon. The Davis Strait population ranges from the Davis Strait to the Labrador Sea. Northern Bottlenose Whales have been sighted on occasion outside of these areas, such as off the Grand Banks (Figure 2), but it is unknown to which population these individuals belong. Many of the sightings have been opportunistic.

<u>Scotian Shelf Population</u>

Abundance estimates have been calculated using mark-recapture models on sightings and photographic data. Whitehead and Wimmer (2005) estimate the population to be 163 individuals (95% confidence interval (CI): 119–214 whales). This is slightly higher than the estimate of 130 individuals from 2000 (95% CI: approximately 107-163 whales; Gowans *et al.* 2000). The difference in these two estimates is due to the mark-recapture models used. The 2005 estimation procedure better reflects the entire Scotian Shelf population, as well as allowing for heterogeneity in identifiably and mortality among individual whales (Whitehead and Wimmer 2005).

Gosselin and Lawson (2004) conducted sightings surveys in the Gully before (April 2003) and during (July 2003) seismic operations. Shortland and Haldimand canyons, which are near the Gully, were also surveyed before seismic activities in an effort to evaluate the effect of seismic activities on marine mammal species composition, distribution, and abundance (Gosselin and Lawson 2004). Based on their findings, they provided abundance indices for the Gully. They detected eight individuals in April and 29 in July which provides abundance indices of 44 whales (95% CI: 19–105 whales) and 68 whales (95% CI: 20-230 whales), respectively. These indices are similar to the estimate of 44 whales present in the Gully at any given time derived from photo-identification techniques used previously (Gowans *et al.* 2000). These estimates were not corrected for sighting availability or detection from the trackline, nor for the animals' attraction to vessels, which would have respectively increased or decreased the estimates for these deep-diving whales. Gosselin and Lawson (2004) did not provide an estimate of total abundance.

Davis Strait

There is no abundance estimate for the Davis Strait population of Northern Bottlenose Whale. (COSEWIC 2011). Vessel-based and aerial survey efforts between 2003 and 2007 yielded few sightings and so abundance is presumed to be low.

2. **Evaluate recent species trajectory for abundance and range*.***

Scotian Shelf

Whitehead and Wimmer (2005) have indicated that the size of the Northern Bottlenose Whale population found on the Scotian Shelf has been relatively stable during the period from 1988 to 2003. Their best estimate of trend from their models indicated a rate of increase in population abundance of about 0.025 yr^{-1}, but this trend was not significantly different from zero. Little is known about historical population sizes (outside of whaling numbers) and so it is not clear if this population was much larger in the past than its present day size.

Not enough information is available to determine whether range is increasing or decreasing. No areas outside of the current distribution have been identified in whaling records to suggest that range has been reduced.

Davis Strait

Whalers took approximately 1669 whales from, Davis Strait and the waters off Greenland (236 from Davis Strait and near the Cumberland Sound) between 1877 to 1893 (Reeves *et al*. 1993). Between 1969 and 1971, whalers took 818 whales off Labrador (Reeves *et al*. 1993). The catches are much larger than the 87 whales taken from the Scotian Shelf which suggests that, historically, the Davis Strait population was much higher than the Scotian Shelf population. It is likely that this long-lived species is still recovering from whaling. The population trajectory cannot be evaluated because there are no estimates of historical or current abundance. There is insufficient information to determine if range has increased or decreased.

3. Estimate, to the extent that information allows, the current or recent life history parameters for the species (total mortality [Z], natural mortality[m], fecundity, maturity, recruitment, etc.) or reasonable surrogates, and associated uncertainties for all parameters.

See Table 2.

HABITAT CHARACTERISATION

4. Provide functional descriptions of the properties of aquatic habitat needed for successful completion of all life-history stages.

Submarine canyons, which are narrow, deep, and steep-sided features, and steep slopes appear to play a key role in determining the distribution of Northern Bottlenose Whales along the continental slope. It appears that this is because they provide exceptionally lucrative foraging opportunities for Northern Bottlenose Whales, and therefore, allow the whales to congregate and carry out life processes (*e.g*., mating and rearing).

As previously discussed, the primary prey item for the Northern Bottlenose Whales is *Gonatus* squid. *G. fabricii* are mainly found at depths between 400 and 1100 metres (Moiseev 1991, Bjørke and Gjøsæter 1998). *G. fabricii* have been sampled to 2700 metres in depth in the Norwegian Sea (Kristensen 1981a). The dependence of Northern Bottlenose Whales on this squid likely explains their association with deep waters. Unfortunately, there have not been direct studies of the abundance of *Gonatus* squid in eastern Canadian waters. Uncertainty remains regarding the diet composition of the population. A minimum prey availability ‘threshold’ that would allow congregation and mating by Northern Bottlenose Whales has not been determined. Therefore, it would be difficult to identify specific critical habitat areas based on a metric of prey density.

Northern Bottlenose Whales appear to prefer sea surface temperatures ranging from 1°C to 6.3°C (Compton 2004), though they have been observed in waters ranging from -2°C to 20°C (Reeves *et al*. 1993, COSEWIC 2011).

Given the above information, important habitat has been determined to be characterised by waters of more than 500 metres in bottom depth, particularly around steep-sided features such as underwater canyons, that provide access to sufficient accumulations of prey (*Gonatus* squid) to allow Northern Bottlenose Whales not only to meet their individual caloric requirements, but also to socialise, mate, and rear their young.

The Recovery Strategy for the Scotian Shelf population identifies the entirety of Zone 1 of the Gully MPA (Figure 11) and areas with water depths of more than 500 metres in Haldimand Canyon and Shortland Canyon as habitat for the Scotian Shelf population. Since Northern Bottlenose Whales use the full depth range in these areas, breathing and socialising 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 (DFO 2010a).

5. Provide advice on any tradeoffs (*i.e.*, pros and cons) associated with habitat allocation options, if any options would be available at the time when specific areas are designated as Critical Habitat.

Tradeoffs related to habitat allocation options are not considered because the development or use of the oceanic habitat in such a way as to alter or destroy it is not being considered.

6. Evaluate residence requirements, if any.

Under the *SARA*, Threatened and Endangered species’ residences are protected. In Section 2 (1) the act 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…”

Northern Bottlenose Whales do not have any known dwelling-place similar to a den or nest during any part of their life cycle; hence, the concept of “residence” does not apply.

7. Recommend research or analysis activities that are necessary in order to complete these habitat-use Terms of Reference if current information is incomplete.

A number of research activities are necessary in order to complete the habitat use Terms of Reference. The distribution and abundance of Northern Bottlenose Whales, both seasonally and geographically, needs to be described for the Davis Strait population. Additional data on the distribution of the Scotian Shelf population in winter is needed to better describe seasonal patterns in habitat use. The stock origin of the whales sighted on the Grand Banks, and in what capacity they are using that area, should be determined. Further study of Northern Bottlenose Whale diet in Canadian waters is required.

THREATS

8. Quantify the magnitude of each of the major potential sources of mortality identified in the COSEWIC Status Report, from DFO sectors, and other sources.

The human-induced threats causing most concern are ocean noise and commercial fishing.

Potential sources of acoustic disturbance include military exercises (SONAR, detonations), marine scientific research using sound, oil and gas exploration and extraction, vessel traffic, aircraft traffic, and construction. Military SONAR has been implicated in fatal stranding events in other beaked whale species. There have been no documented cases of harm or mortality to a Northern Bottlenose Whale in Canada due to ocean noise.

During the past 30 years, nine entanglements or catches have been documented. Of these, two whales were released alive. One was presumed to have sustained fatal injuries and one was reported as dead. The condition of the other whales upon release is not known. Two of the fisheries (squid fishery and the silver hake fishery) are no longer prosecuted and effort in a third (Greenland halibut longline) has been greatly reduced. Although the magnitude of mortality cannot be quantified, it is presumed to be low.

9. Identify the activities most likely to result in threats to the functional properties of habitat of Northern Bottlenose Whales, and provide information on the extent and consequences of these activities within the species' range.

Future climate change and trophic changes are the only threats to the functional properties of Northern Bottlenose Whale habitat. No reduction in habitat quantity or quality has been documented to date.

The effects of climate change on the physical, chemical, and biological oceanography of the Northern Bottlenose Whale's habitat is unknown and difficult to predict. Northern Bottlenose Whales have a fairly specialised diet consisting predominantly of squid of the *Gonatus* genus. The development of a large-scale fishery directing for or capturing these squid as bycatch may compromise Northern Bottlenose Whales' ability to meet their energetic requirements.

Activities that would alter the seabed, such as large scale mining, or construction of structures that could impede the whales' access to or movement within habitat (such are oil and gas platforms) are other potential threats. No such activities are currently being undertaken.

10. Assess how activities identified in Step 9 have resulted in reductions to habitat quantity and quality to date, if at all.

No reduction in habitat has been documented or quantified.

MITIGATION AND ALTERNATIVES

11. Develop an inventory of all feasible mitigation measures that could be used to minimise the threats to Northern Bottlenose Whales and their habitat.

<u>Ocean Noise</u>

DFO has developed a Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment (DFO 2013). 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. The Statement of Practice has been adopted and implemented by hydrocarbon regulators throughout the Canadian range of Northern Bottlenose Whales. Moving north to south, those regulators include Indian and North Affairs Canada (INAC), the Canada-Newfoundland and

Labrador Offshore Petroleum Board (CNLOPB) and the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB).

Adoption of the Statement of Practice is an important measure, though in practice, threats were already minimal as a result of very few seismic programs being conducted in and near Northern Bottlenose Whale habitat. Canadian waters off Nunavut have not been subject to seismic exploration in recent years and no new commercial surveys are proposed[1]. Exploration licences have been issued and some seismic has been and will continue to be acquired on the Greenland side of the Davis Straits[2], but those activities are not thought to pose a significant threat to Northern Bottlenose Whales in Canadian waters.

A few speculative surveys have been undertaken further south off the coast of northern Labrador. However, most of the longer duration seismic programs approved for offshore Newfoundland and Labrador have been associated with active exploration licences far south of the Davis Straits population centre. A few of those surveys were undertaken on the Labrador Shelf, but most were conducted in frontier areas along the Newfoundland Shelf and Grand Banks (CNLOPB 2010).

The Scotian Shelf has witnessed short duration site surveys and project related geophysical investigations involving lower energy acoustic sources, but there have been no full commercial seismic exploration programs conducted in offshore Nova Scotia since 2006[3]. However, the area is highly prospective to the petroleum industry. The Shortland and Haldimand canyons are both of specific interest to both the petroleum industry and as proposed Species at Risk Habitat (CNSOPB 2010). The area has experienced several phases of exploration where several gas discoveries and a number of gas shows were made by wells drilled on the shelf confirming an active petroleum system. Researchers at the CNSOPB (the Board) and the province of Nova Scotia have identified this region as one holding great promise for petroleum accumulations in shallow and deep water settings. The probability of land nominations (Calls For Bids) and related petroleum exploration in the eastern Scotian Slope region in the near future (one to three years) is considered high (CNSOPB 2010).

The Department of National Defence has established protocols to protect marine mammals from disturbance and/or harm from the use of military active sonar. The purpose of Maritime Command Order 46-13 is to implement Standard Operating Procedures when conducting Exercises-Operations that involve the use of Underwater Sound Generating Systems (Weapons, Communications, active Sonobuoys, Hull Mounted Sonars), Variable Depth Sonars, Helicopter Active Dipping Sonars or Ship Active Sonars) that may pose a pervasive disturbance, harassment, or injury risk to marine mammals. Ship's personnel receive training in marine mammal identification and detection and are to avoid transmission of sonar any time a marine mammal is observed within the defined mitigation avoidance zone, which is established specific to each type of sonar.

Entanglements and Bycatch

Entanglements appear to be relatively infrequent (one every three years for the entire range of Northern Bottlenose Whale in Canada). Although there is no evidence that entanglements in fishing gear are going unreported, this possibility cannot be dismissed.

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[1] Please visit Aboriginal Affairs and Northern Development Canada (formerly know as Indian and Northern Affairs). (Last accessed September 27, 2013).

[2] Please visit Greenland National Oil Company (last accessed September 27, 2013).

[3] Please visit Canada-Nova Scotia Offshore Petroleum Board (last accessed September 27, 2013).

Only one fishery that has been implicated in an entanglement on the Scotian Shelf (swordfish longline) is currently prosecuted, and the whale in question was released alive. Due to the rarity of these events and the protection afforded by the MPA, a reasonable approach would be to educate members of industry on safe handling and release techniques should a whale be caught. The potential biological removal was calculated to be 0.3 whales per year (Harris *et al*. 2007). Thus, it is important that when these events occur, the whale be released alive and unharmed whenever possible.

Reports of entanglements in the Davis Strait are infrequent. Of the three entanglements that have been reported, one whale was released alive, one was dead, and the fate of the third is unknown. The impact of the fisheries on the Northern Bottlenose Whales in NAFO Divisions 0A and 0B is not known. Narwhal overwintering grounds and deep-sea corals that are found in the southeast corner of NAFO Division 0A are currently protected by licence conditions that restrict fishing effort in these areas (DFO 2006). Similar measures could be used to protect the Davis Strait population of Northern Bottlenose Whales. Further study to identify areas of high risk of entanglement, should they exist, would be required to determine if these measures would be feasible and effective. The paucity of fishery independent data for this whale population prevents such analyses at this time. The education of industry members on safe handling and release techniques would mitigate harm to a whale should an entanglement occur.

The inshore fishery does not appear to overlap with the current distribution of Northern Bottlenose Whales.

12. Develop an inventory of all reasonable alternatives to activities that are threats to Northern Bottlenose Whales and their habitat, but with potential for less impact.

Other gear types could be used to catch swordfish. The pelagic longline fleet also fishes with harpoon and trolling gear. There is also a separate harpoon-only swordfish fleet.

Both mobile (bottom trawl) and fixed (gillnet and longline) gear types have been implicated in Northern Bottlenose Whale entanglements. Thus, there is no reasonable alternative for the Greenland halibut fishery.

13. Develop an inventory of activities that could increase the productivity or survivorship of the species.

No activities are planned for the purpose of increasing productivity or general survival of Northern Bottlenose Whales in Atlantic Canadian waters. The mitigation measures outlined above are aimed at improving survival of individuals in our waters. However, no other opportunities for increasing productivity or survivorship have been identified and so no additional measures are being proposed.

14. Provide advice on feasibility of restoring habitat to higher values, if supply may not meet demand by the time recovery targets would be reached.

Habitat limitations do not seem to be an issue for Northern Bottlenose Whales in Atlantic Canadian waters. No habitat restoration efforts are required.

15. Estimate the expected impact on abundance and distribution from identified mitigation measures, alternatives, restoration activities, and activities that may alter the productivity or survivorship.

The expected impact of the measures proposed in this assessment on abundance and distribution of Northern Bottlenose Whales is unknown. Further study will be required to determine the effects of the proposed mitigation measures.

RECOVERY TARGETS

16. Estimate expected abundance and distribution targets for recovery, according to DFO guidelines.

It is not clear what abundance would constitute the minimum size for a secure Scotian Shelf population of Northern Bottlenose Whales. The population is small but has been relatively stable between 1988 and 2003 (Whitehead and Wimmer 2005). Little is known about historical population sizes and so it is not clear if it was much larger than its present day size. Whaling operations took a high number of whales; 87 reported relative to the current size of the Scotian Shelf population (Reeves *et al*. 1993) (Figure 9). The pre-whaling population abundance is not known. Gowans (2002) suggested that this population is still recovering from whaling.

Most Scotian Shelf Northern Bottlenose Whales are sighted in and around underwater canyons, namely the Gully, Shortland Canyon, and Haldimand Canyon, along the edge of the eastern Scotian Shelf. On occasion they are seen off the shelf edge. There is no evidence to suggest that the Scotian Shelf population of Northern Bottlenose Whales has reduced its geographic range.

The overall goal of the recovery strategy of the Scotian Shelf population of Northern Bottlenose Whale is to achieve a stable or increasing population and to maintain, at a minimum, current distribution (DFO 2010a). Given that there is no new information on a secure population size, no change in recover target is proposed for the Scotian Shelf population.

There are no estimates for historical or current abundance of the Davis Strait population of Northern Bottlenose Whales. Whalers took large numbers, with the most recent catches only 40 years ago. It is likely that this population is still recovering from exploitation.

The distribution of the Davis Strait population is not known to have changed. Despite the scant information, the whales are still found in most areas where whaling was reported.

A reasonable recovery target for the Davis Strait population is to achieve a stable or increasing population and to maintain, at a minimum, its current distribution.

ASSESSMENT OF RECOVERY POTENTIAL

17. Given current population dynamics parameters and associated uncertainties, project expected population trajectories over three generations (or other biologically reasonable time), and trajectories over time to the recovery target using DFO guidelines on long-term projections.

The task in this item of the RPA is to estimate a general time frame for recovery under the assumption that the population is only exposed to natural mortality (human-induced mortality is set to zero). A recovery target set on abundance has yet to be determined for either population. However, rough estimates of future population trends using long-term projections of existing, published models were evaluated for the Scotian Shelf population in 2007 (Harris *et al*. 2007).

Population estimates are available for use in construction of simple population projection models. Whitehead and Wimmer (2005) used photo-identification of individual whales to fit an open mark-recapture model that incorporated sighting heterogeneity using mixture models. Sightings data were collected in most years during the period of 1998 to 2003. Separate models were fitted using photographs of either the right side or left side of animals. Population parameters were estimated by maximum likelihood, and model fits to the data were evaluated using Akaike's Information Criterion (AIC).

AIC values indicated that models with and without trends had similar fits (Whitehead and Wimmer 2005). The model with the best fit to right side photographic data included heterogeneity in mortality and identifiably, plus inclusion of a trend in abundance. The model with best fit to left side data included heterogeneity in mortality and identifiably, but did not include a trend. The right-side model provided the best estimate of trend, indicating an increase in population size during the time series of 2.5% over the time period of 1988 to 2003, but this increase was not significantly different from zero (Whitehead and Wimmer 2005). The right-side model population estimate was 171 animals (95% bootstrap CI = 123-227 whales). The left side model estimated a population increase of 0.031% over the time period (Whitehead and Wimmer 2005), and provided a population estimate of 155 animals (95% bootstrap CI = 114-201 whales).

The trend and uncertainty estimates from Whitehead and Wimmer (2005) were used to parameterise a crude logistic population growth model. Little information exists to enable robust quantification of anthropogenic mortality rates, but what little evidence is available suggests that this rate is not substantial. Thus, in the projection model, it was assumed that current levels of human-induced mortality are negligible, which allowed the use of the population growth rates reported in Whitehead and Wimmer (2005) without modification.

During separate simulations, the value of r, the proportional rate of increase, was varied according to either normal or uniform distributions fit to match the mean and confidence intervals reported in Whitehead and Wimmer (2005). Each model run was projected into the future for a period of 30 years. Two hundred iterations of the model were undertaken during each simulation to capture uncertainty in the model projections due to annual variation in r. Initial abundance in all simulations was set to the average of the two population estimates from the left- and right-side mark-recapture models: (171+155)/2 = 163 animals.

The first simulation used the best estimate of population trend of a 2.5% increase during the time period ($r=0.025$) which was estimated from the “full”, left-side model reported in Whitehead and Wimmer (2005). This rate of increase was allowed to vary according to a normal distribution with mean, $\mu=0.025$, and standard deviation, $\sigma=0.02$. In each trial, a rate of increase was selected randomly from this distribution and applied across the entire time period of each model iteration (Figure 13). As one would expect, variation in abundance increased with time. The population doubling time was approximately 25 years. The next simulation was formulated as above, but uncertainty in r was modeled through selection of r values from a uniform distribution bounded by the confidence intervals associated with the best estimate of population trend (2.5 % increase) (95% bootstrap CI - 1.6; 6.4) reported in Whitehead and Wimmer (2005) (Figure 13). The simulation exhibits greater variation among individual runs, but the pattern is very similar to the previous runs with normally distributed r values. The doubling time from the initial population abundance is again approximately 25 years.

18. Given alternative mortality rates and productivities associated with specific scenarios identified for exploration, project expected population trajectory (and uncertainties) over three generations (or other biologically reasonable time), and to the time of reaching recovery targets.

Insufficient data exists to model the relative effects of various alternate mitigation strategies on the likelihood of attaining hypothetical recovery targets.

19. Assess the probability that the recovery targets can be achieved under current rates of population dynamics parameters, and how that probability would vary with different mortality (especially lower) and productivity (especially higher) parameters.

Insufficient data exists to model the relative effects of various alternate mitigation strategies on the likelihood of attaining hypothetical recovery targets.

20. Assess the degree to which supply of suitable habitat will meet the demands of the species when it reaches recovery targets for abundance and range.

There is currently no evidence that suitable habitat has been reduced or that it is limiting the species abundance or range, and so presumably the supply is adequate for when the species reaches its recovery targets for abundance and range.

There is little information on historical abundances or range, or if declines in either have occurred. As noted above, the apparent lack of population growth and low birth rates in the Scotian Shelf population could mean that Northern Bottlenose Whales are close to or at carrying capacity, but low birth rates could be unrelated to carrying capacity. A habitat suitability index for Northern Bottlenose Whales in Canada developed by Compton (2004) suggests that most of our Atlantic coast constitutes marginal habitat. It is unlikely that the whale's critical habitat has been altered and there are currently no known demonstrated threats occurring. Global climate change may alter the areas designated as critical habitat but these effects are unknown.

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TABLES

Table 1. Reports of entangled Northern Bottlenose Whales.

Year	Data Source	Location	Fishery/Gear	Comments
1981	Observer	Scotian Shelf	Squid	Only reference "discard"
1990	Observer	Scotian Shelf	Silver Hake/ Trawler	-
1991	Observer	Scotian Shelf	Silver Hake/ Trawler	Only reference "discard"
1993	Observer	Scotian Shelf	Silver Hake/ Trawler	Only reference "discard"
1999	Whitehead Lab, Dalhousie University	Scotian Shelf	Swordfish/ Longline	Wrapped in unattached gear. Presumed fatal.
2001	Observer	Scotian Shelf	Swordfish/ Longline	Released alive
2002	Observer	Davis Strait	Greenland halibut/ Trawler	-
2003	Observer	Davis Strait	Greenland halibut/ Longline	Photo available, wrapped in line, freed
2008	Fisherman	NAFO 0A	Greenland halibut/ Gillnet	Dead whale entangled by caudal peduncle in gillnet

Table 2. Life history parameters for the Northern Bottlenose Whale in Canada.

Parameter	Male	Female	Reference
Age at maturity	7-11 years	8-12 years	Benjaminsen and Christensen 1979
Natural mortality	-		-
Population growth	2.5%		Whitehead and Wimmer 2005
Birth rate	-	0.5	Benjaminsen and Christensen 1979

FIGURES

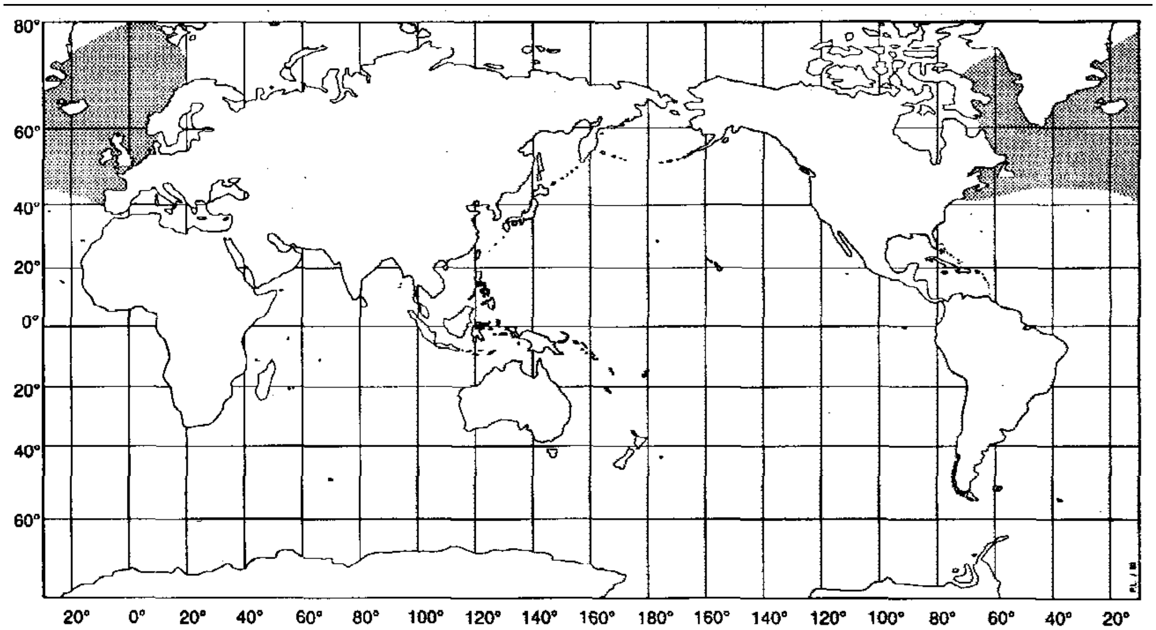

Figure 1. Global distribution of Northern Bottlenose Whale (Hyperoodon ampullatus). (From Jefferson et al. 1993).

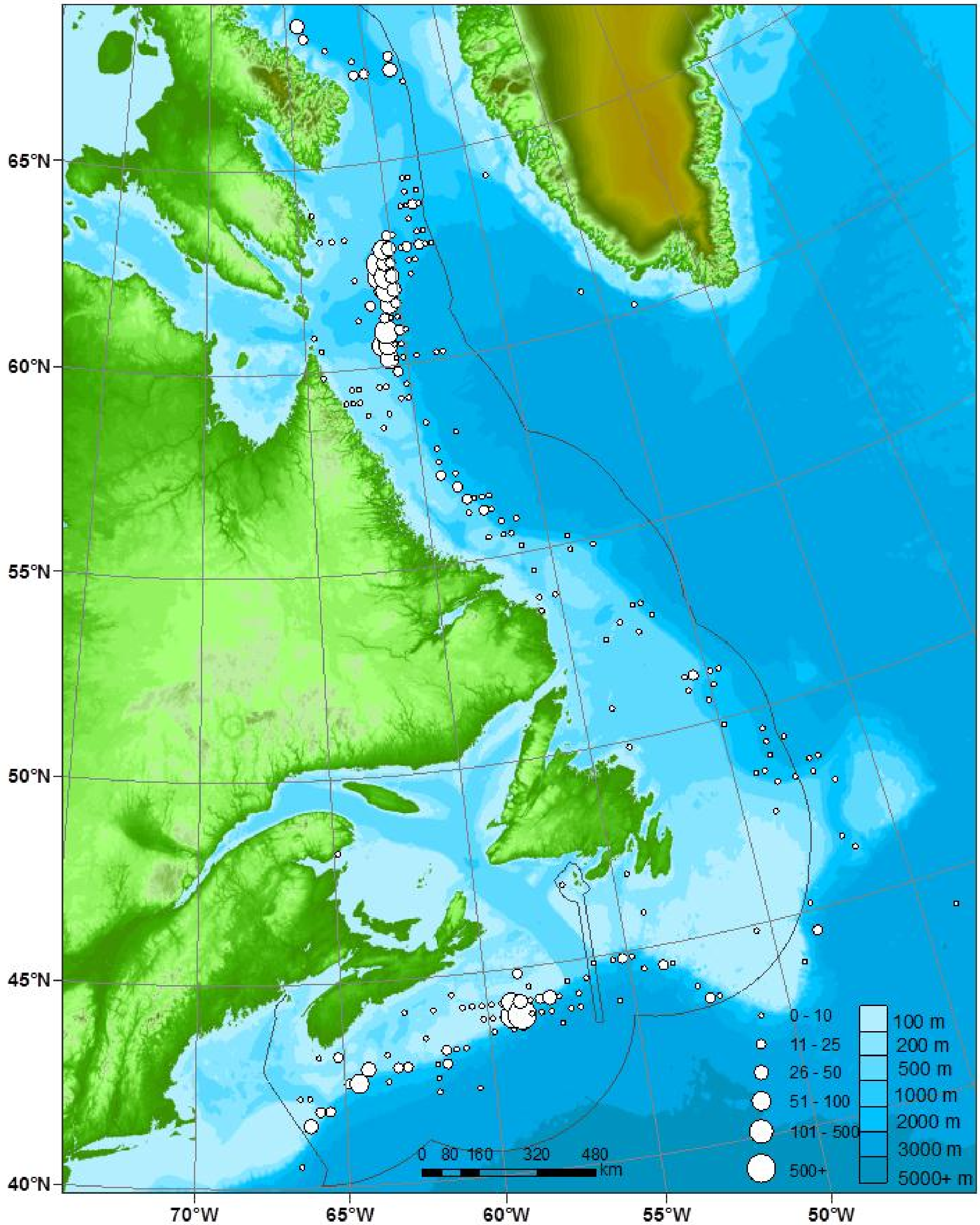

Figure 2. Distribution and magnitudes of sightings of Northern Bottlenose Whales from 1977 to 2010. Data are aggregated (summed) by 20-minute squares. Sightings obtained from the 'Whalesitings' database maintained by DFO-Maritimes. Sightings are from various sources, many are opportunistic, and not corrected for effort.

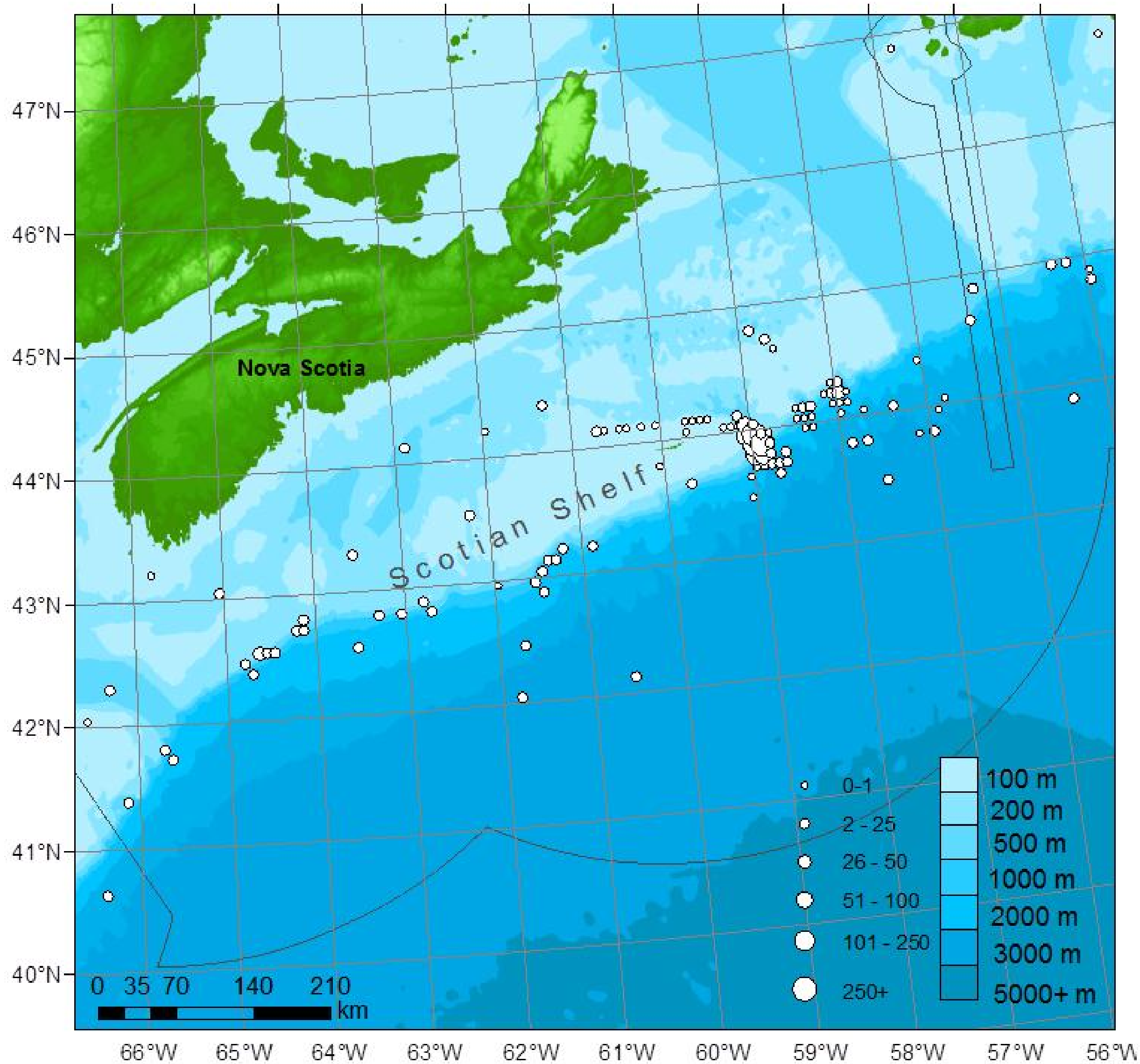

Figure 3. Locations and magnitude of sightings of Northern Bottlenose Whales in the southern part of their distribution in the northwestern Atlantic. Data are aggregated by 5 nautical miles[2]. The black line represents the Exclusive Economic Zone (EEZ). Sightings obtained from the 'Whalesitings' database maintained by DFO-Maritimes. Sightings are from various sources, many are opportunistic, and not corrected for effort.

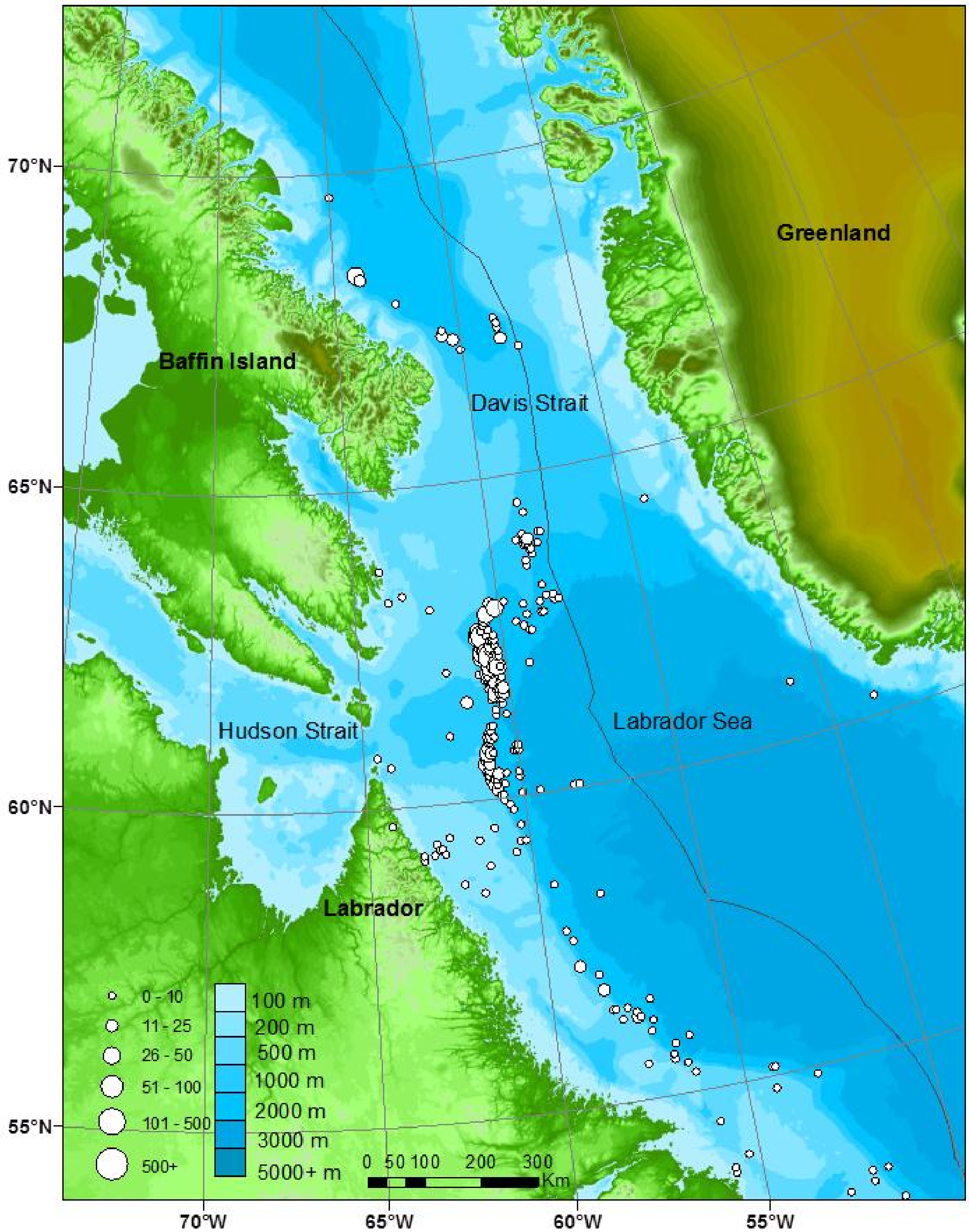

Figure 4. Locations and magnitudes of sightings of Northern Bottlenose Whales in the northern part of their distribution in or near Canadian waters. Sightings obtained from the 'Whalesitings' database maintained by DFO-Maritimes. Sightings are from various sources, many are opportunistic, and not corrected for effort.

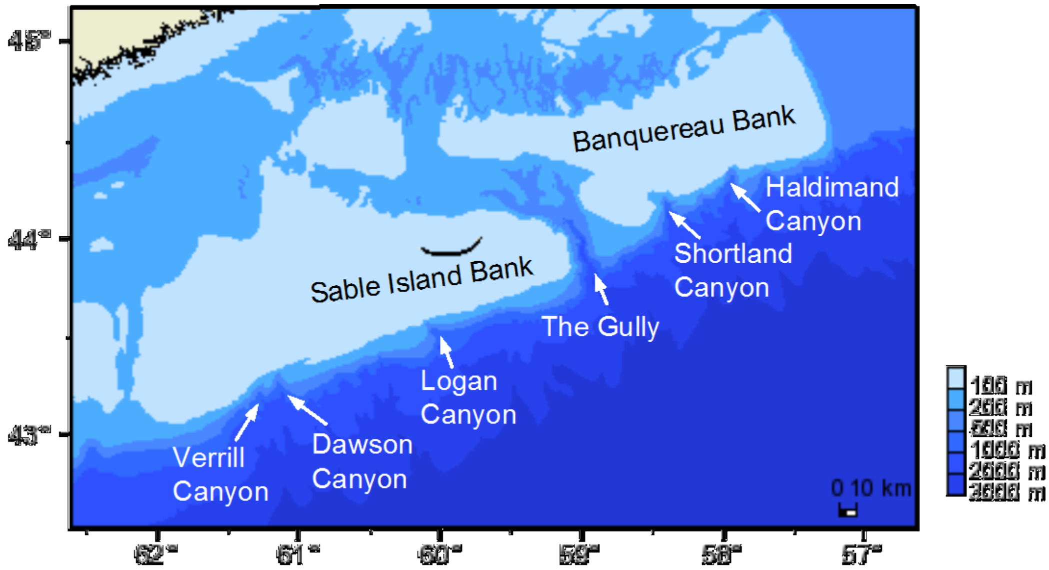

Figure 5. Locations of underwater canyons on the Scotian Shelf.

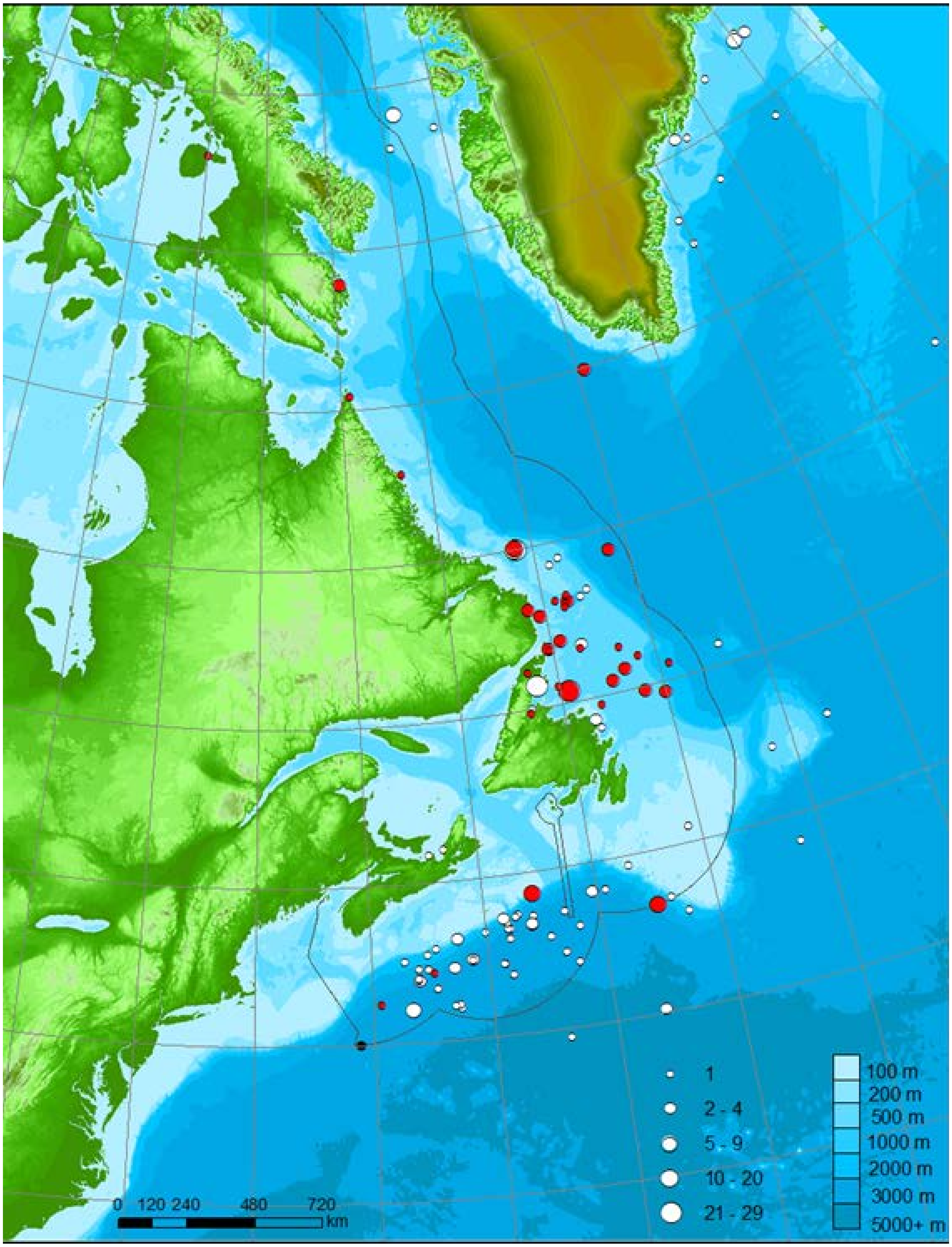

Figure 6. Distribution of squid; G. fabricii (white), G. steenstrupii (white) and Gonatus sp. (red). The black line represents the Exclusive Economic Zone (EEZ). Data are obtained from the Atlantic Reference Centre and CephBase.

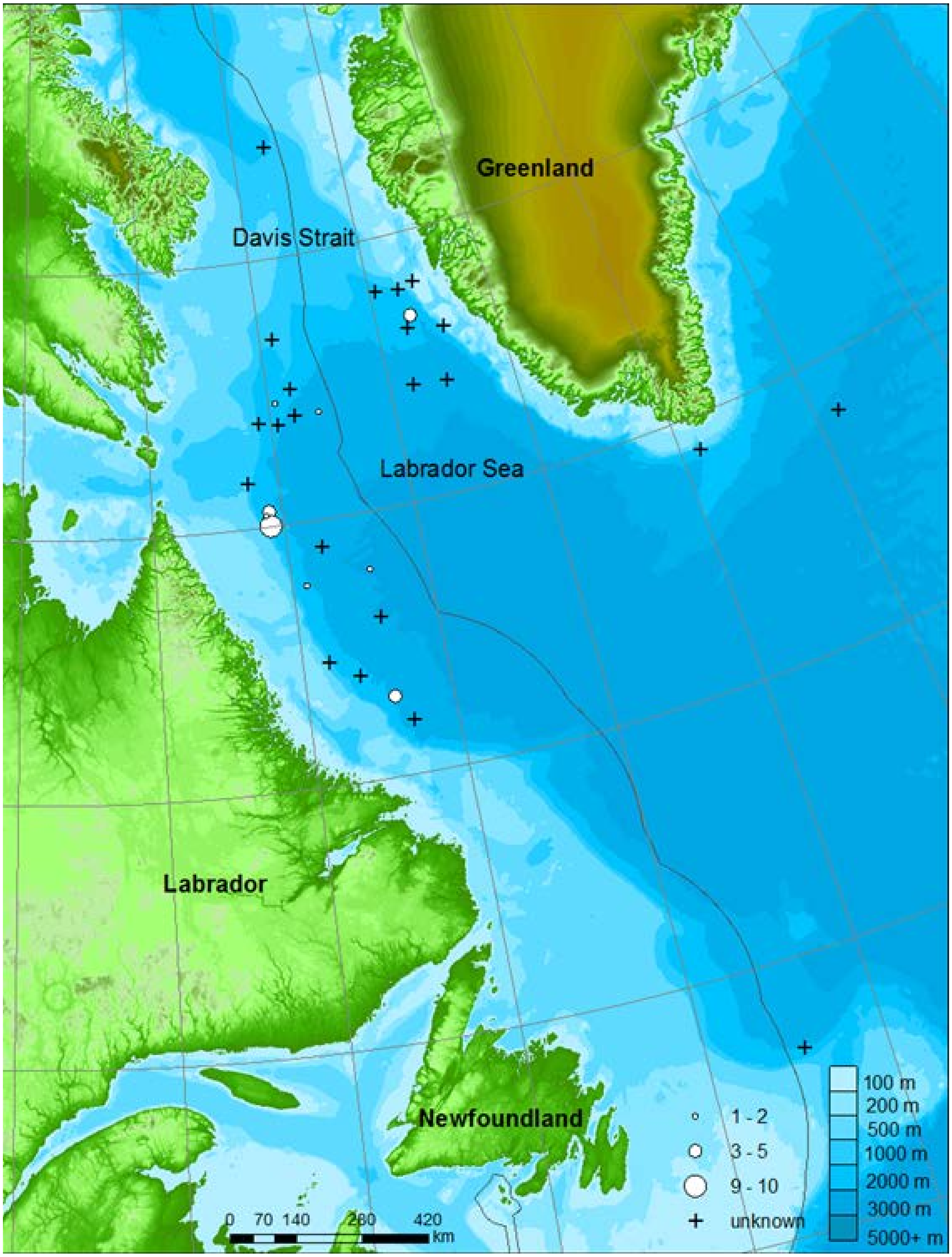

Figure 7. Catches and observations of Northern Bottlenose Whales by Scottish whalers from 1862 to 1913. The '+' symbol was given where the number of whales was not recorded. Data are from Reeves et al. (1993).

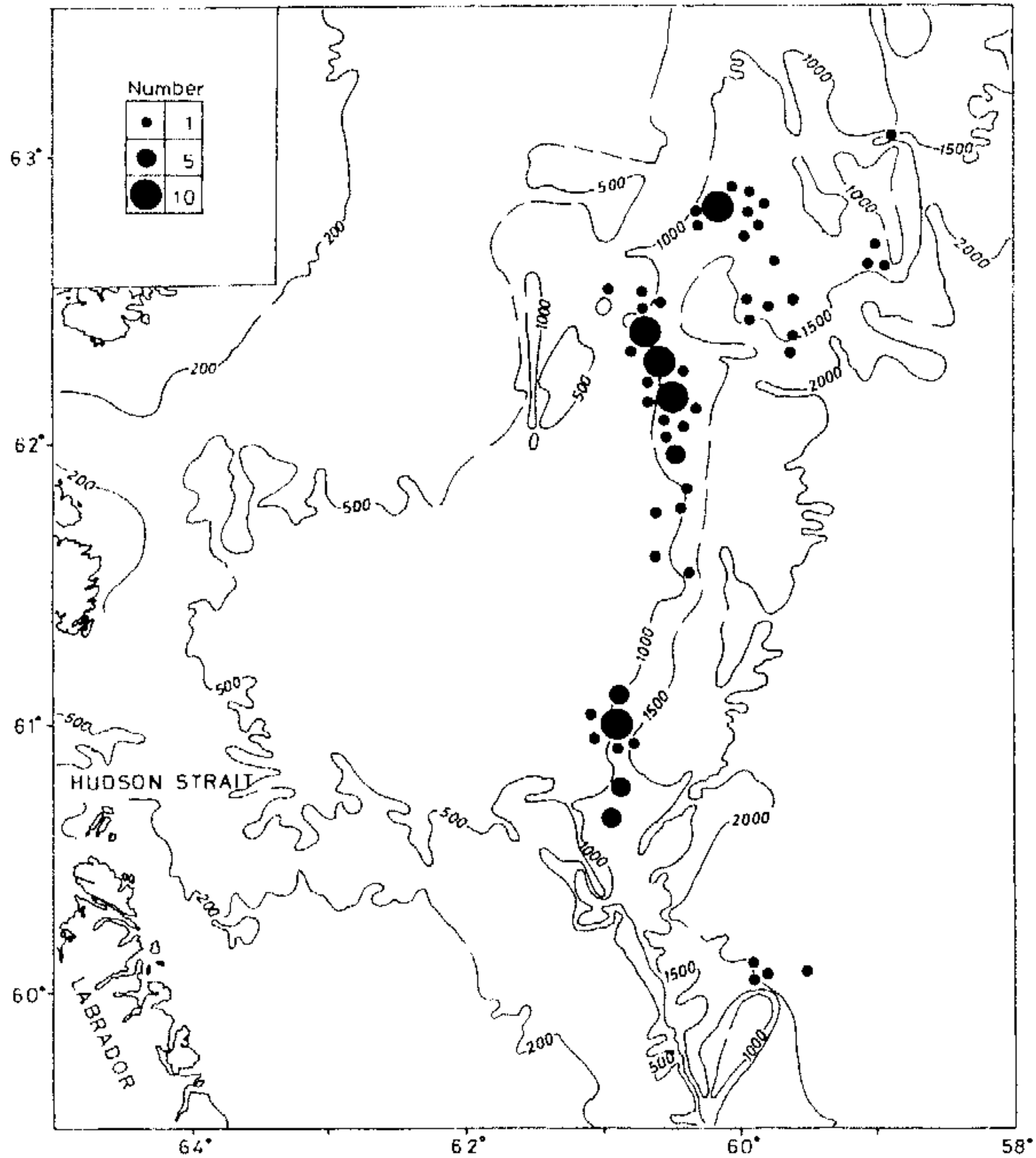

Figure 8. Locations and magnitudes of Northern Bottlenose Whale catches by Norwegian whalers in the Davis Strait in 1971. Depth contours in metres. (From Benjaminsen and Christensen 1979).

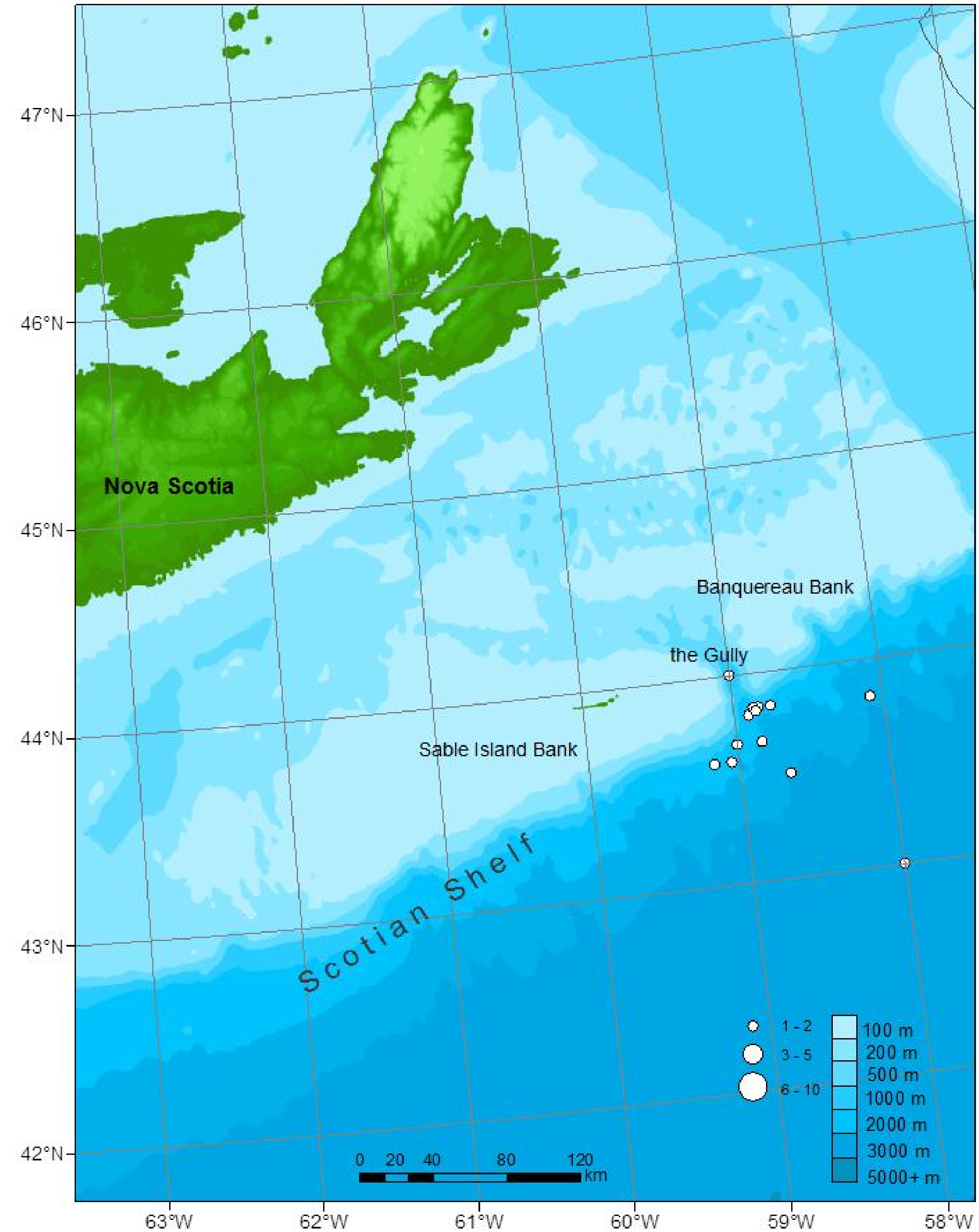

Figure 9. Locations and magnitudes of Northern Bottlenose Whale catches off Nova Scotia, 1964-1967. Data are from Reeves et al. (1993).

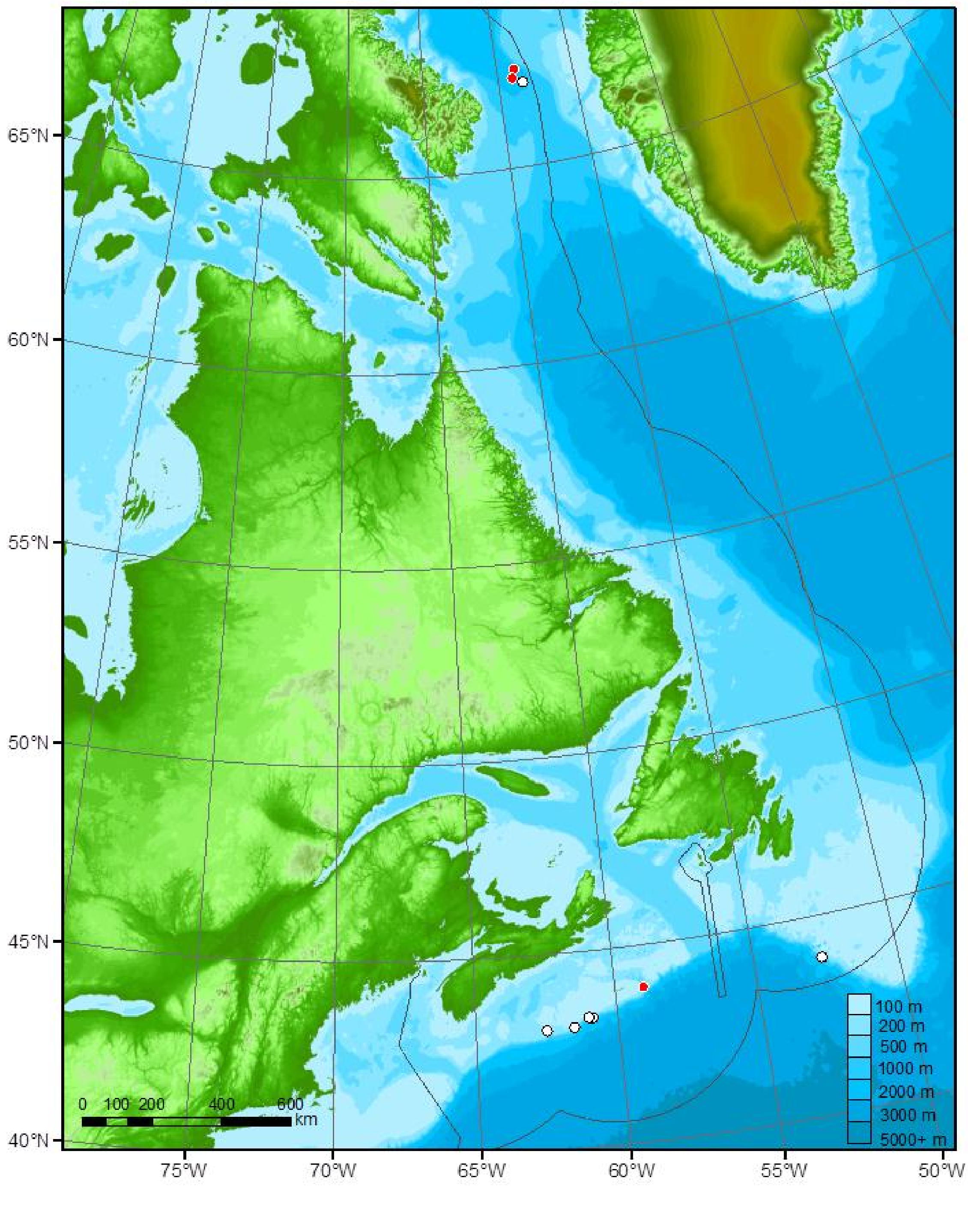

Figure 10. Locations of all reported entanglements or bycatch of Northern Bottlenose Whales in Canada. The white circles represent events for which location data were available. The red circles represent approximate locations of events. Data are from DFO and Dalhousie University.

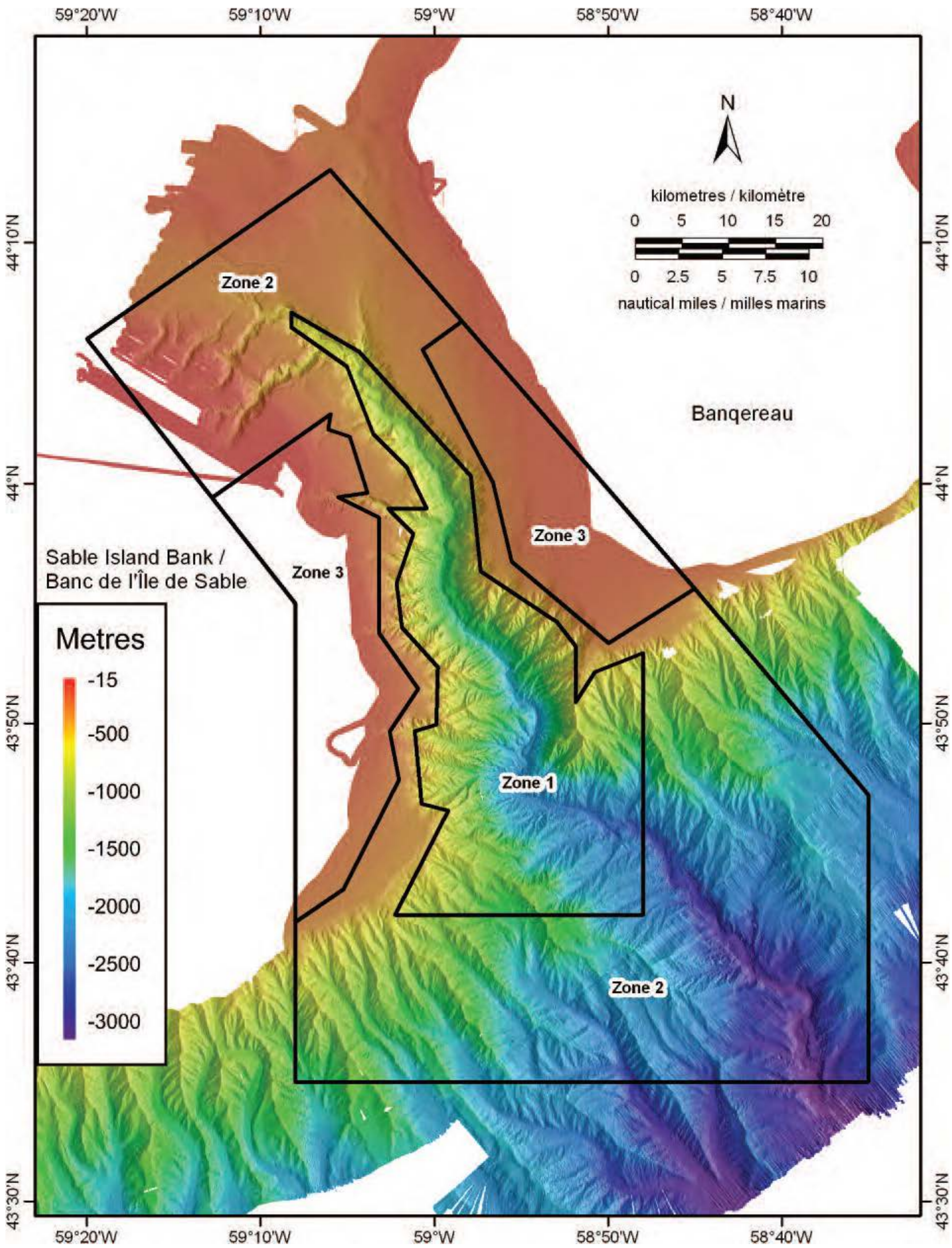

Figure 11. The Gully boundary area and management zones from the Gully MPA Management Plan (from DFO 2008).

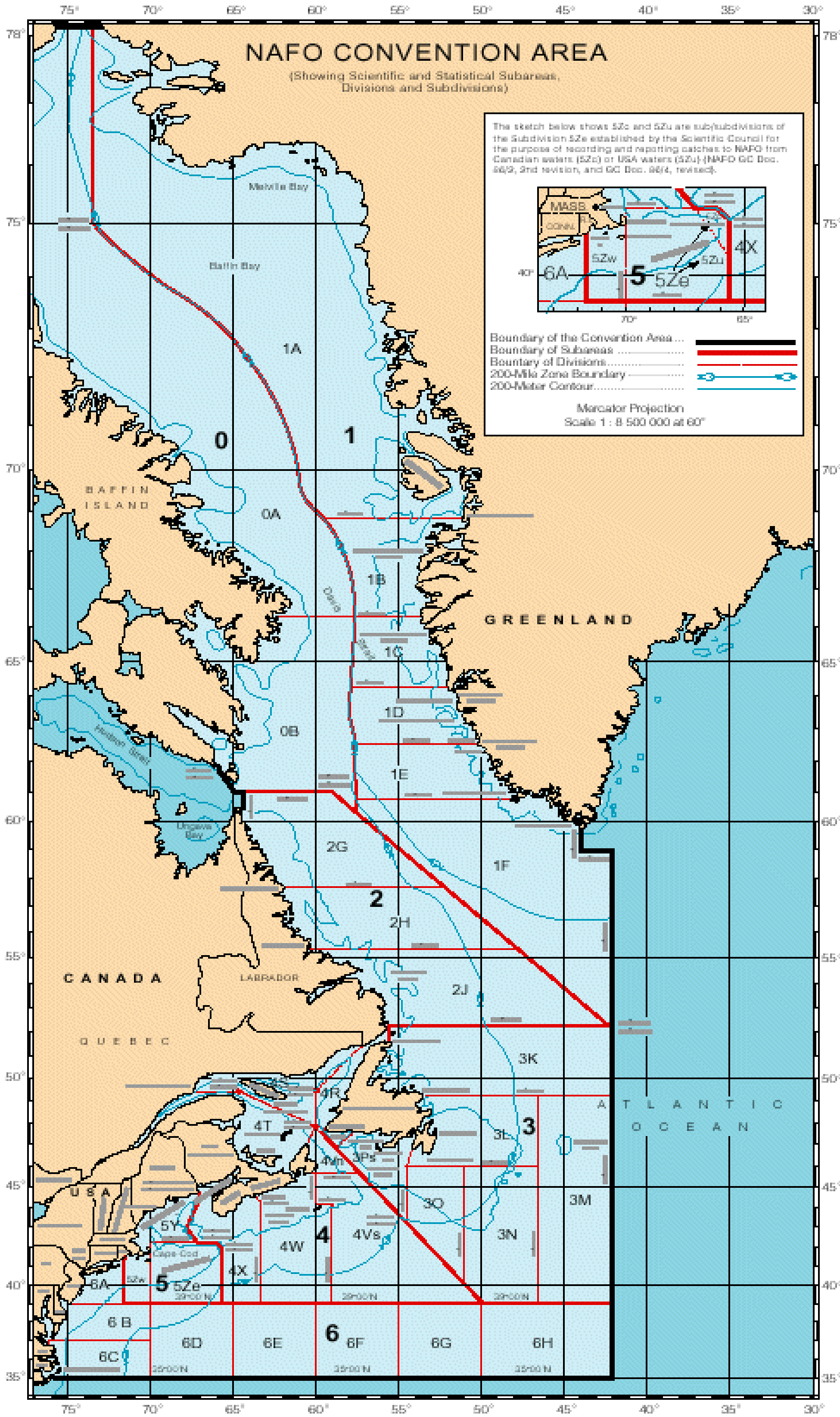

Figure 12. North Atlantic Fisheries Organization (NAFO) statistical areas.

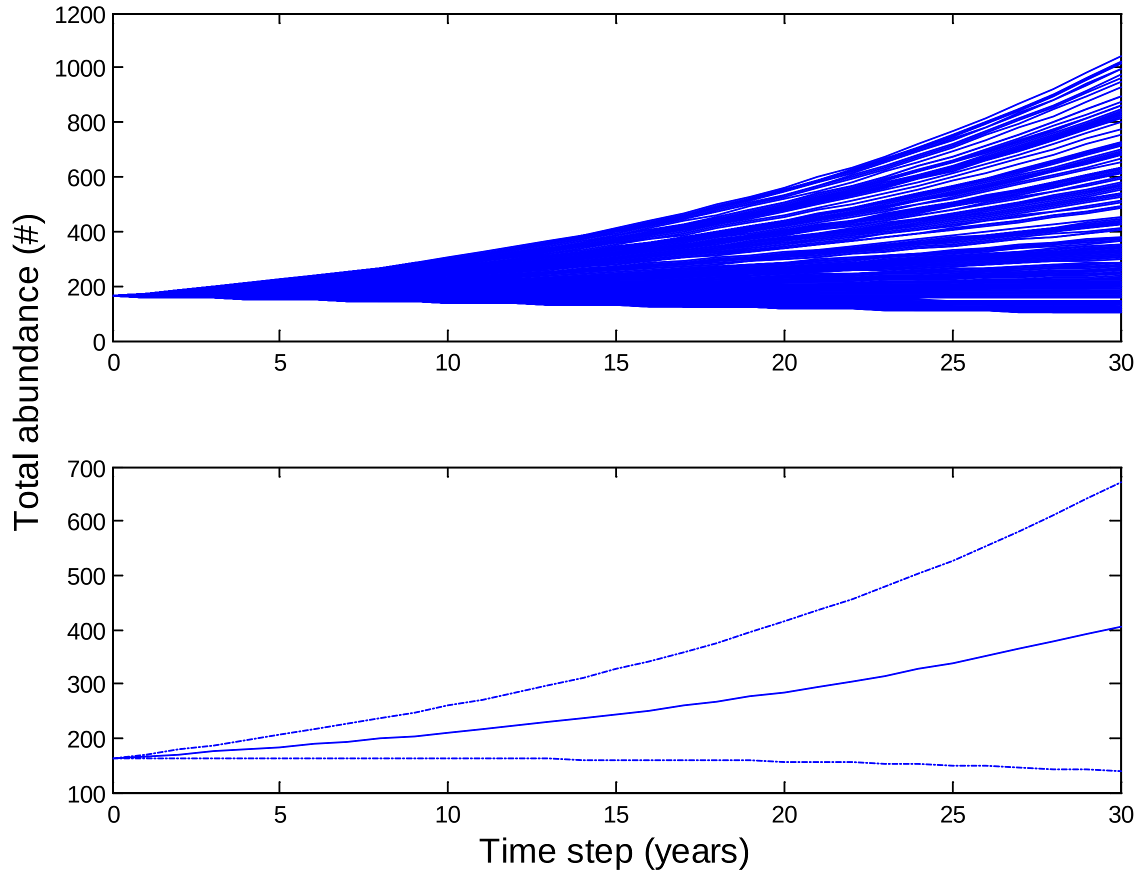

Figure 13. Population projection of the Scotian Shelf Northern Bottlenose Whale population. Initial population abundance = 163 whales. Proportional rate of increase, r = 0.025, with variance modeled as uniformly distributed with mean, μ=0.025, and standard deviation, σ=0.02. Two hundred model iterations undertaken. Individual model runs (top panel), and mean trajectory (± 1 standard deviation) of the population projection (bottom panel). (From Harris et al. 2007).